Asia Pacific Network (APN)

Workshop on

Networking
&
Capacity Building for Global Change Research

Islamabad, Pakistan

20th to 22nd November 2000

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ABBREVIATION	DESCRIPTION
ADB	Asian Development Bank
APN	Asia--Pacific Network For Global Change Research
ASEAN	Association Of South-East Asian Nations
BAHC	Biospheric Aspects Of The Hydrological Cycle
CCCM	Canadian Climate Centre Model
CEA	Council Of Europe
CLIMAG	Climate And Agriculture Project
CSIR	Council Of Scientific And Industrial Research
ENRICH	European Network For Research In Global Change
ENSO	El Nino-Southern Oscillation
ESCAP	Economic And Social Commission For Asia And The Pacific (UN)
FACE	Free Air Carbon Dioxide Enrichment
GC	Global Change
GCTE	Global Change & Terrestrial Ecosystems
GEC	Global Environmental Change
GECaFS	Global Environmental Change & Food Systems
GFD3	Geophysical Fluid Dynamics Laboratory R-30
GMO_S	Genetically Modified Organisms
HMG/N	His Majesty Government / Nepal
IAI	Inter-American Institute For Global Change Research
IARI	Indian Agricultural Research Institute
ICIMOD	International Centre For Integrated Mountain Development
IGAC	International Global Atmospheric Chemistry Project
IGBP	International Geosphere Biosphere Program
IGM	Inter-Governmental Meeting
IHDP	International Human Dimensions Program
INDOEX	Indian Ocean Experiment
IPCC	Inter-Governmental Panel On Climate Change
ITCZ	Inter – Tropical Convergence Zone
LBA	Large Scale Biosphere-Atmosphere Experiment In Amazonia
LMO_S	Living Modified Organisms
LOICZ	Land-Ocean Interactions In The Coastal Zone (Igbp)
LUCC	Land Use And Land Cover Change Project

ABBREVIATION	DESCRIPTION
MOPE	Ministry Of Planning And Environment (Nepal)
NIO	National Institute Of Oceanography
OTC	Open Top Chamber
PPBV	Parts Per Billion By Volume
SASCOM	South Asia START Committee
SAS-RC	South Asia START Research Center
SASRN	South Asia START Research Network
SPG	Scientific Planning Group
SPREP	South Pacific Regional Environment Programme
START	Global Change System For Analysis, Research and Training
START-SSC	START- -Scientific Steering Committee
TEACOM	Temperate East Asia
TRIPS	Trade-Related intellectual Property Rights
UNEP	United Nations Environment Programme
UVB	Ultraviolet-B
WCD	World Commission On Dams
WCRP	World Climate Research Program
WTO	World Trade Organization

OVERVIEW

The APN-sponsored workshop on "Networking and Capacity Building in Global Change Research" for South Asian countries was held in Islamabad, Pakistan on 20-22 November 2000. The workshop was organized in pursuance of the decision of the APN 5th Inter-Governmental Meeting (IGM) held in Islamabad on 29-30 March 2000 to strengthen networking and capacity building in selected countries in South Asia and South East Asia that had not effectively participated in the APN activities so far. Bangladesh, Nepal, Pakistan and Sri Lanka were identified as the countries to participate in the workshop.

A total of 44 persons participated in the workshop. This included 11 resource persons from international organizations and within the region, 5 from Bangladesh, 5 from Nepal, 4 from Sri Lanka, and 19 from Pakistan. In addition senior persons from concerned government departments in Pakistan attended the inaugural sessions and some other sessions in which they were particularly interested.

The inaugural session started with welcoming remarks and a brief background of the workshop by Amir Muhammed, chairman of the organizing committee. This was followed by introductory statements about APN and START programs by Gerhard Breulmann and Hassan Virji. Wendy Broadgate then described the IGBP and its projects with a somewhat detailed description of GCTE. After these introductory statements the chief guest, Mr. Omar Asghar Khan, Minister for Environment delivered the inaugural address in which he strongly supported research in environmental aspects especially pollution and climate change and supported regional and international collaboration in global change (GC) research.

In the next session, selected international global change research programs were discussed. Holger Hoff described the activities of the BAHC project and suggested some subjects dealing with hydrological issues relevant to the South Asia region. Taufiq Siddiqi described the results of the project dealing with greenhouse gas emissions in South Asia and the perspective for climate change in the region. The activities of the South Asia START Committee (SASCOM) were then briefly described by Amir Muhammed who highlighted the on-going and planned projects in the region. This was supplemented by a report about the activities of the South Asia START Regional Centre (SAS-RC) by Sumana Bhattacharya who also described the on-going global change research in India. The last presentation of this session dealt with funding opportunities for GC research for the scientists from South Asian countries especially through the APN and ENRICH grants which was described by Breulmann and Virji.

Session 3 was devoted to a discussion of the national activities in GC research and priorities for capacity building. Brief presentations were made by Chaudhry (Bangladesh), Shrestha (Nepal), Shuja Khan (Pakistan) and Ratnasiri (Sri Lanka). They described the existing situation with respect to GC research, national priorities for research in selected disciplines and priority mechanisms for capacity building. This was followed by general discussion on the current situation with respect to GC research in the region, measures to strengthen the research activity and possibilities of funding promising research projects. The participants then split into two groups that discussed GC research issues dealing with water, and agriculture respectively. The break-out groups reviewed the national and regional needs and identified high priority research topics common to most of the countries of the region that needed to be pursued for further research. The proposals of the breakout groups were discussed in plenary and a list of priority research topics was decided that could be taken up by research scientists from the target countries in collaboration with colleagues from developed countries for developing research projects for funding from APN and other organizations. Finally the group discussed measures for networking and capacity building in the region. It was decided that the agreed recommendations about research topics and measures for networking and capacity building may be submitted to APN and START for appropriate follow- up action.

Slide presentations of several speakers were transcribed into papers for publication in this report. by Dr. Sumana Bhattacharya, APN Liasion Scientist for South Asia. Because of shortage of time it was not possible to include literature references in all the papers. I would like to thank Dr. Bhattacharya for help in compiling the report and Mr. Ahmed Qadir for all the logistic arrangements for the workshop and printing of the report.

Amir Muhammed

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Welcome Address

Amir Muhammed,
Chairman, Organizing Committee

Honorable Minister, distinguished colleagues from international organizations and SASCOM members, workshop participants, ladies and gentlemen,

It is a great pleasure for me to welcome all of you to this important workshop. I am particularly grateful to Minister Omar Asghar Khan for making a special effort to be able to participate in this function in spite of his pressing engagements.

The workshop has been organized as a follow-up of the decision of the APN Inter-governmental meeting held in Islamabad during March 2000 to undertake networking and capacity building activities in several countries of the Asia-Pacific region that have hitherto not been able to participate effectively in the APN-sponsored competitive grants in priority areas of global change research. The IGM noted that in the South Asia region, scientists from Bangladesh, Nepal, Pakistan and Sri Lanka needed further strengthening of the global change research capabilities to enable them to become effective partners in the global change research effort. I am sure Dr. Breulmann; Program Director of APN will elaborate this point further in his address.

The global scenario has witnessed major changes after the 2nd World War and especially during the last two decades. Rapid industrial development in the North with the inevitable adverse consequences for the global environment especially due to the increased emission of greenhouse gases and the resulting increase in global warming and other climate changes are affecting the whole world. Globalisation of the economy and the mounting debt burden of the poor countries have resulted in increasing impoverishment of the population of these countries. There are many other demographic, socio-economic, physical and biological developments in different parts of the world that affect the whole Globe. These need to be studied carefully to save the world from their negative consequences that can in some cases be disastrous for the human race. This requires a strong emphasis on different aspects of global change research in all countries, especially the relatively poor developing countries that are likely to become major victims of the negative impacts of the global changes unless mitigation measures are taken well in time.

In Pakistan, we have witnessed a major deterioration of the environment especially the quality of air that we breathe and the water that we drink. The large number of cases of bone deformity and deaths in the Kasur area near Lahore recently because of severe pollution of the drinking water should be an eye-opener to us about the state of environment in the country. Similarly, the major climate changes that have a profound impact on country's agriculture deserve well-organized multi-disciplinary research effort to prepare for the anticipated global warming and changes in rainfall pattern. Rapid growth in population, large-scale rural-urban migration, and the mounting national debt burden that has paralysed the national economy are the demographic and socio-economic consequences inevitably linked to global changes that we need to study carefully in close collaboration with the global research community.

The difficult economic situation of most of the countries of South Asia has resulted in a major reduction in funds to support scientific research. This paucity of funds has particularly affected the research effort in different aspects related to global change. We hope this workshop will provide a major stimulus to encourage research in this vital area and focus attention of the national governments and the international community to support this research effort.

I would like to extend a warm welcome to the participants from Bangladesh, Nepal, Sri Lanka and Pakistan. It is our hope that this workshop will equip them with a perspective of the global change research so that

they are able to develop research projects in priority areas. We will discuss the current status of global change research and future priorities in the participating countries and will also identify project titles for future research along with names of potential collaborating scientists, towards the end of this workshop.

I am grateful to colleagues on the South Asia START Committee (SASCOM) from Bangladesh, Nepal and Sri Lanka who kindly agreed to participate in the workshop, present an over-view of the current situation with respect to global change research in their countries and contribute in the discussion on identification of priority areas for global change research in the region.

My special thanks to colleagues from the International Geosphere Biosphere Program (IGBP) and the IGBP core project BAHC (Biospheric Aspects of the Hydrological Cycle) for joining us and to deliver lectures on their respective programs for the benefit of the participants. I am especially grateful to Dr. Toufiq Siddiqi, President, Global Environment and Energy in the 21st Century (GEE-21) for kindly agreeing to deliver a lecture on the Greenhouse Gas Emissions in South Asia and especially to cover the global climate change aspects with special reference to South Asia.

As I mentioned earlier, APN has sponsored this workshop with funds provided by the Environment Agency of Japan. I am especially grateful to Dr. Gerhard Breulmann for all the effort that he has put in to organize this workshop. The International START (SysTem for Analysis, Research and Training) Secretariat has been closely associated in the conception of the idea of capacity building and organization of this workshop. Dr. Roland Fuchs, the Director of START was one of the prime movers of this idea and I am grateful to Dr. Hassan Virji Deputy Director of START for the enthusiastic support that I received in the organization of this workshop.

Last, but not the least, I want to thank colleagues on the Organizing Committee- Mr. Mahboob Elahi APN-National focal Point and Joint Secretary Ministry of Environment, Mr. Asif Shuja Khan, Director-General, Environment Protection Agency, Ministry of Environment, and Dr. Munir Ahmed Bhatti Member (Science) Pakistan Science Foundation for their keen interest and valuable support in the organization of this workshop.

In the end, I would again like to welcome the distinguished guests and workshop participants and hope that this workshop will stimulate interest in global change research in various public and private sector research organizations, not only in biological and physical sciences but especially in the social sciences and human development aspects of global change.

INAUGURAL ADDRESS

H.E. Mr. Omar Asghar Khan,
Minister for Environment Local Government and Rural Development, Government of Pakistan

Dr. Amir Muhammed, distinguished scientists from international organizations, workshop participants, ladies and gentlemen,

Asslam-o-alaikum

I am grateful to the organizers of this important workshop for inviting me to this inaugural session. It is indeed my pleasure to be with you second time in a function organized in association with Asia Pacific Network on Global Change Research (APN) this year. I clearly recall that in the Fifth Inter-Government Meeting of APN held in Islamabad in March this year, the need for capacity building and networking in Global Change research in several countries of South Asia and South East Asia was stressed. I am pleased to note that APN has promptly responded to this request and have helped in organizing this workshop at Islamabad.

I am especially pleased to see participants from Bangladesh, Nepal and Sri Lanka in this workshop and extend them a warm welcome to Pakistan and wish them a very enjoyable and professionally rewarding stay in our capital. Presence of eminent scientists from several international organizations including APN, START, IGBP, IHBP in this workshop as resource persons is an ideal opportunity for us to foster a lasting collaboration between Pakistani and other colleagues from region in different aspects of global change research.

The evidence of global changes are evident in the form of deforestation, decreased land cover and water shortage. With the on-set of globalization new challenges also confront us. These include involvement of large corporations in agriculture sector under the facilities offered by WTO agreement. Pakistan is Party to WTO and its subsidiary agreements, such as Agreement on Trade Intellectual Property Rights (TRIPS), Agreement on Agriculture and Agreement in Textile and Clothing. The advances on biotechnology and the introduction of genetically modified organisms (GMOs) and living modified organisms (LMOs) would be rampant. Developing countries like Pakistan has to be careful in the choice and use of GMOs and LMOs due to their possible adverse effects on human health and environment. Multinational corporations would also seek patents of agricultural products and other life forms. In such cases, benefits- sharing by the local communities who have protected the indigenous species and plant must be ensured. In this regard, there is a need to be careful of research sponsored by multinationals that invariably ended up supporting their actions and products. We are not against adopting new technologies but we must follow the principal precautions and to mitigate their negative effects at the out set for instance, in a recent tragedy at Kalanwawala in Lahore region of Pakistan where high concentration of fluoride has resulted in bone deformities in the community. There was hardly any scientific monitoring of the pollutants being released by the industry. Unfortunately, we often respond late to such tragedy and it is often the poor who suffers the most.

There is also a need to collaborate regionally to address local, national, and global environmental problems. Only by working together could there be a perceptible response to the emerging global environmental problems. While Pakistan is already facing various environmental problems, new ones keep on adding to our lists such as global warming and its impact on agriculture, water resources and coastal zones Pakistan has had higher than normal temperatures during the year and a much reduced level of rainfall. The pattern monsoons are also shifting.

Distinguished participants**…**

Pakistan attaches a high priority to both the local, national and global environment problems. Pakistan actively participated in Rio Conference and developed consensus on different issues, as chair of Group of 77 and China. We have rectified all major environmental conventions and protocol and are taking measures for their implementation. We are also working with other partners in the Asia-Pacific and other regions for the realization of these objectives. I should specifically mentioned that a number of steps have been taken in Pakistan for the implementation of United Nations Framework Convention on Climate Change and Male Declaration and Control of Air Pollution Tran boundary Air Pollution. We are seriously considering ratification of Kyoto Protocol and signing of Cartagena Protocol on Bio-Safety. We strongly believe that working with other members of the world community can only bring about a perceptible response to the emerging global environmental problems.

In terms of Global Change Research, climate change is the single serious most challenge threatening the very basis of human survival on the plant earth. Even though, Pakistan is an agricultural country with a negligible contribution to green house gas emissions, its stands to suffer disproportionately from the adverse effects of climate change. We are therefore, with the world community for a collective response. The burden sharing has, however, to be assumed by the developed country proportionate to their contribution to the accumulation of these gasses responsible for climate and global warming. It is practically the life style and production process of industrialize countries that are largely responsible for the emission of gases that are causing climate change being experienced by us. Global warming is a serious threat to the humanity and all countries should be fully involved in the debate and agenda of global environmental change.

We are also fully aware of the benefits of clean, healthy environment for national development and the very serious often-disastrous consequences of a polluted unhealthy environment. The government has taken several measures to improve the national environment. A national environment action plan is under finalization to provide for a focused attention on key environmental issues at the national level, like clean air, clean water, solid waste management and conversation of bio-diversity. Regarding other sectors of economy, we are closely working with other federal and provincial government agencies to ensure integration of environment and development.

This year we had higher then normal temperatures for most of the year and a much-reduced rainfall in monsoons as compared to normal. This has resulted in low storage in our major reservoirs and a severe water shortage for the current rabbi crop. While we are doing our best to meet the current situation, we are more concerned about the global phenomena relating to climate change and their impact on agriculture, human and animal health and overall economic development. I am pleased to learn that a major project relating to global climate change is being launched by several international agencies that will be implemented by the International START Secretariat, Washington DC, and the Third World Academy of Sciences, Trieste Italy. I understand that this workshop will also devote a session to identifying research projects aim at studying the global climate change phenomena in different countries of the regions and plans to mitigate the adverse effects of climate change. We are keenly interested in this project and will fully support the research activities in Pakistan related to this project.

Ladies and Gentlemen:

I must admit that the Pakistani economy is currently under pressure due to huge debt burden accumulated over the past several decades. There is, however, need for integrating environmental concerns in the social development programs. The government has therefore, to resort to several measures to reduce public sector expenditure but we are committed to allocate adequate funds for social development and environmental programs as we consider this as an investment in the social and natural capital of the country. The government has taken many steps to address the national environment problems. A National Environmental Action Plan is under finalization to provide focused attention on key environmental issues as clean air, solid waste management, and conservation of bio-diversity. We are nonetheless committed to increase public sector outlays for scientific research. These national efforts however, need to support by regional and global initiatives so that the potential of science and technology for human development are fully harnessed.

We will therefore, welcome all projects and programs for capacity building and global change research relevant to our needs. I do hope that Pakistan scientists will be able to compete successfully for the research grants provided by APN and other international funding agencies as the activity in global change research picks up in the country, we would also like to establish a National Center for Global Change Research in one of the existing research institutions to provide a focal point for such research activities in the country. We will of course share our experience in organizing global change research activities with other member countries of SAARC for mutual benefit.

In the end I would like to thank the organizing committee, especially its Chairman Dr. Amir Muhammad for making the necessary arrangements for this important workshop in such a short period. I once again extend at hearty welcome to all the participants of the workshop and wish the workshop success.

APN AND THE NETWORKING AND CAPACITY BUILDING PROGRAM

Gerhard Breulmann

Programme Manager, APN Secretariat Kobe, Japan

Background

An understanding of the complex mechanisms and impacts of global environmental problems on human health and ecosystems is becoming increasingly important in order to reduce uncertainties related to global environmental change. Global change research cannot succeed without a high level of international cooperation, as can be seen in collaborative projects implemented at the scientific level under the international research programs. Inter-governmental networks now support global change research in three major regions of the world--North and South America, Europe and Africa, and the Asia-Pacific. The Asia Pacific Network (APN) is one of these networks, as is the European Network for Research in Global Change (ENRICH), and the Inter-American Institute for Global Change Research (IAI).

The establishment of these networks follows the invitation from former President Bush of the United States, during the 1990 White House Conference on Science and Economics Research related to Global Change, to countries of the world to join the U.S. in developing three regional research institutes. This endeavour was made to link the interests and capabilities of developed countries and their scientific communities that focus on broadening global change research in the developing world, providing support for truly multi-disciplinary research and education and encouraging the development of a sound scientific underpinning that supports national and international policy making needs.

The Asia-Pacific is an important region for understanding global environmental problems. Important atmospheric and oceanic phenomena occur here, such as the Asian Monsoon and the El Nino phenomena, which affect the world climate, and the region also has tropical forests, deserts, and mountains. At the same time, the Asia-Pacific region has a population of nearly 3 billion - more than half of the world's total human population. In addition, its economic growth rate is the highest of any region in the world. Because of its population growth rate and its economic activities, this region contributes to global climate change in a major way. Degradation of the environment, such as deforestation and desertification, is becoming a matter of great concern, as are natural disasters, which occur as a result of this degradation, such as floods and droughts. Thus, observation, monitoring, and research on global change in the Asia-Pacific region are indispensable to understanding environmental changes taking place on a global scale. The countries in the Asia-Pacific region are carrying out many research activities in the field of global change, but much closer trans-national cooperation, coordination and information exchange are needed. In addition, stronger links are needed between the science community and policy makers. The Asia-Pacific Network for Global Change Research (APN), an inter-governmental network, was created to answer these needs. The 21 APN member countries include Australia; Bangladesh; Cambodia; China; Fiji; India; Indonesia; Japan; Korea; Laos; Malaysia; Mongolia; Nepal; New Zealand; Pakistan; Philippines; Russia; Sri Lanka; Thailand; USA and Vietnam.

Objectives and strategies of APN

The APN provides a platform to support research through funding on areas related to change in complex climate, ocean and terrestrial systems, and on physical, chemical, biological and socio-economic processes in the Asia-Pacific Region. It aims to increase developing country participation in that research, and to strengthen links between the science community and policy makers through

- Supporting regional cooperation in global change research on issues that are particularly relevant to the region;

- Standardization, collection, and exchange of scientific data relating to global change research;
- Improvement of scientific and technical capabilities and research infrastructure of nations in the region;
- Cooperation with research networks in other regions;
- Providing scientific knowledge to the public, and input to policy decision-making; and
- Development of appropriate mechanisms for transfer of know-how and technology

The strategies which APN uses to achieve these objectives are through Identification of key scientific priorities with relevance to policy issues, Initiating research activities and funding, Promoting multi-country research with a partner ship approach, Involving of policy makers in research agenda setting, Building a human network

APN Research Framework

APN is committed to promote research in the areas of:

- Changes in Atmospheric Composition
- Changes in Coastal zones and inland waters
- Climate change and variability
- Changes in Terrestrial ecosystem and Bio-diversity

All the findings from these research areas should be integrated with the findings of the natural sciences with social and economic factors with an input to policy making and implementation. Furthermore the APN has a system of Key Scientific Priorities, which allows to extent the focus on issues that are of specific interest for the region. The current Key Scientific Priorities are the 'Human Dimensions of GC' and 'Climate Change & Variability'. The Key Scientific Priorities only want to stress areas of special importance (the topics selected commonly remain in force for 3 years). Proposals are still sought under any relevant topic.

The Global Environmental Change Community

Existing research programs created by large scientific unions such as the International Human Dimensions Global Environmental Change Programme (IHDP), International Geosphere-Biosphere Programme (IGBP) and World Climate Research Programme (WCRP) provide an important basis for achieving APN goals. These three programs have developed plans for capacity building and strengthening research on regional contributions to and impacts from global change through the Global Change System for Analysis, Research and Training (START). The APN cooperates closely with START, and its regional committees in the APN region, including the South Asia START Regional Committee (SASCOM), South East Asia Regional Committees for START (SEA-START), Temperate East Asia Regional Committee for START (TEACOM), START Oceania (OCEANIA) and the PAN-AFRICAN network. Also APN activities are linked to the other intergovernmental research networks such as the IAI and the ENRICH.

For regional activities to be successful they have to be build on national programs, which are related to national priorities. Many governments have established national bodies to provide advice on policies and programs related to global change, and to foster global change research. Research communities in many countries have established academies and councils that can provide a focus or point of coordination or harmonization for global change work. The level of success of the APN and the global programs depends in large measure on forging continuing, effective links with and among these national arrangements.

APN's Organizational Structure

APN activities are decided by the annual Inter-Governmental Meeting (IGM), and supported by the Steering Group (SG) and Scientific Planning Group (SPG). Governmental representatives who are appointed by the countries participating in the APN attend the annual IGM meeting, the highest decision-making body of APN. In addition, observers are invited from the global change scientific programmes, from the International START (System for Research Analysis and Training) Secretariat, START regional

committees (Temperate East Asia, Southeast Asia, Oceania and South Asia), and the APN's sister networks ENRICH and the IAI. The SPG's role is to recommend a scientific program for consideration by the Inter-Governmental Meeting, work with the Steering Group and Secretariat in arranging scientific program activities, interact on APN's behalf with other international research programs on global change and respond on other science related issues referred to it by the IGM or SG. The SG consists of a representative from the last host country of the IGM, the next host country, the co-chairs of the Scientific Planning Group, and the Director of the APN Secretariat, as well as an observer from the International START Secretariat. Besides the above bodies, APN has provision for an APN Liaison Officer corresponding to each START Regional Committee to coordinate information flows, i.e. Temperate East Asia, Southeast Asia, South Asia, and Oceania.

Why a Networking and Capacity Building Workshop?

Examples for projects approved by APN for funding in 2000-2001 are Atmospheric aerosol and UV radiation, Climate and Agriculture, Bio-geo chemical budgeting and socio economic modelling, Land use and Land cover change for South east Asia, Policy implications of global change, CO_2 enrichment and rice cultivars, Sea level change and costal management or Urbanisation. The Principal investigators (PI) of these projects are from Australia, Japan, China, India, Malaysia, New Zealand, Sri Lanka, Korea, and Thailand. Several countries, i.e. Pakistan, Nepal, Bangladesh in South Asia and the Indo-China countries Cambodia, Laos and Vietnam are missing in the PI list. The APN Secretariat therefore presented a proposal for an APN Networking and Capacity Building Programme, funded by the Environment Agency of Japan (now Ministry of Environment, Japan), designed to increase the involvement of those countries that have until now been least involved in APN activities in the SPG/IGM meeting. It was proposed to target Bangladesh, Cambodia, Laos, Pakistan, Sri Lanka and Vietnam in the first year, but to extend the trial period to 2 years with Mongolia and Nepal to be involved in the second year. The programme was warmly welcomed and received strong support from the members. It was clarified that the countries involved would decide their own research priorities within their regional groups, and that these discussions had already begun for the South Asian countries. The delegates expressed their desire that this programme be expanded to include a larger number of developing countries in the longer term. In this context therefore a one-day APN capacity building and networking awareness workshop was organised in Sri Lanka in September 2000 and a three day workshop has been arranged in Islamabad, Pakistan, in November 2000 to generate projects by Investigators from Pakistan, Nepal, Bangladesh and Sri Lanka for possible funding by APN. Another 3 – day workshop will be held in Hanoi, Vietnam in February 2001.

START AND ITS ROLE IN CAPACITY BUILDING

Hassan Virji

Deputy Director, International START Secretariat, Washington D.C.

Global Change - Regional Challenges

Interest worldwide is emerging over environmental change issues and the implications for continued habitability of planet Earth. Topics such as greenhouse gas emissions, depletion of stratospheric ozone, reduction in biodiversity, deforestation and desertification, have moved into positions of prominence on the international agenda.

In order to appropriately address sustainable socio-economic development, it is necessary to base discussion on careful scientific assessments and prediction. However, it is not yet clearly understood how the interactive physical, chemical, biological and socio-economic processes regulate the total Earth system and how this system will respond to anthropogenic influences. The scientific community has risen to this challenge by developing international research programmes that are aimed at reducing such scientific uncertainties. Together these programmes-the International Human Dimensions of Global Environmental Change Programme (IHDP) the International Geosphere-Biosphere Programme (IGBP) and the World Climate Research Programme (WCRP) constitute a concerted international effort to reduce the scientific uncertainties regarding global environmental change and to improve the knowledge base essential for sustainable development.

The Promise of START

To understand global environmental change and develop appropriate responses, a regional approach to research is desirable since:

- Regional differences in such characteristics as biogeography, climate and human patterns of development make research difficult to conduct on a global scale alone. In order to develop a truly global perspective regional level research must also be conducted.
- The goal of a practical predictive capacity for global environmental change requires that such a capacity be developed at regional level where the ability to predict global change is of greatest value to decision makers.

In order to meet these challenges, IHDP, IGBP and WCRP have jointly sponsored START. START assists the regional implementation of these global science programmes and helps developing regions to design and implement programmes of regional relevance as well as global significance.

In some parts of the world, particularly the developing regions, the ability to conduct regional research is hampered by a lack of scientific personnel and adequate infrastructure. The START initiative is intended to enhance the indigenous capacity of these regions to participate in the various global scientific change research programmes.

A world-encompassing set of regions was initially identified through the START initiative some of which are being developed under other initiatives. All of the regions are important to understanding global change because each has distinctive environmental and socio- economic characteristics. Priority is given by START to establishing regional research networks in the developing world where the needs are greatest.

The START Mission

- To develop a system of regional networks of collaborating scientists and institutions:
- To conduct research on regional aspects of global change
- To assess the causes and impacts of regional global change,
- And to provide relevant information to policy makers and governments

- To enhance scientific capacity in developing countries by strengthening and connecting existing institutions, by training global change scientists and by providing them with improved and enhanced access to data, communication technology and research results.
- To help mobilize the resources required to augment existing global change scientific capabilities infrastructure and activities in developing countries.

The START Regional Research Networks

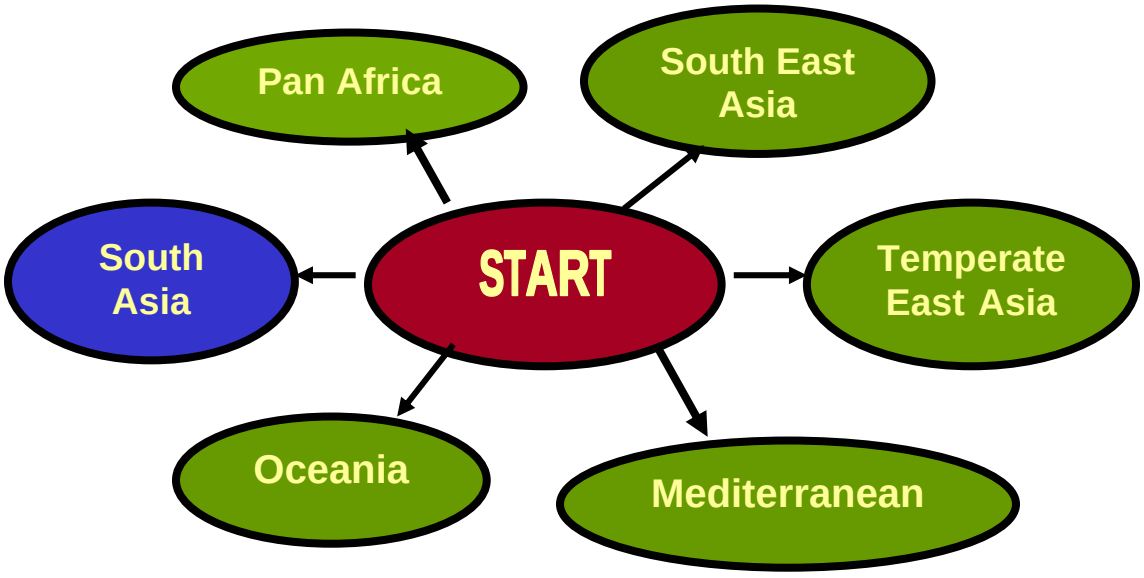
The fundamental objectives of START regional networks (Fig 1) are:

- To promote regional cooperation in global change research
- To mobilize scientific manpower and resources to conduct collaborative regional research concerned with global change
- To provide a framework to support the regional scientific syntheses and assessments relevant to policy development

The START regional networks also serve as a means of:

- Developing coherence and greater efficiency among global, regional and national research agendas
- Enhancing the exchange of data and the communication of research results
- Providing scientific information to the public and inputs to policy making bodies

Fig 1: START'S REGIONAL RESEARCH NETWORKS



The START Structure

Direction and oversight for START is provided by the START Scientific Steering Committee. The START-SSC also serves to provide an informal forum for discussions between governmental and non-governmental initiatives. Members of the START-SSC include scientists associated to its three sponsoring programmes (IGBP, WCRP, and IHDP) as well as individuals connected with national, multilateral and intergovernmental bodies. For example, member of the START-SSC are affiliated with components of the UN systems, the International Group of Funding Agencies, the Asia-Pacific Network for Global Change Research (APN), the European Network for Research in Global (ENRICH), and the Inter-American Institute for Global Change Research (IAI).

The development of the various START regional networks is guided by regional START committees comprised of scientists and representatives of appropriate national and regional level bodies. The International START Secretariat, located in Washington, DC, is responsible for the implementation and development of START research networks.

Partnerships and Affiliations

The need for inter-governmental cooperation on the issue of global change research has been recognized by many nations of the world, as evidenced by the participation of most of the worlds leaders in the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in June of 1992. START has strong ties to intergovernmental organizations. Joint programmes and other efforts have been undertaken with APN, ENRICH, EC, IAI. Partnerships with these organizations allows START to promote regional cooperation on critical issues of global environmental change. It further enables the implementation of a structure to assist national and regional level policy development related to global change.

Through its programme co-sponsors, START is closely affiliated with the International Council of Scientific Unions, which is a parent body of all these co-sponsors.

Regional Collaborative Research and Capacity Building Activities

Global change research activities conducted under the auspices of START fall into four major thematic categories:

1. Land use change and its impacts on terrestrial ecosystems
2. Regional climate variability and change
3. Changes in atmospheric composition and its impacts
4. Global change and coastal zones, land-ocean interactions and international waters

Inherent in all START activities is the development of regional collaborative networks with the purpose of entraining scientists and institutions from developing countries into the larger suite of international global change programs. START projects foster a regional, inter-disciplinary approach with an emphasis on developing products for policy making.

START also offers training and educational opportunities to scientists from developing countries to interact with colleagues in developed countries to foster collaborative research partnerships. Since 1994 through

2000, ninety of these awards have been granted to individuals working in a wide range of global change research endeavours, including land use change, climatic variability, coastal zone management, forest monitoring and management, paleo-climatology, integrated assessment models, and many other disciplines.

In addition to these, capacity is built through sponsoring of training workshops and summer schools. Some of the recent training workshops that have been organized in the year 2000 are the GIS training workshop in Africa, IHDP/START workshop on human dimensions in the coastal zones, and training course on Analysis of climate change simulations for south-east Asia, in Australia.

START also annually grants awards to promising young scientists from Asia and Africa for excellence in global change research as demonstrated by a peer reviewed paper.

GLOBAL CHANGE RESEARCH OF THE IGBP

Wendy Broadgate,

Deputy Director, Natural Sciences, IGBP, Stockholm.

The International Geosphere-Biosphere Programme (IGBP) conducts research into global biogeochemical cycles and the impacts and feedbacks of global change on the Earth System. Global change phenomena include population increase, changes in atmospheric composition (particularly carbon dioxide and methane), climate (particularly temperature and rainfall), land use and cover, nitrogen availability, water availability and biodiversity, to name a few. They include global phenomena, such as global mean temperature or carbon dioxide and site-specific phenomena which collectively are globally significant, such as impact on crop yield or soil erosion. Owing to the delicate balance of impacts and feedbacks a thorough understanding of the Earth System is needed in order to predict changes in the future.

The programme is focused on acquiring basic scientific knowledge about the interactive processes of biology and chemistry of the earth as they relate to Global Change. The goal of the programme is:

> *To describe and understand the interactive physical, chemical and biological processes that regulate the total Earth system, the unique environment that it provides for life, the changes that are occurring in this system, and the manner in which they are influenced by human actions.*

Priority is placed on those areas in each of the fields involved that deal with key interactions and significant changes on timescales of decades to centuries, that most affect the biosphere, that are most susceptible to human perturbations, and which will most likely lead to a practical, predictive capability.

IGBP is not a funding agency, but a coordinating body which brings together scientists internationally to conduct collaborative research towards commonly agreed goals. Issues which are particularly important for the South Asia region include land use and land cover, water resources and agriculture. These are the topics of research of the IGBP ongoing Core Projects , LUCC (Land Use and Land-Cover Change), BAHC (Biosphere Aspects of the Hydrological Cycle) and GCTE (Global Change and Terrestrial Ecosystems). In addition, in collaboration with the World Climate Research Programme (WCRP) and the International Human Dimensions Programme on Global Environmental Change (IHDP), we are currently establishing three Joint Projects on Carbon, Food Systems and Water Resources. In this presentation, I will describe the activities of GCTE research, focussing on Agro-ecology and Production Systems, and then introduce the emerging Joint Projects on Food Systems and Water.

Global Change and Terrestrial Ecosystems (GCTE)

The objectives of the GCTE Project are to:

- predict the effects of changes in climate, atmospheric composition and land use on terrestrial ecosystems including agriculture, forestry and soils, and ecological complexity.
- determine how these effects lead to feedbacks to the atmosphere and the physical climate system.

There are four foci of GCTE Research:

Focus 1 - Ecosystem Physiology

Focus 2 - Change in Ecosystem Structure

Focus 3 – Agro-ecology and Production Systems

Focus 4 - Biodiversity

In Focus 3, Agro-ecology and Production Systems, research is carried out into impacts of global change on production systems of staple crops (e.g. rice), adaptation of production systems to cope with global change (e.g. subsistence rangelands) and mitigation of climate change (e.g. soil organic matter management). This is implemented through Core Research Projects and networks of experimenters and modellers contributing to a given Core Research Project. Figure 1 depicts the GCTE Focus 3 core activities and the associated networks shown in italics

The objectives of the Networks are to refine and adapt simulation models for use in global change studies in a wide variety of conditions and to design and undertake experiments to provide improved mechanistic understanding of global change impact on processes, to aid in model development. These objectives are achieved through the following activities:

Compilation and circulation of detailed, standardised descriptions of contributed datasets and models (metadata) in the GCTE Report Series and on the WWW Data and model code exchange

Model sensitivity and comparison workshops

Collaborative experimentation and synthesis workshops

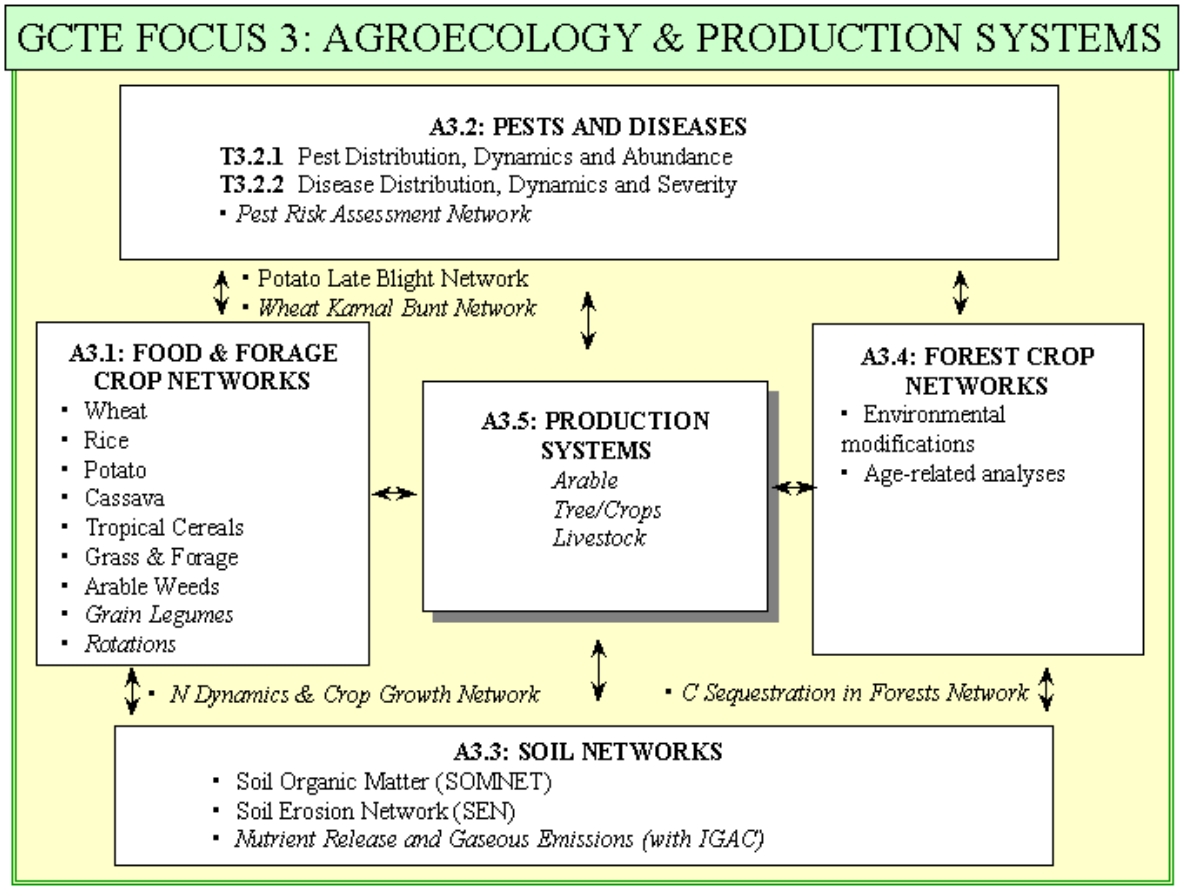


Figure 1 - Networks of GCTE Focus 3.

For further involved of how to get involved in GCTE Focus 3, visit the website, ***http://mwnta.nmw.ac.uk/GCTEFocus3/***

Global Environmental Change and Food Systems (GECaFS)

The provision of food in sufficient quantity and quality to certain sections of society is a major problem in many parts of the world. Global Environmental Change (GEC, which includes independent and interactive changes in the physical and biophysical environment) will in many cases, bring *additional* complications to the already difficult task. However, not all individuals and sections of society are equally *vulnerable* to GEC. Their *capacity to cope* with existing variability in biophysical and socio-economic systems, and their *ability to perceive GEC* and *adapt food systems* accordingly varies considerably. This is because these factors are controlled by the flexibility with which *food provision* (i.e. supply, availability and access to food and related, essential resources) is mediated by institutions governing how biophysical and socio-economic factors interact (e.g. land tenure, access to credit, exploitation rights of renewable resources, etc.).

IGBP, IHDP and WCRP are developing a Joint Project within the context of three "fundamental questions":

1. How does GEC additionally affect food provision and vulnerability in different regions and among different social groups?

2.How might different societies and different categories of producers adapt their food systems to cope with both GEC and changing demands?

3. What would be the environmental and socio-economic consequences of adaptations to these changes?

Of ultimate interest is the link between GEC and societal well-being (rather that the link with food systems *per se*) but this is addressed through the researchable issues needed to understand the relationships between GEC and food systems. It is this that requires an innovative, interdisciplinary approach.

Goal

> *To estimate the impacts of Global Environmental Change on food production, availability and accessibility across biophysical and socio-economic systems from regional to global scales, and to analyse the effectiveness of adaptive strategies to reduce societal vulnerability.*

Science Foci

Focus 1 - Impacts: Effects of Global Environmental Change on Food Provision
Focus2 - Vulnerability and Adaptations: Global Environmental Change and Options for Enhancing Food Provision
Focus 3 - Feedbacks: Environmental and Socio-economic Consequences of Adapting Food Systems

These inter-related science foci would identify this project as a well-defined, interdisciplinary approach addressing the relationships between GEC and food provision. Innovative approaches include the additional complications GEC may bring to meeting demand, at a range of scales from regional to global; and the feedbacks to environment of adapting food systems to meet changing demands.

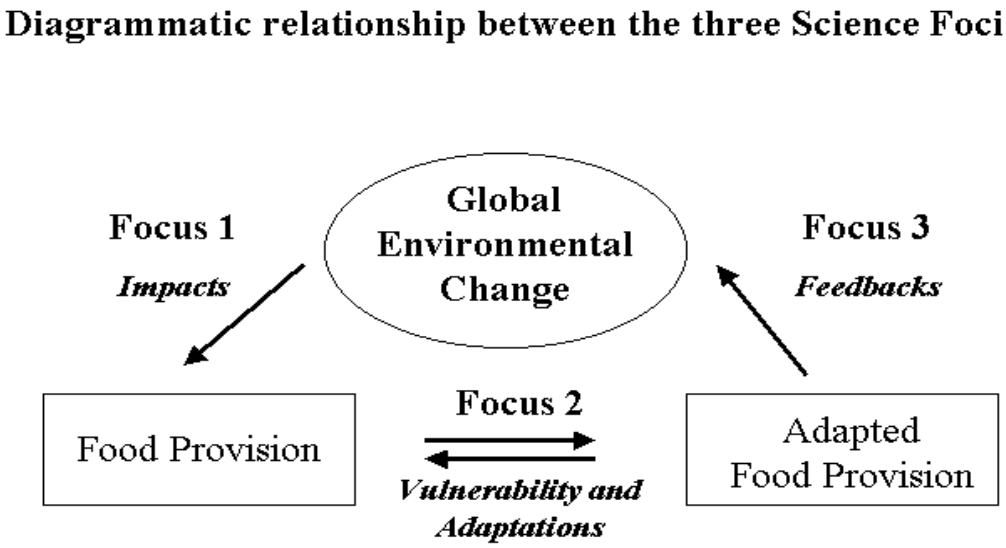


Figure 2 – The relationship between the tree science foci in GECaFS

Implementation

The project will likely be implemented as a set of commissioned studies within the context provided by questions that frame the study. Ongoing, individual projects, which are suitable for inclusion in GECaFS will be encouraged to become involved to share their expertise in project design and implementation, and in the synthesis process.

Unsolicited proposals would also be welcome. The overall goal will be addressed by synthesising the commissioned studies along thematic and/or geographic lines. An International Project Office is proposed to provide research coordination, synthesis and dissemination of results.

Water Resources

The availability of water in sufficient quantity and quality is a major problem in many parts of the world now and water stress is likely to increase globally in the future. Global Environmental Change will in many cases, bring additional complications to the already difficult task. A joint project on Water is currently being established by IGBP, WCRP and IHDP. The pressing questions facing water research will be closely entwined with those of Food research outlined above. Information will be available via the IGBP web site as the project planning develops: ***www.igbp.kva.se***

Acknowledgements:

The material presented in this presentation is a result of the ideas of a wide variety of scientists in the IGBP research network. In particular, I would like to thank John Ingram, coordinator for GCTE Focus 3 and the GECaFs project.

GLOBAL CHANGE AND WATER RESOURCES

Holger Hoff
Executive Officer, BAHC Project of IGBP, Potsdam, Germany

Water Resources, BAHC and South Asia

Globally more than half of the accessible surface freshwater is put to use by humans, 2/3rd of all Earth's rivers are regulated and major rivers often don't reach the sea any more (Vitousek, Mooney, et al 1997). Human activity (deforestation) is likely to have nearly halved the evaporative power of the vegetation on a global scale (Gorshkov, 2000). More than1/5th of all people do not have access to safe drinking water. More than one half of humanity lacks adequate sanitation (UNGASS, 1997) and it is predicted that by 2025 most of the world's population may not have enough water to grow their basic food requirements (UNESCO, 2000). BAHC, an interdisciplinary project of IGBP attempts to look into these issues by:

(a) Studying the:

- Energy, Water and Carbon Fluxes at the Patch Scale - FLUXNET
- Role of Below-ground Processes
- Parameterization of Land-Atmosphere Interactions
- Land Use-Climate Interactions at the Regional Scale
- Global Terrestrial Vegetation-Climate Interactions
- Influence of Climate Change and Human Activities on Mobilization and Transport of Matter through Riverine Systems
- Mountain Hydrology and Ecology
- Development and Production of Global Data sets

(b) Combining and integrating expertise from many disciplines to:

- develop techniques and algorithms to provide climatic data needed at the scales of hydroecological research, which study changes of the conditions at the land surface, and
- provide soil-vegetation-atmosphere transfer models at larger scales, in particular, the Arial pattern of heat and moisture fluxes according to land-surface heterogeneity.

The South Asian region, characterised by high vulnerability of water resources, with changes threatening human livelihoods and environmental integrity is governed by:

- Monsoon climate, and strong seasonality of rainfall
- High evaporative losses of lower reaches of Ganges and Indus, and
- High population densities of the river basins.

Other characteristics of South Asian region are:

- the region has the second lowest water availability world-wide - 1700 m^3 per capita and year
- South Asian total water withdrawals exceed those of Europe, South America, Africa, Australia and Oceania combined
- Agriculture uses 90% of the water resources
- Groundwater resources are over-exploited yielding lowering of groundwater tables and saltwater intrusions from the sea
- Water quality indicators, such as suspended solids, BOD, faecal coliforms are higher than in most other parts of the world

Integrated Water Management

A widely accepted approach to these water related problems is the integrated management of water resources aiming at a reduced vulnerability to changes. Sustainability science or Earth system science can

support this approach by providing integration of various biophysical and socio-economic aspects of water resources. Interactions and feedbacks of a combination of stresses acting upon water resources are assessed in this approach through observation, modelling and prediction. This research integrates all relevant disciplines for the vulnerability assessment, usually at river basin scale. Stakeholders should be included in the definition of this research, in order to formulate issue driven research questions and deliverables that are relevant for integrated water resource management. Stakeholders in water resources include local people, policy makers, water resource managers, NGOs, industries and others.

In order to cater to the integrated management approach regarding water issues BAHC has formulated cross-cutting themes such as the:

Integrated Water Resources Management

Integrated Water Resources Management is based on the perception of water as an integral part of the ecosystem, a natural resource and social and economic good (Agenda 21). It recognizes that all natural physical aspects of the surface water and groundwater resource systems, including variations in time and space; all sectors of the economy that depend on water and hence the complete inputs and outputs related to water; and the complexity of spatial resource distribution and competing "demands", such as upstream-downstream interactions, inter-basin transfers, shared watercourses etc. (Global Water Partnership 2000).

Some of the Integrated regional (river basin) studies conducted on water resources are in China (Yellow river); Brazil (Amazon river) (LBA); South Africa (Mgeni river); USA (McKenzie river); Germany, (GLOWA Elbe), GLOWA Danube and in the South Asian river basin.

Vulnerability assessment of Water and Land Systems

Vulnerability is an aggregate measure of human welfare (Bohle, 1994). Vulnerability addresses issues such as critical thresholds, development, equity, sustainability. Developing countries have generally higher vulnerability, due to stronger exposure to multiple stresses and lower adaptation potential.Vulnerability assessments select a particular group or unit of concern and seeks to determine the risk of specific adverse outcomes for that unit in the face of a variety of stresses.

Vulnerability is emerging as a multidimensional concept involving exposure - the degree to which a human group or ecosystem comes into contact with particular stresses; sensitivity - the degree to which an exposure unit is affected by exposure to any set of stresses; and resilience - the ability of the exposure unit to resist or recover from the damage associated with the convergence of multiple stresses (Clarke, 2000).

A joint Project on Water Resources of IGBP, WCRP, IHDP, IAHS, UNESCO-HELP, SIWI, SCOWAR and others has the following research goals:

Links between hydrological cycle and biogeochemical cycles (e.g. carbon) and effects of changes on the Earth system.

The main questions in this respect are:

- What is the **state** of the world water system, why has it changed over the last 50 years?
- What needs to be done to increase the **robustness** of the water system in the face of global environmental change?
- What is the **vulnerability** of human systems to changes in water supply and quality?
- What is the changing role of **extreme events** in the water system and how can water resource management strategies be designed to deal with expected changes?

Other programs related to water resources

Some of the other water related issues such as dams are an important part of water management structures in South Asia. They are relevant with respect to:

- Water supply, irrigation
- Eco-hydrological changes, such as:
  - -River flow and water retention, peak flows
  - -Groundwater recharge
  - -Water quality, nutrient and sediment retention
  - -Impacts on biota
- Social, cultural and political aspects of river valley flooding
- Conventional water management solutions (e.g. large dams) vs. alternatives
- Government involvement vs. private involvement
- Involvement of international organizations
- Environmental and social impact assessments

The World Commission on Dams (WCD) has produced a report to:

- Review the development effectiveness of dams and assess alternatives
- Provide a framework for future decision-making on dams through international standards

Ten case studies of dams in major river basins around the world were performed and regional consultations held on ‚large dams and their alternatives in South Asia: experiences and lessons learned'.

Water resources and likely project proposals from South Asia

Addressing water scarcity and droughts, probably the most important current global change effects in the South Asian region, it was suggested to develop a proposal to APN that would cover policy relevant aspects, such as water availability, links to food security, human health impacts, forecasting of extreme events, shared use of international water resources, water pricing etc. A potential APN project of that kind would not only yield scientific information in support of sustainable management of water resources, but it would also emphasize the societal relevance of the underlying global change research.

A proposal to APN would come from a small number of coordinators within the participating countries. It would have as a goal to set up a research cluster that integrates available knowledge and research expertise of the leading institutions in the region, for an integrated river basin study on water resources. This proposal to APN as well as the actual development of the research cluster would be supported by IGBP (BAHC), START and possibly IHDP and WCRP in order to integrate with international research in this field and provide capacity building for the region. Activities to be supported by APN under this proposal could be:

- the establishment of a regional water resources research network;
- a workshop that would bring together relevant scientists and other stakeholders for defining and initiating the research cluster; and
- the development of new research proposals to national and international funding bodies, targeted at knowledge gaps of global change and water resources.

During the APN workshop in Islamabad a first outline for such a research cluster on integrated water resource management under global change was developed:

- Regional change
- Climate variability, monsoon climate, extreme events
- Climate and land use scenarios
- Changing water resources (quantity and quality), droughts and floods, dams
- Impacts of change:
  - -on agriculture and food security
  - -on natural vegetation and biodiversity
  - -on human livelihood, well being
- Integrated water resources management
- Indicators for sustainable development
- Data and information system
- Adaptation options, water pricing, increased water use efficiency, institutional change etc.

It was envisaged during the workshop that following APN proposals for the areas Climate Change & Variability or Changes in Coastal Zones & Inland Waters could address issues such as:

- Growing water demand and limited resources – bridging the gap
- Water and food security – improving water use efficiency in agriculture
- Water quality problems, human health impacts and relations to poverty
- Extreme events, hazards of droughts and floods, improved forecasting and preparedness
- Scenario information for decision makers.
- Competing water uses, shared use of international resources
- Displacement and marginalization of people due to water scarcity, equitable allocation of water
- Biodiversity and ecosystem services under water scarcity, integrating ecological and human water needs

Sustainable water use, participation of stakeholders in research definition and results transfer to water resource management Institutional structures adequate to deal with changes. The central achievement of this joint project will be a consolidated scientific input on water resources to the international sustainability process and major conventions.

GREENHOUSE GAS EMISSIONS AND GLOBAL CLIMATE CHANGE: PRESPECTIVES FOR SOUTH ASIA

Toufiq Siddiqi
GEE-21, Honolulu, Hawaii

Introduction

There is a small but vocal minority that disputes the existence of the Greenhouse effect, and that human activities are affecting the global climate. They argue that there is no need as yet to reduce our emissions of greenhouse gases or take other actions to address a problem that may not exist. In contrast, the vast majority of scientists are convinced of the reality of the Greenhouse Effect, and of human contributions to it. The various Reports of the Intergovernmental Panel on Climate Change (IPCC) discuss the evidence in considerable detail.

The Greenhouse Effect refers to the warming of the planet due to the existence of certain gases in the atmosphere. The net solar radiation of 240 W/m^2 at the top of the atmosphere of the earth must be balanced by net output of infrared radiation. About $1/3^{rd}$ of the incoming solar radiation is reflected and the remainder is mostly absorbed by the surface of the earth. The outgoing infrared radiation is absorbed by naturally occurring greenhouse gases and by clouds, keeping the surface about 33^oC warmer than it would be otherwise. The Greenhouse Effect exists on other planets as well. The surface temperature of Venus would have been -46^o C, instead of 477^oC, if there had been no such effect. Similarly, the surface temperature of Mars would have been -57^o C, instead of the actual -47^oC.

The correlation between levels of greenhouse gases such as carbon dioxide and global temperatures is also evident from measurements of Antarctic ice cores, based on ice deposited over more than 150,000 years. Direct measurements of CO_2 concentrations and temperature in recent decades have extended this record to the present day, and confirm that the CO_2 concentration on earth has increased from 280 ppmv from the pre-industrial times to about 370 ppmv at present. Similarly CH_4 concentration has increased from 700 ppbv to about 1714 ppbv. The N_2O concentration in the atmosphere has increased from 275 ppbv to about 320 ppbv.

Continued increases in the concentrations of greenhouse gases could lead to wide ranging impacts on rainfall patterns, agriculture, human health, the frequency of occurrence of storms and a rise in the sea level. It has been estimated, for example, that a one-meter rise in sea level could cut Bangladesh's rice production approximately in half.

Concern about global climate change and its implications have led the countries of the world to try and formulate a strategy for addressing the problem. An important step in this effort was the signing in 1992 of the United Nations Framework Convention on Climate Change (UNFCCC) and its subsequent ratification by most countries of the world. The subsequent Kyoto Protocol is an attempt to take specific measures to address the problem. It requires the industrialized countries, which have been the source of most of the emissions of greenhouse gases to reduce their emissions an average of 7% below those in 1990. The developing countries, which are signatory to the convention, but belong to the Non-annex I group are not yet bound by the convention to reduce their emission levels for which negotiations are going on through meetings of the Conference of Parties every year. The major industrialized countries, many of which feel that it would be unfair and ineffective if the developing countries continue to emit greenhouse gases in increasing amounts, have not ratified the Kyoto Protocol regarding emission of carbon dioxide from the use of fossil fuels. To provide a perspective on the relative contributions of different regions of the world, we show in Figure 1 the 1996 emissions of carbon dioxide from the combustion of fossil fuels, the largest anthropogenic contributor to greenhouse gas emissions.

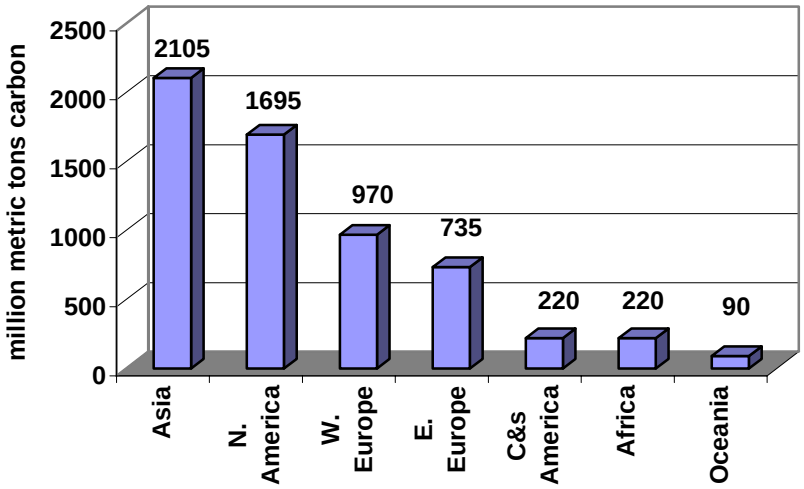


Figure 1: Estimated carbon dioxide emissions from fossil fuels, by world region, 1996

As seen in Figure 1, Asia's emissions (including Japan) now exceed those of North America and Europe, including Russia. However, on a per capita basis, emissions of USA are about 8 times those of China, and about 20 times those of India, as shown in Figure 2. In terms of total emissions, the largest emitting countries in 1996 were USA with1465 million tons carbon (MtC), China (805), Russia (400), Japan (290), Germany (240), and India (230). Thus 3 of the six largest emitters are in Asia. Further, Asia's emissions are increasing much faster than the emissions from N. America or Europe. Whereas the emissions of CO_2 in USA increased from 691 MtC in 1950 to 1465 MtC in 1996, during the same period the increase in China was from 22 MtC to 805 MtC, and in India from 18 MtC in 1950 to 230 MtC in 1996.

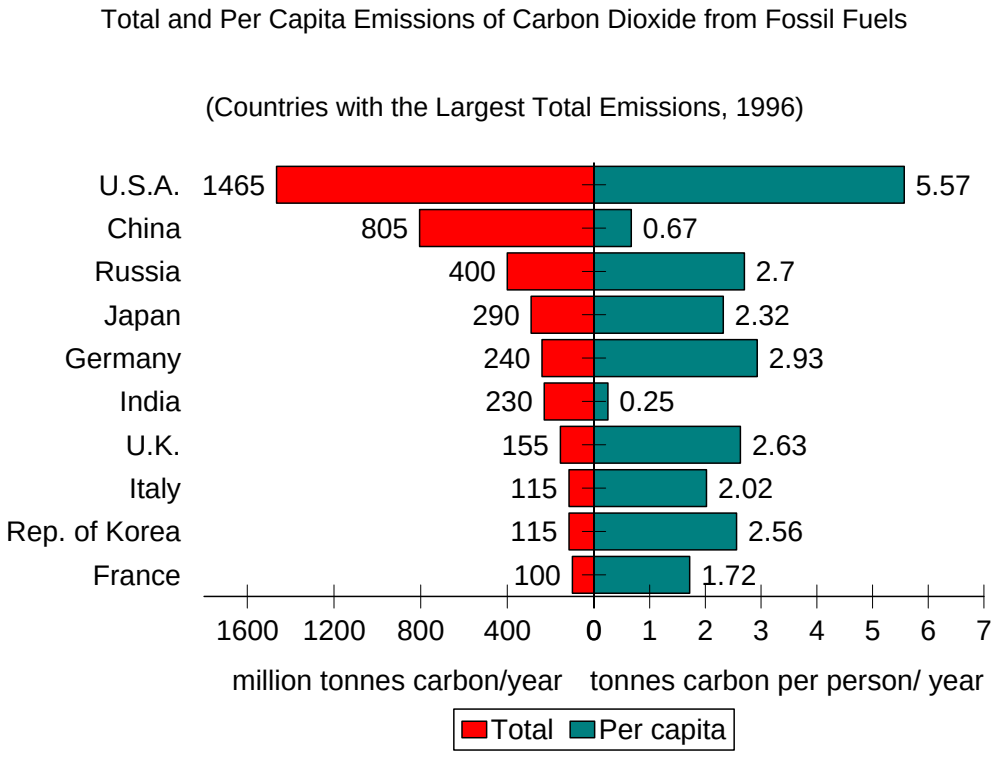


Figure 2. Total and Per Capita Emissions of carbon dioxide from fossil fuels

The data shown in Figures 1 and 2 indicate why it has been so difficult to make rapid progress in addressing the problem of global climate change. They show that the per capita emissions of CO_2 are much larger in the industrialized countries than in the developing countries, providing a basis for the latter that the emission reductions must come from the industrialized countries. At the same time, the data also show that emissions from the developing countries, particularly the large ones in Asia such as China and India, are also increasing rapidly, and have already overtaken emissions from many industrialized countries such as U.K. and France. Thus a long-term solution of the problem requires the active participation of at least the larger developing countries at some stage.

Approaches to Reducing GHG Emissions in South Asia

Although the countries of South Asia are not required at present to limit their emissions of greenhouse gases, there are economic and environmental benefits from doing so. As energy has become increasingly expensive, it is clearly in every country's interest to use it more efficiently. There is a potential for doing so in almost every sector. For example, through the use of more efficient technology, Pakistan can conserve about 250 thousand tons oil equivalent (toe) per year in the iron and steel sector, about 240 thousand toe per year in brick manufacturing, about 150 thousand toe per year in the fertilizer and pesticide manufacturing sector, and about 120 thousand toe per year in the textile sector (ENERCON, 1994).

More efficient cooking technologies can also be used to reduce GHG emissions. This is true for traditional stoves as well as for those using liquid fuels, gas, and those using electricity.

Changes in the use of different sources of energy can also assist in reducing GHG emissions. For the same amount of energy supplied, coal produces more CO_2 than oil, which in turn produces more than natural gas. From the point of view of local pollution as well as global pollutants, natural gas is the preferred fuel. As

shown in Figure 3, India obtains most of its commercial energy from coal, with natural gas supplying a relatively modest amount. In Pakistan, natural gas and oil provide roughly equal amounts of energy, whereas coal is only a small contributor.

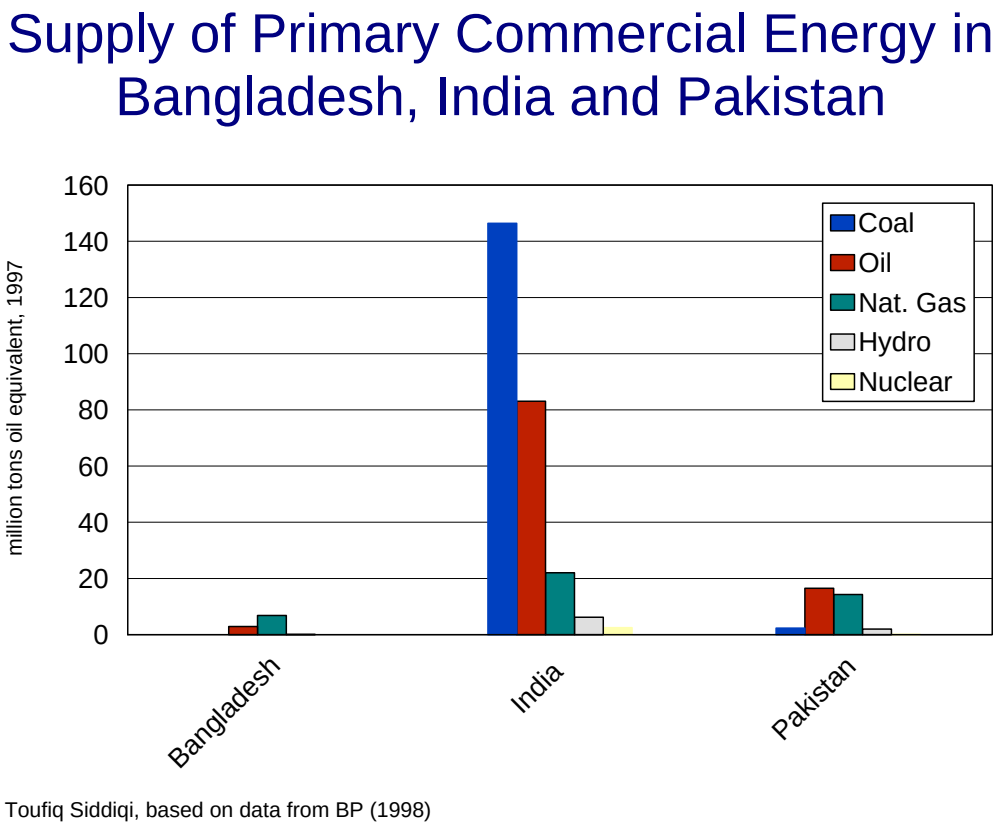


Figure 3. Contribution of different Energy Sources to Commercial Energy Supply in Bangladesh, India and Pakistan.

Neither India nor Pakistan is in a position to greatly increase the supply of natural gas, since the proven reserves of this fuel are relatively modest. However, there are large reserves of natural gas available in the countries near India and Pakistan, and it would be possible to import sizable quantities of this preferred fuel. The magnitude of these reserves is very large, especially in terms of the requirements of the countries themselves (The reserve to production or R/P ratio). These are shown in Figure 4. Bangladesh has discovered additional reserves recently, and there is a debate going on within the country on the size of the reserves and whether these are sufficient to permit exports to India.

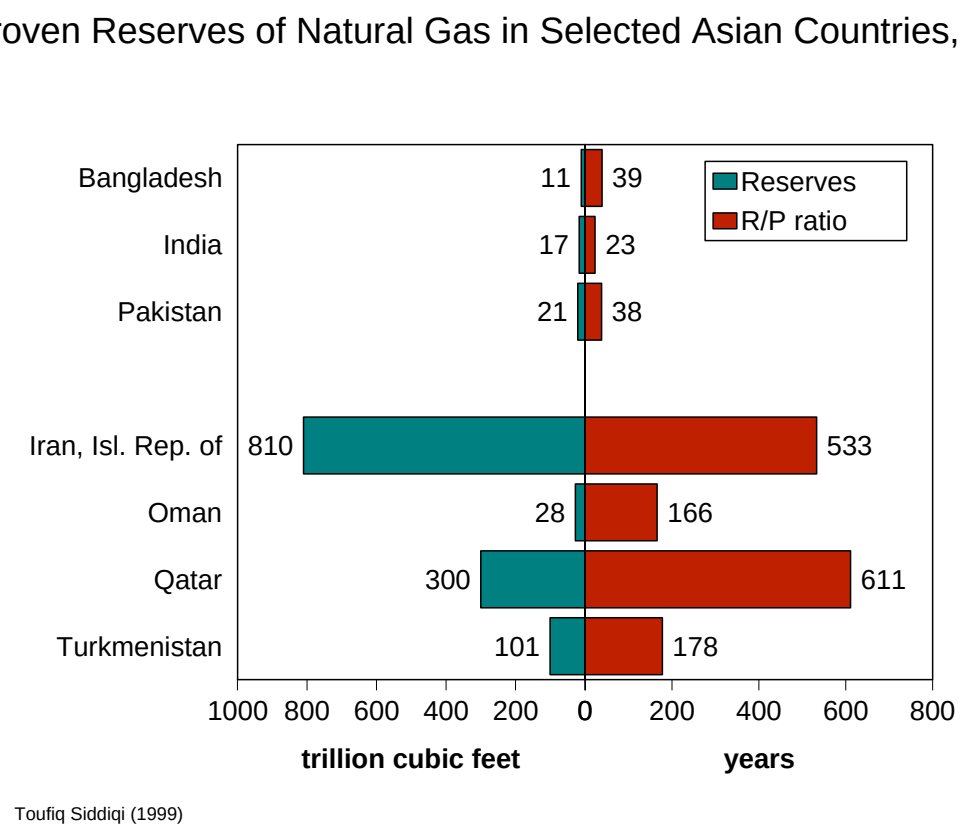


Figure 4. Potential sources of natural gas supplies to India and Pakistan.

There has been considerable discussion during recent years on the possibility of building a pipeline to transport natural gas from Iran to Pakistan and India. There are considerable economic benefits to both countries from such a project, but political tensions between them have made such cooperation difficult.

Other Sources of Greenhouse Gas Emissions

In Asia, many countries have seen rapid deforestation over the last two decades. Such deforestation results in additional emissions of the carbon that had been stored in the trees and soil. The rate of deforestation has declined only modestly in Pakistan, from 3.5% during1980-1990 to 2.8% during the 1990-95 period. In India no net deforestation took place in the period 1990-95.

After carbon dioxide, methane is the largest contributor to anthropogenic GHG emissions. A number of activities contribute to such emissions, including rice production, and ruminant livestock. The country with the largest emissions (44 Tg) is the former Soviet union, the main contributor being the oil and natural gas sector. In China the CH_4 emissions are 28 Tg, followed by USA at 27 Tg. In the case of China, rice cultivation is the largest source, whereas in the USA, urban waste and livestock are the largest sources. India is the fourth largest emitter with about 18tG, and the largest source of emission is enteric fermentation from livestock followed by rice cultivation (Figure 5).

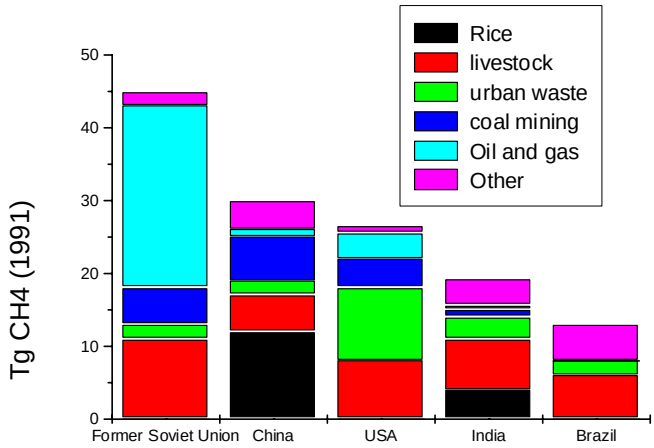


Figure 5: Anthropogenic emissions of methane from different sources in the five largest emitting countries.

Conclusion

This has been a quick overview of the concerns related to global climate change, and the relative contributions of different regions and countries to the emissions of greenhouse gases. South Asia is emerging as a region with an important role to play in addressing global climate change, both in terms of the technological expertise available and in terms of the steps it can take on its own to use energy more efficiently and to make increasing use of less polluting energy sources such as natural gas and wind power.

References

British Petroleum (1999). BP Statistical Review of World Energy June 1999. London: BP.

Hydrocarbon Development Institute of Pakistan (1999). Pakistan Energy Yearbook 1999. Islamabad: Ministry of Petroleum and Natural Resources.

Intergovernmental Panel on Climate Change (1995). Climate Change 1994: Radiative Forcing of Climate Change and An Evaluation of the IPCC IS92 Emission Scenarios. Cambridge: Published for the IPCC by the Cambridge University Press.

Tata Energy Research Institute (1998). TERI Energy Data Directory and Yearbook 1998/99. New Delhi: TERI.

World Bank (1998). World Development Indicators 1998. Washington DC: The World Bank.

ONGOING ACTIVITIES AND FUTURE PLANS OF SASCOM

Amir Muhammed,
Chairman, South Asia START Committee (SASCOM)

Introduction

SASCOM is the regional committee of START for the South Asia region. START-the Global Change SysTem for Analysis, Research and Training is co-sponsored by IGBP, IHDP and WCRP and its International Secretariat is located in Washington DC. START's mission is:

a) to develop a system of regional networks of collaborating scientists and institutions to:
   - conduct research on regional aspects of global change
   - assess the causes and impacts of regional global change, and
   - provide relevant information to policy makers and governments to assist in formulating adaptation strategies;

b) To enhance scientific capacity in developing countries by strengthening and connecting existing institutions by training global change scientists and by providing them with improved and enhanced access to data communication technology and research results; and

c) To help mobilize the resources required to augment existing global change scientific capabilities.

The global change research activities under the auspices of START fall under four major categories:

1 Land use change and its impacts on terrestrial ecosystems

2 Regional climate variability

3 Changes in atmospheric composition and its impacts

4 Global change and coastal zones

START accomplishes these activities through its 6 regional research networks dealing with South East Asia (SARCS), Pan Africa (PACOM), South Asia (SASCOM), Temperate East Asia (TEACOM), Oceania, and Mediterranean (MEDCOM).

SASCOM Membership

The member countries of the South Asian Regional Research Network (SAS-RN) are Bangladesh, India, Maldives, Mauritius, Nepal, Pakistan and Sri Lanka. Bhutan has also been invited to join the network. The research, training and capacity building activities of the network are guided by the South Asia Planning Committee of START, which consists of senior scientists from each of the member countries of the Network and is currently chaired by Dr. Amir Muhammed from Pakistan. The main activities of SAS-RN consist of planning and supporting mutually beneficial collaborative research through organisation of workshops and training programs. SASCOM also prepares directories of scientists and institutions active in global change research in the member countries and provides global databases and other relevant information about global change research to scientists in the region. The capacity building activities supported by SASCOM consist primarily of exchange of scientists and organisation of training courses. The START South Asian Regional research Centre is located at the National Physical Laboratory in New Delhi with Prof. A. P. Mitra as its Director.

South Asian region has some unique characteristics. The region has a higher population density and growth rate as compared to most other regions of the world (Table 1).

Table 1: World Population Increase 1990 to 2025

Region	*Population ($x10^6$)*		*%*
	1990	**2025**	
World	5,284	8,294	+ 57
USA	250	331	+ 32
China	1,155	1,526	+ 32
South Asia	1,128	2,004	+ 78

Source: **World Resources Institute, Washington D.C.**

Thus while the global population is projected to increase by 57% from 1990 to 2025, the population in USA and China will increase by only 32% during this period. However, the population in the South Asia region will increase by 78% during the same period.

The South Asia region is also one of the poorest regions in the world and has a lower quality of life and human development index compared to most other regions. Most countries in the region are making concerted efforts to shift emphasis towards industrial development in addition to improving agricultural productivity through adoption of modern technology. All these developments will inevitably increase the evolution of CO2 and other GHGs and result in an increase in the total carbon emission from the very low amount of 0.1 ton/capita in 1990 to 0.8 ton/capita in 2025 Table 2). This represents a 700% increase although in absolute terms it will still be far below the US carbon emission level of 5.4 t/capita in 1990. However the substantial increase in GHG emission, the increasing urban pollution especially of the aerosols and underground water will pose a serious threat to human life. These issues and those related to global warming and climate change are therefore high on the list of priorities of the SASCOM Planning Group.

SASCOM Collaborative Research Projects

1 FACE-Free Air CO_2 Enrichment

The objective of this APN-supported project is to study the impact of increased CO_2 in the atmosphere on plant growth and crop yield in different crop species especially rice. Scientists from Nepal, Bangladesh, Sri Lanka and India were trained in the use of Open Top Chambers (OTCs) to create an atmosphere of enriched CO_2 where paddy is grown and their growth monitored. The 2-week training programmed was held in September/October 1999 at the IARI premises in New Delhi under a project funded by APN. Two scientists from Pakistan were later on imparted training at the IARI in the use of OTCs. The research program is now going on in all the participating countries, where the collaborating scientists have been supplied the OTCs and imparted essential training. The mid-FACE activity has been made operational at IARI to undertake experiments under the field conditions.

2 Aerosol Data Synthesis Study

A regional workshop on Aerosol Data Synthesis was held in December 1999 in New Delhi as a part of the Asia-wide APN-funded project. The participants were given a CD-ROM containing the database and papers presented at the Workshop. A Science Policy Workshop on Aerosol Project was held on 28th Feb-1st March 2000 at Kobe, Japan. Prior a CD-Rom for the SASCOM region containing meta-data directory of Scientists, Institutions, Instruments, Parameters measured and the duration of measurement etc. Country reports of India, Nepal and Sri Lanka with some published aerosol data was released. Aerosol data from Pakistan has also been compiled and is being published as a report.

3 INDOEX Project

A consortium of Universities and Research Institutes in USA, Europe and India has been conducting the Indian Ocean Experiment (INDOEX) to Collect data on aerosol composition, trace gases, solar radiation flux, wind and Water vapor distribution in the height range from the surface up to the Lower stratosphere over the Indian Ocean extending down to Mauritius. A Variety of instruments on board aircrafts, ships and

ground have been employed. A special observatory has been established in the island of Kaashidoo in Maldives for this purpose.

The key finding of the experiment was the discovery of a dense, brown Haze of aerosol particles extending up to about 1-3 km from the ocean surface over the Indian Ocean above the Inter-Tropical-Convergence-Zone (ITCZ), During the months of January to March when winds blow from NE towards The equator. These particles, which are generally less than an μm in diameter, comprise soot, soleplates, nitrates, organic molecules, fly ash and mineral dust. It is feared that this cloud of pollutants could Affect the regional radiation budget, the climate, marine food production and The hydrological cycle, bringing adverse impacts on the people. The key results will be brought out in a special issue of the JGR.

4 CLIMAG Programme

This project has been undertaken by India and several developed Countries to demonstrate that the use of climate predictions in agriculture decision-making can lead to improvements in crop yield. Additional countries of the region especially Pakistan and Sri Lanka have also been included in the project and collaborating institutions and scientists identified. The project has recently organized a training workshop of all the participating scientists in Australia that will facilitate data collection on a standardized format.

5 Coastal Zone Programme

As part of the SASCOM program for 1999, the Regional Workshop on Estuarine Modelling and Coastal Zone Management organized by the National Committee of IGBP of Sri Lanka and with support from START and LOICZ was held in Colombo in April 1999. The Workshop decided to formulate a project Proposal for a collaborative study of estuarine systems, with a view to establish a regional network of coastal researchers.

In the mean time, a proposal was formulated to conduct a Regional Training Workshop on Biogeochemical Budgeting and Socio-economic modelling for Coastal scientists in the region. It had transpired from the April 1999 workshop that the coastal scientists of the region are not very familiar with the mathematical tools used for modelling for which additional training was considered desirable. After consulting scientists from NARA, CEA, NIO (Goa), NIO (Karachi), START Secretariat and LOICZ Project Office, Texel, Netherlands, the proposal was submitted to APN. The project was approved and the APN-supported workshop was held in Colombo in September 2000 in collaboration with LOICZ.

6. Urbanization, Industrial Transformation and Environmental change

A broad project covering the above subjects has been under discussion of the APN for the Asia-Pacific region. SASCOM is actively associated with the planning of this project. In the initial phase, changes in the hydrological cycle and the impact of human activities on the usable water supplies for large cities is being planned including Kobe, Tianjin, Bangkok, Bandung, Suva, Singapore, Karachi, Phnom Penh and Kuala Lumpur. Another aspect being investigated is the GHG budgets, urban air pollutants and their future scenarios. The cities selected for detailed study of these aspects are: Tokyo, Beijing, shanghai, Manila, Delhi and Calcutta. Seed money for studies on this project has been received and further grant has been applied for from APN.

Another aspect that is planned to be studied as part of this project is the State of options of transportation system for the growing cities of the Asian Region.

Future SAS Projects

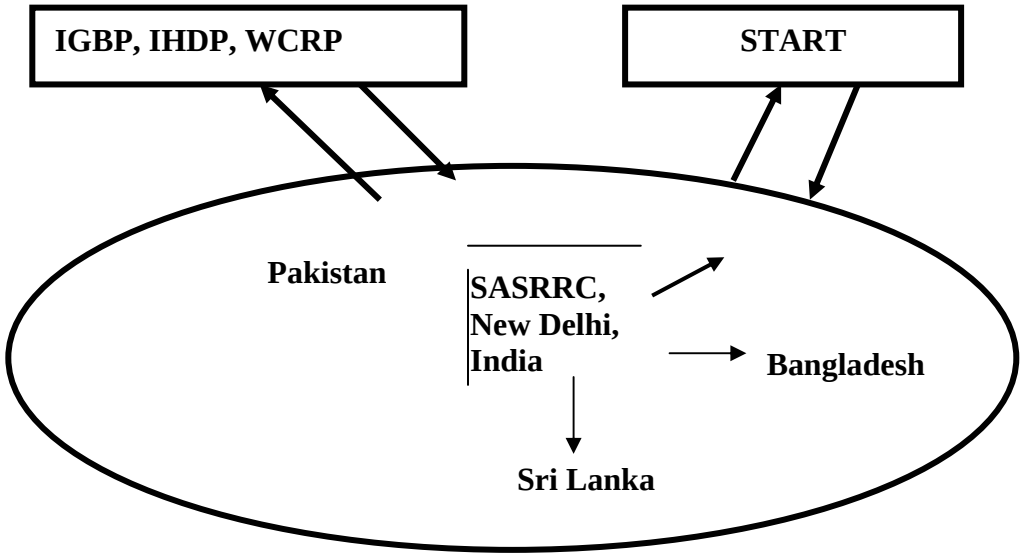
SASCOM has identified the following subjects for developing collaborative research projects during the coming years:

- Land quality indicators for water availability in the Indo-Gangetic Plains (submitted to APN)
- Surface ozone levels in SAS related to human & crop health (submitted to APN)
- Eco-hydrological impacts of global change on Himalayan mountain river basins (submitted to APN)
- Assessment of nutrient, sediment & carbon fluxes in coastal zones and their relationship to human activities (submitted to APN)
- Water Balance in the Indo-Gangetic plain (Collaboration with Ohio State University, USA)
- Air pollution transport modelling in mega-cities
- Impacts of climate change on production of tea (likely to be submitted to APN)
- Anthropogenic and impacts of climate on mangrove forest ecosystems

ACTIVITIES OF SOUTH ASIAN REGIONAL RESEARCH CENTRE AND INDIA SPECIFIC PROGRAMS

Sumana Bhattacharya
APN Liasion Officer, New Delhi

The South Asian Regional Research Centre, located in National Physical Laboratory, New Delhi, since 1994, is a major hub of Global Change activities in the South Asian region and is a part of the START (System for Research Analysis and Training Network) regional networks. It links the Global change research nodal centres in Bangladesh, India, Nepal, Pakistan, and Sri Lanka. Being a part of the START research network, its activities are governed by the general scientific research outlines of the IGBP, IHDP and the WCRP and is linked to the governmental community through the Asia Pacific Network for Global Change research (APN). The schematic diagram below indicates the linkages.



The basic activities of the South Asian Regional Research Centre include:

- Facilitating the formulation and execution of Collaborative Research projects through networking in the region
- Capacity building through nurturing of young scientists, regularly publishing directory of scientists working in the area of global change research, publication of SASCOM reports on various activities.
- Archival and dissemination of data generated in the various collaborative research projects through Web site and specific program CDs and the SASCOM news letter
- To help in organising periodic research workshops cum training programs on topics of regional interest
- To facilitate exchange of scientists from laboratories of repute to the region and vice-versa through various arrangements for visiting fellowships etc.
- To liase in fund raising and other exercises with International START secretariat, and other relevant international organizations to bring the best benefits to the region.

The Research Centre acts as the nodal point for research activities in the area of Atmospheric Chemistry over the Indian region, atmospheric photochemical modeling, a data centre etc. It offers facilities such as the greenhouse gas monitoring training, minor constituents measurement facilities, access to use major research facilities of India such as radar, satellite remote sensing data applications, oceanic research vessels, to name a few. It also hosts the APN liaison Office for South Asia and the South Asian IGAC project office. The SASRRC helps in facilitating the International collaborating channels of CSIR, and Visiting scientists schemes/fellowships of CSIR. Publication facilities are available through the National Institute of Mass Communication, and the Publication and Information Directorate of CSIR located within the campus. The SASRRC has also scientific linkages within India with organisations such as the various universities, Departments of Science and Technology, Department of Ocean Technology, Department of Space, Ministry of Information technology, Ministry of Environment and Forests, Indian Council of Agriculture etc. through various collaborative projects

Some of the major projects of the SASRRC in collaboration with scientists from countries in the South Asian region and other countries are:

- The Asia Least Cost Greenhouse gas abatement strategy project funded by ADB
- Asian Aerosol Data synthesis (APN)
- FACE (Free Air Carbon dioxide Enrichment) : CO2 Enrichment Impact Studies on Rice, funded by APN
- CLIMAG:Climate and Agriculture Production, funded by START
- Urbanization & Industrial Transformation Program in Asian Mega-cities (IHDP-IT), funded by APN
- INDOEX: Indian Ocean Experiment, funded by Department of Space, Govt. of India
- START synthesis report for the South Asian region, funded by START

Some of the other in-house on-going experiments relevant to India are:

- India wide Nitrous Oxide measurement campaign
- High altitude atmospheric constituent measurements
- Determination of emission factors through measurements of emissions due to various types of biomass
- Acid rain study network
- Greenhouse gas, other trace gases and pollutant inventory estimates

Major programs coming up in the year 2001 are related to Climate change and its impact in India, and the development of suitable abatement strategies. These projects are being undertaken by different Agencies such as the Indian institute of Technology, New Delhi, Indian Institute of Management, Ahmedabad, Indian Agriculture Research Institute, the Indian Institute of Tropical Meteorology, the National Institute of Oceanography, National physical laboratory and the Indian institute of Science. Some of these are:

- **Development of Climate change scenarios over India:** This is to assess the magnitude of future warming over the Indian subcontinent due to anthropogenic forcing and associated changes in key hydrological parameters including the intra-seasonal and international variability at optimal spatial and temporal scales for vulnerability and impact assessment studies
- **Development of socio-economic scenarios:** to identify the non-climate variables required for climate change impact assessments in agriculture, water resources, forests, coastal zones, health and energy, industry and transport in India. This will include socio-economic scenarios for 2020, 2050 and 2080 and to examine the feedback, interaction and synergies between climate change impacts and socio-economic scenarios.

- **Impacts of Climate Change on Agriculture:** This project will assess the inter and intra seasonal climate variability on yield of major crops in selected agro-ecological zones, and to identify suitable agro-management options to sustain yields under this variation. This project will also develop, calibrate and validate crop growth models to evaluate climate change impacts on soil processes and yields of crops, and also to see the impacts of changes UVB, aerosols and ozone on the above parameters. The 4th objective of this project will be to understand the climate change impacts on agriculture in different agro-ecologies and finally to understand the socio-economic aspects of food grains in relation to climate change such as the cost benefit analysis for alternate land use options, evaluate demand supply of food grains under different climate change scenarios.
- **Impacts of Climate change on water resources:** The objective of this project will be to look into the spatio-temporal variability of precipitation over major river basins of India based on recorded data, with special reference to long term changes, to estimate past changes in water availability (including ground water) and their sensitivity to climate variability, to validate climate model simulations of precipitation over India and to develop suitable down scaling techniques, to prepare future scenarios of water availability and water quality, under different climate change scenarios.
- **Extreme sea level variability along the coast of India:** this project will identify extreme events like storm surges in data collected from tide gauges over the last 15 years and use statistical methods to analyze these data to determine the probability of occurrence of extreme events and their return periods. These estimates will form the basic input for identifying vulnerable areas in the coastal zone, and will give a knowledge of return periods, which are important for designing off shore structures.
- **Impacts of Climate change on energy, industry and transport:** Impact assessment will be made on the transport infrastructure in terms of roads, rails, bridges, inland water ways, and transport of energy sources. The impacts on energy infrastructure will be looked into through analysis of energy demands (fossil fuel, biomass, electricity, total energy), energy transport etc. Impacts on industrial and general infrastructure will be mainly studied on agro-industries, urban infrastructure and tourism.
- **Impacts of Climate Change on forests in India:** This project will develop the base line vegetation and socio-economic scenarios at national and western ghats, particularly linking vegetation, climate and socio-economic parameters; will evaluate different vegetation response models and modify or adapt to the present studies. Use the regional climate projections and vegetation response models to assess the impacts on forest ecosystem bio-diversity, forest regeneration, forest growing stock, and the biomass growth rate. This project will also assess the current dependence of the local communities and the economy on the forests, particularly in the Western ghats and mountain ecosystems. In addition it will assess the implications of the projected impacts of climate change on vegetation, socio-economic systems, and consider potential adaptation strategies.
- **Impacts of Climate change on human health:** This project will look into the impacts of climate parameters such as temperature, precipitation and humidity on malaria incidences and using the predicted climate change scenarios will develop scenarios of incidences for 2020, 2050 and 2080. Impacts of El-Nino and La-Nina events will also be looked into. The incidence of malaria will also be studied in terms of growth in urbanization in specific cities in India. The other aspects that will be looked into are the impacts of aerosols linked to respiratory diseases and UV-B on cataract and corneal damage in India.

The post INDOEX program will look into the effects of aerosols on monsoon system, its onset, variability and effect on hydrological cycle; Source characterization/ inventory of black carbon/carbonaceous particles which are affecting the radiative forcing of the atmosphere in addition to GHGs, their role in atmospheric systems, and impacts of aerosols on agriculture and health.

FUNDING OPPORTUNITIES FOR GLOBAL CHANGE RESEARCH PROJECTS

G. Breulmann, (APN) & Hassan Virji (START)

The APN Mission

An understanding of the complex mechanisms and impacts of global environmental change on human health, welfare and ecosystems is becoming increasingly important for humanity. The Asia-Pacific Network for Global Change Research (APN) is an inter-governmental network whose mission is to foster global environmental change research in the Asia-Pacific region, increase developing country participation in that research, and strengthen interactions between the science community and policy makers. It is believed that international cooperation among governments and scientists will help increase the understanding of the complex mechanisms and impacts of global environmental change on ecosystems and human society in the Asia-Pacific region. This is necessary to identify and address the problems that may arise from that change.

The Annual APN Call for Proposals

As part of its programme of activities the APN issues an annual Call for Proposals. A guide for application for submission of proposals can be downloaded from the APN Homepage (http://www.apn.gr.jp) or can be directly received from the APN Secretariat on request. APN Call for Proposals also involves an optional pre-proposal stage, and the APN recommends all those who intend to apply for APN funding to submit a pre-proposal, particularly those researchers who have never previously been successful in an APN Call for Proposals.

Eligibility for Application of Proposals to APN

To be eligible for consideration under the APN Call for Proposals, a proposal must meet the following basic criteria:

- it must relate to an area of scientific interest within the APN's Research Framework;
- it must be an approved activity of interest to the APN;
- the proponent must be based in an APN Approved Country;
- it must involve action or contributions from at least three APN Approved Countries, **at least two of which must be developing countries**;
- it must arrive at the APN Secretariat no later than **midnight (24:00) on 30 September 2000**, and
- it must follow the format specified in Appendix 3 and include the one page cover sheet.

Any proposal which fails to meet these basic criteria will not be considered for funding by the APN under this Call for Proposals.

Funding

The APN normally applies a limit of US$100,000 per year on funding requests for an individual project. Proponents may, however, request partial support for a larger project. The total budget the APN sets aside for its Call for Proposals annually is approximately US$1,000,000. The APN does not guarantee multi-year funding although multi-year proposals are considered, provided that a clear breakdown of the year by year funding requirements is given, together with the expected outcomes at each stage of the project. If multi-year funding is approved, financial support in subsequent years will depend on the successful progress of the project and review by the APN Scientific Planning Group.

Evaluation
The four most important criteria against which the eligible proposals are evaluated are the:

- **Extent and quality of regional collaboration**

Proposals **must** involve action or contributions by three or more APN Approved Countries, at least two being developing countries, or promote the basis for initiating such collaboration, for example, through a workshop or similar activity. Due regard should be given to proposals from or involving less developed countries. The overall goal should be the generation of long-term sustained regional collaboration, not just a one-time event or project.

- **Technical soundness**

Proposals should generate confidence about research excellence, data quality, capacity for program management, and willingness and ability to pursue activities from a multidisciplinary perspective, as appropriate. It should be made clear in the proposal the extent to which it is based on or part of a planning and scoping activity in or about the region, as activities based on adequate planning and scoping processes are more likely to lead to successful long-term outcomes.

- **Building regional and national capacity for global change research**

It is expected that proposals will contribute to the fundamental APN goal of building regional and national capacity (technical expertise) for researching global environmental change issues. The result should be a long term gain, for example, by increasing local skills and knowledge, improving decision making processes for increasing or improving national involvement in international processes. Proposals should also show how existing resources (buildings, laboratories, research sites, equipment, libraries, data sets, communication facilities, travel budgets, etc.) can be used more efficiently or how their potential value can be better realized as a result of the proposed activity.

- **Developing and strengthening links with government policy and programs**

The APN is committed to improving science-policy links and fostering harmony between its activities and policy issues which concern most governments in the region. Proposals should include an indication of how the activity might assist with national government and business decision-making processes, or support national, regional or global scale programs aimed at dealing with global change problems. Harmonisation with the work of other bodies active in the region (for example, APEC, ASEAN, UNEP, ESCAP, SPREP) is desirable. The APN emphasizes the need to contribute to solving ecological, social and economic problems associated with global change impacts, such as those identified in IPCC processes.

The other evaluation criteria which are also looked into are the:

- **Administrative support**

Proponents should indicate how necessary administrative support will be provided for the proposed activity. Ideally administrative support would be provided by one of the parties involved in the project, freeing any APN funding for the proposed core activity. APN funding is not available for administrative staff payments, or to supplement the pay of existing researchers.

- **Consideration of funding options**

The APN encourages co-financing arrangements. Also it is the APN's concern that the funding from other sources should be secured. It also encourages in-kind contributions from proponents.

- **Increasing synthesis and analysis work at national and regional levels**

The APN believes that more attention needs to be paid to synthesis and analysis work derived from the many research outcomes already available. This will require the development and use of appropriate integrative techniques, and will often involve research teams drawn from several disciplines and from policy and decision making interests.

- **Developing and strengthening relations with regional and international global change programs and inter-governmental bodies and mechanisms**

A key goal of the APN is to strengthen cooperative relations amongst the global change research community. Accordingly, proposals should specify how the activity incorporate cooperation with global change programs such as START, IGBP, IHDP, WCRP, DIVERSITAS and other environmental research programs with global change components. The existing or proposed extent of the project's involvement in START or other Global Change Research Programmes if any should be clearly stated. ENRICH and IAI related projects and proposals be considered within APN procedures provided that they comply with the APN requirements. The APN encourages regional initiatives to be seen as part of a global effort.

- **Raising awareness of global change issues with the general public**

APN members have consistently stressed the importance of good public knowledge of global environmental change issues, to help ensure the successful development and implementation of response strategies to these issues. Proposals should indicate how the proposed activity could lead to better public knowledge. Any proposed consultation processes should be indicated, and information provided about how results will be disseminated.

- **Meeting standardised data collection and user needs, and open access to research sites**

In the interests of the highest benefit in the shortest time for the greatest number of countries in the region, the best proposals will promote better data collection, analysis and dissemination, open access (to existing and new data sets) and access to research material and sites.

- **Improving communications**

The best proposals will contribute to lasting improvement in communications among APN members, including both the enhancement and use of communications networks.

Timeline of Proposal Review

The following is the time line for evaluation of the projects in a given year:

- Rapid Assessment Stage — Nov
- Initial Reviewer's rating — Jan
- 1st stage replies to proponents — Jan
  (proceed to 2nd stage or rejection)
- Response to reviewer's comments — Jan
- Revised reviewer ratings — Feb
- IGM/SPG decision — Mar
- Final decision issued to PI — Apr

Proposals can be sent to

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NATIONAL PRIORITIES FOR RESEARCH AND CAPACITY BUILDING

Leading experts from the participating countries of the region presented the national perspective regarding on-going research on global change issues and the national priorities for research on different subjects dealing with global change. Following presentations were made:

- Current status and future priorities of global change research in Bangladesh including flood and drought aspects: ***A.M. Choudhury***

- Global Change Research Activities in Nepal - An Overview**:** ***Kedar Lal Shrestha***

- Priorities for Global Change Research and Capacity Building Needs in Pakistan**:** ***Asif Shuja Khan***

- Global Change Research in Sri Lanka: Current Status and Future Priorities**:** ***J. Ratnasiri***

CURRENT STATUS AND FUTURE PRIORITIES OF GLOBAL CHANGE RESEARCH IN BANGLADESH INCLUDING FLOOD AND DROUGHT ASPECTS

A.M. Choudhury

Chairman, Bangladesh Space Research and Remote Sensing Organization (SPARRSO), Dhaka

Introduction

Global warming and the subsequent climate change, sea level rise, etc., are subjects of worldwide scientific and economic importance today. These issues have become an international concern because of the fact that some models of long-term climate prediction associated with greenhouse warming suggest significant changes of a few parameters of the global environment in the near future. According to model results, notable changes of temperature, rainfall patterns, floods, sea level, and frequency of cyclones are likely to occur in many parts of the globe within a few decades and may become severe by the end of this century. As a deltaic region, Bangladesh is very vulnerable to natural calamities. Almost every year this country is visited by natural disasters such as floods, tropical cyclones and storm surges, tornadoes, droughts, etc. The coastline of Bangladesh extends to 720 km, and nearly 21% of the total population lives in the coastal belt region. Tropical cyclones and storm surges bring immense miseries to the people of coastal districts and cause heavy damage to the coastal environment and ecosystem. For this reason, the prediction of climate change as well as sea level rise is matter of great concern for this country.

Researches on Global change are carried out in the Department of Environment, Bangladesh Space Research and Remote Sensing Organization, Bangladesh Meteorological Department, SAARC Meteorological Center, Bangladesh Unnayan Parishad etc.

In this paper some highlights of researches carried out in this field in Bangladesh are described.

Temperature Rise

The surface air temperature is an important climate parameter for public health, agriculture, and other sectors. Using 32 years of monthly mean maximum and minimum temperatures of the month May from observational records in the eight selected stations of Bangladesh, we notice that inter annual variation of maximum or minimum temperature has a cycle with periodicity of 3-5 years all over Bangladesh. In Linear regression analysis shows an increasing trend of maximum temperature in five places out of eight stations. This trend is between 0.11 and 0.20^0C for the 32-year period at the 95% confidence level. In the 7-year moving average, it is seen that the temperatures vary with an approximate periodicity of 20-22 years. These temporal representations exhibit a decrease of the maximum temperature from the mid-1960 to mid-1970s and thereafter almost a linear increase is observed in most of the stations. However, increasing trend of mean maximum temperature of May is pronounced in the west (Rajshahi) and southeast (Chittagong) regions. In the case of minimum temperature of the month of May, a linear tendency of decrease is observed in Bangladesh except in the southeast (Chittagong) area which is close to the coast of the Bay of Bengal. Increasing tendency of monthly mean minimum temperature of May is noticed over the latter region (Chittagong).

The monthly mean maximum and minimum temperature of December have wide ranges of year-to-year variations but show no periodic cycle with a definite time period as observed in the case of May

temperature. In the regression analysis of the maximum and minimum December temperature data, increasing trend is noticed at six and five places, respectively, out for eight stations. The overall trend is toward positive by about 0.33^0C in the 32-year period at the 95% confidence level. If this trend continues, a rise of temperature in the winter season (December-February) by 1^0C may be expected at the end of this century.

The prediction of temperature rise over the South Asian subcontinent demon-started by three GCM simulations (GFDL, GISS and NCAR) for the doubling of CO_2 scenario is around 2-4^0C for the winter season (December-February) and 1-2^0C for the monsoon season (June-August), respectively. The results from the greenhouse warming simulation of the MPI climate model suggest a rise in annual mean surface temperature of between 2 and 3^0C over the South Asian sub-continent during the next hundred years. For Bangladesh and its neighborhood, the projected rise in temperature in the winter season is around 3^0C and in pre-monsoon and monsoon seasons are around 2-2.5^0C and 1.5-2^0C, respectively. The annual mean temperature rise for Bangladesh is around 2.5^0C.

In a warmer atmosphere, the monsoon trough is likely to advance further northward as a result of an enhanced ocean continent pressure gradient (itself a consequence of more intense warming of the land surface in the pre-monsoon season). The MPI model simulation reveals an increase in mean sea level pressure by 0.5 mb to south of 20° N and to the east of 70° E and a decrease by 1-2 mb to the north of 20° N due to enhanced greenhouse effect. This should lead to an enhanced north-south pressure gradient and hence a strong monsoon circulation. The wind fields both at the surface and at 850 mb also suggest that the monsoon circulation may shift northward by 5-7° latitude and also intensify by approximately 10% in a warmer atmosphere. The changes indicate a possible shift in the position of the monsoon trough and the associated convective activity over this region.

In the context of projected rise in temperature and strong monsoon circulation over the monsoon region, there is likelihood of more precipitation in Bangladesh and adjoining areas. The intense convective activity in the upper valley of the Ganges-Brahmaputra River Basin resulting in the devastating floods of 1987 and 1988 in Bangladesh is perhaps consistent with the model prediction of shifting monsoon trough farther north. However, the increase in local energy generation and conversion which depends on the cloud feedback processes in climate models is not fully understood yet. Therefore, whether the intense precipitation in the Himalayan valley is due to shifting of the monsoon trough because of global warming or due to any other mechanism is not clear to us at present. Whatever might be the cause, intense raining will increase floods and flood disasters such as loss of life, property, and crops, and will create multiple problems including temporal dislodgment to population and cattle heads, scarcity of drinking water, shortage of food and fodder, and hampering of communication and transport, irrigation, and drainage facilities in Bangladesh.

Sea-Level Rise

For sea level rise, following IPCC estimate, rise in sea level would be 1m. by 2100. Latest research conducted by the SAARC Meteorological Research Centre (SMRC) recently reported that the sea level along the Bangladesh coasts is rising by about 4-8mm a year. With this rise per year at some points linear projection shows that, the sea level rise could be 3m by 2050, a more alarming forecast than the IPCC scenario. With the highest estimates sea level rise in Bangladesh would inundate 18% of the country by 2001 and salinity will increase.

Bangladesh Drought, Flood and ENSO

A study on Monsoon has shown that there is a good correlation between strong Southern Oscillation Index (cold events) and good monsoon years. A study on Bangladesh monsoon rainfall has shown that in general there is decrease in rainfall in El-Nino years in all the seasons the pre monsoon, the monsoon and the post monsoon. It is remarkable that the great Bengal famine year of 1770 when about one third of the population

of Bengal was wiped out was an El-Nino year. Another great famine occurred in Bengal in 1943 which was also an El-Nino year. The years 1940-41 were also El-Nino

Perhaps the combined effect of these consecutive bad monsoon years depleted the crop stock to a great extent and the war procurement accelerated this famine of 1943 in undivided Bengal when again one fifth of the population was wiped out. Another famine occurred in modern Bangladesh in 1974. The years 1972-73 were El-Nino years which continued in 1974 when again there was the recurrence of a great flood. Perhaps a combination of all these depleted the food stock and the famine of 1974 occurred. In recent years, of course, large scale irrigation has been introduced and because of better food policy, shortfall of crops is averted.

Some interesting features have come out with regard to a connection between ENSO and floods in Bangladesh.

The most catastrophic floods in recent years in Bangladesh occurred in 1954, 1955, 1974, 1987 and 1988. The years 1954, 1955 and 1988 are years with positive ENSO index whereas 1974 and 1987 are years of continuing EL-Nino years, the main El-Nino occurred in the previous years and in these years negative anomaly were not that strong. Let us note the major El-Nino years in this period. These are 1951, 1957, 1972, 1976, 1982 and 1986. In these years there was no catastrophic flooding in Bangladesh. Thus we can conclude that during major El-Nino years at least during the first year of El-Nino, Bangladesh can be spared from catastrophic floods. The years 1963, 1965 and 1969 were moderate El-Nino years and in those years there were moderate floods in Bangladesh. Thus we conclude that during positive or weak ENSO (positive and negative) years, Bangladesh can be a victim of flood.

Rainfall and Flooding

Among the climatic parameters, rainfall is of greatest concern to Bangladesh, because national activities such as agriculture, water management, and energy generation are heavily dependent on the amount of annual precipitation.

The annual rainfall of Bangladesh exhibits wide variations on a year-to-year basis. The regression analysis shows a linear increasing trend of annual rainfall between 150 and 350 mm in 32 years in most of the places at the 95% confidence level; i.e., the annual increase per year is around 8 mm. In recent years the frequency of severe floods in Bangladesh has increased. A devastating flood of the decade occurred in 1988 when two-thirds of the country was submerged, with all the rivers flowing above the danger levels and the capital city, Dhaka, under flood water for a period of 2 weeks. The flood vulnerability of the country is increasing because of enormous rainfall in the upper valley of the Himalayan-Tibetan Plateau in recent years.

The increased flow of the Ganges-Brahmaputra River system should drain through Bangladesh, but heavy siltation in all the rivers prohibits the easy flow of excess water and results in more colossal floods in this country.

In the changed scenario of possible temperature rise, there is likelihood of a slight increase of precipitation because of high evaporation over Bangladesh and its neighborhood. Models GISS and NCAR do not predict any change of seasonal and annual precipitation over northeast India and Bangladesh. Model GFDL only predicts an increase of monsoon (June-July-August) rainfall by 3mm/day. The greenhouse warming simulations have been carried out with the coupled MPI climate model over a 100- year period from 1985 to 2084. In the IPCC's Business-as-Usual Scenario, the model simulated an increase in total annual precipitation of about 18cm/ year over central and northeast India and Bangladesh. A moderate increase in precipitation over northeast India and Bangladesh and adjoining Bay of Bengal is possible during the premonsoon and monsoon seasons.

In a warmer atmosphere, the monsoon trough is likely to advance further northward as a result of an enhanced ocean continent pressure gradient (itself a consequence of more intense warming of the land

surface in the premonsoon season). The MPI model simulation reveals an increase in mean sea level pressure by 0.5 mb to south of 20° N and to the east of 70° E and a decrease by 1-2 mb to the north of 20° N due to enhanced greenhouse effect. This should lead to an enhanced north-south pressure gradient and hence a strong monsoon circulation. The wind fields both at the surface and at 850 mb also suggest that the monsoon circulation may shift northward by 5-7° latitude and also intensify by approximately 10% in a warmer atmosphere. The changes indicate a possible shift in the position of the monsoon trough and the associated convective activity over this region.

In the context of projected rise in temperature and strong monsoon circulation over the monsoon region, there is likelihood of more precipitation in Bangladesh and adjoining areas. The intense convective activity in the upper valley of the Ganges-Brahmaputra River Basin resulting in the devastating floods of 1987 and 1988 in Bangladesh is perhaps consistent with the model prediction of shifting monsoon trough farther north. However, the increase in local energy generation and conversion which depends on the cloud feedback processes in climate models is not fully understood yet. Therefore, whether the intense precipitation in the Himalayan valley is due to shifting of the monsoon trough because of global warming or due to any other mechanism is not clear to us at present. Whatever might be the cause, intense raining will increase floods and flood disasters such as loss of life, property, and crops, and will create multiple problems including temporal dislodgment to population and cattle heads, scarcity of drinking water, shortage of food and fodder, and hampering of communication and transport, irrigation, and drainage facilities in Bangladesh.

Cyclones in Bangladesh and ENSO

We also note that during strong El-Nino years, Bangladesh is not struck by any catastrophic cyclone. We also note that when the ENSO index is small (positive or negative) and when 28.5C isotherm, just as in the case of floods stays left of 165^0E longitude chance of Bangladesh being hit by a cyclone is high. This explains why between 1960-70 cyclone occurrence in Bangladesh was highest. During this period there was no strong El-Nino, ENSO index was moderate, and 28.5^0C, isotherm with the exception of 1965 stayed left of 165^0E and there were eighteen cyclones in Bangladesh in eleven years.

References

The Vulnerability Assessment of the SAARC Coastal Region Due to Sea Level Rise : Bangladesh Case SMRC Report No. 3, Dhaka, 2000.

A.M. Choudhury, M.A. Haque and D.A. Quadir : Consequences of Global Warming and Sea Level Rise in Bangladesh, Marine Geodesy, Vol. 20, No. 1, pp 13-32, 1997.

A.M. Choudhury: Bangladesh Flood, Cyclones and ENSO Proc. on International Conference on Monsoon Variability and Prediction IC TP, 9-13 May, 1994, published by WMO, 1994.

M. Reazuddin and Md. Sohrab Ali : Bangladesh Activities in Climate Change - Paper presented at the APN-SASCOM Workshop on CO2 enrichment Rice Research and Policy Interaction, Dhaka, Bangladesh, 18-20 February, 2000.

IPCC, 1990: Climate Change - The IPCC Impact Assessment Ed. by M.G. Tegart, W.J. Sheldon and D.C. Griffiths, Canberra, Australian Govt. Publishing Service.

GLOBAL CHANGE RESEARCH ACTIVITIES IN NEPAL – AN OVERVIEW

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1. Introduction

Human activities in the world have currently expanded to a scale that has started affecting the whole geosphere and biosphere with a threat on the long run to the very life supporting system. Man made global changes with adverse impacts to the well being of humanity has thus become areas of serious concern. Although the developing countries contribute little towards the cause of these global changes, they are the ones most vulnerable to the consequent impacts because of their weak capacities and capabilities to mitigate the consequences or to adapt to the changes.

The developing countries therefore need to develop capacity, including skills, analytical tools and databases to be able to understand and make endogenous decisions regarding adaptation to and mitigations of global change impacts. They also need to be able to provide early warning of global change.

In a developing country like Nepal, global change research is not yet a priority area. The true extent to which global changes underpin issues such as economic development and food security is often ignored. Nevertheless, because of international obligations and commitments as well as due to some external participation, the global change research activities that have been going on in Nepal, though in scattered and isolated forms, are briefly presented here.

2. Background

2.1 Biophysical Features and Resources

Nepal, nearly rectangular in shape with an east-west span of about 885 km and a north-south span of about 193 km, occupies an area of 147,181 sq. km. Lying between China in the north and India in the south, east and west, it is a landlocked country. Due to its geology, altitude relief and location, it presents a great physical, biological and cultural diversity. While the Terai in the south is the extension of Indo-Gangetic plain, the Siwalik, north to it, is composed of tertiary sandstone, siltstone and shale. The Middle Mountains and High Mountains, further north, are composed of phylillite, quartzite, schist and Tethys sediments.

The altitude varies from only 60 m. a.s.l. on the south, to 8848 m a.s.l. on the north, within a short north-south span of 160 km. The country's topography is thus rugged with over three-fourth of the total area made up of mountains and hills and inter-mountain valleys. The southern narrow strip of Terai plain occupying about 23.1 percent of the total land area carries largest population proportion of 46.7 percent. The hill region, largest in terms of area (about 41.7 percent) and geologically fragile but favorable for human habitat, shares another 45.5 percent of the total population. The Himalayas occupying 35.2 percent of the total area, own very few people residing in patch form and sharing only 7.8 percent of the total population

Because of the sharp altitudinal variation, the climate ranges from tropical in the south to arctic in the High Himal in the north. Several micro climatic conditions prevail in between due to the different altitudes and orientations of the mountain range. Because of the diverse biophysical conditions, it presents more than 35 different forest ecosystems with over 5,400 species of vascular plants including 240 species of endemic plants and 700 species of medicinal plants; as well as 130 species of mammals and 800 species of birds. Nepal lies on the crossroad of a floristic region including Sino-Japanese, Irano-Turanean Central Asiatic and Indo-Malaya type. Due to the young and fragile nature of the Himalayas, the natural systems in the mountain regions are in particular highly vulnerable to the impacts of global changes.

Water is the largest natural resource of Nepal. Mean annual rainfall is about 1,700 mm, 75 percent of which occur during the monsoon season from June through September. Around 224 billion cubic meter of surface water per year is renewable. There are over 6000 rivers and rivulets that are very important in terms of water volume and potential development. The annual mean flow for the snow-fed rivers is estimated to be 4,930 m^3/sec that amounts to 70 percent of the total surface runoff. Due to the sharp topographical gradient, the country possesses a huge hydropower generation potential estimated at 83,000 megawatts, the second largest in the world. But it has up to now generated only 0.3 percent of the total potential.. Ground water resource is estimated to be around 12 billion m^3. It is however depleting fast due to excessive extraction to meet the growing demands for drinking purpose and irrigation. With 3.6 percent of the total land surface being covered with snow and ice, glaciers and snow- melt constitute very important perennial source of water. The water resource in the country however faces high vulnerability to global change impacts threatening human livelihood and environmental integrity. In the context of increasing water scarcity and water quality degradation in the densely populated areas, as well as in that of major hydropower development schemes, integrated water resource management under global change is also a major challenge confronting the nation.

Forest is another major natural resource of the country. But because of growing demands for fuel wood, fodder and timbers, the forest is depleting fast both in area and quality. It has in turn been adversely affecting the green house gas emission as well as its sink. The forest depletion has further led to many other environmental degradations in the country such as landslides, soil erosion, floods, diminishing of soil fertility, etc.

2.2 Socio-Economic Setting

The total population of the country has more than doubled from 8.3 million in 1952/54 to 18.5 million in 1991 throughout with an annual growth rate of more than two percent. By 2008, the population in the country is expected to reach 24.0 million. The density of population has increased in each successive census year with 102 persons per km^2 in 1981 to 152 persons per km^2 in 1999. The ethno diversity ranges from Tibeto-Burma in the north to Indo-Aryan types in the south.

More than 90 percent of the total population is engaged in subsistence agriculture. Agricultural population density in the country in 1991 was 807 persons per km^2. It is very high in high mountain areas (1248 persons per km^2). Livestock constitutes an integral part of the agricultural economy in the country. In terms of livestock unit, it has also increased by more than 2 percent from 8.31 million in 1981/82 to 9.98 million in 1991/92.

The national economy thus grossly relies on agriculture. But, due to the lack of adequate agricultural infrastructure such as irrigation, the agriculture sector is squarely dependent on weather conditions. The estimated contribution of the agricultural sector to GDP in 1997/98 was 40.3 percent with a growth rate of 2.4 percent. Under normal weather condition in 1996, the growth of GDP in agricultural sector was 4.1 percent. But due to bad weather conditions, in 1997 for example it reduced to 1 percent.

Fuel wood is the major source of energy. Fuel wood provides 78 percent of the total energy consumption in the country. Commercial sources provide only 10 percent (petroleum products contribute 8 percent while coal and electricity each contribute 1 percent) and remaining 12 percent is obtained from agricultural and animal waste. The average per capita energy consumption is rather low (14 GJ per capita). The residential sector consumes by far the largest share of 91.2 percent, while the industrial and the transport sectors consume 9.2 and 3.3 percent respectively.

3. Current Status of the Global Change Research and Studies

An overview of some of the global change study and research activities being undertaken in Nepal is briefly presented here. Major institutions currently involved in global change studies in Nepal is presented in Annex 1. Sporadic studies have been made, either through indigenous initiatives or external supports, to prepare inventory of anthropogenic greenhouse gas emission and aerosols as well as to assess their effects on climate and other areas of socio-economic concerns. Similarly studies have been carried out to study

land use and land cover dynamics as well as some other global change related areas. Nepal however lacks the adequate institutional framework to carry out such studies on a sustainable long-term basis and hence weak in indigenous capabilities to identify and combat global change issues and challenges, so essential for a long-term sustainable development of the nation.

3.1 Greenhouse Gas Inventory in Nepal

Nepal is a signatory to the United Nations Framework Convention on Climate Change. Being a developing country, Nepal is not required to adopt any greenhouse gas reduction targets, but is required to take steps and report to the UNFCCC Secretariat regarding the natural GHG emission inventory and also the strategies being adopted to deal with mitigating the induced climate change.

Accordingly, some sporadic studies have been made, either through indigenous initiatives or external supports, to prepare inventory of anthropogenic greenhouse gas emission and aerosols as well as to assess their effects on climate and other areas of socio-economic concerns.

As a result of emerging concern about air pollution, particularly in the urban areas, some measurements and computational exercises were conducted to estimate gaseous emissions from the various sectors and sources. However, the emission factors and other assumptions and parameters used in such estimates all need scientific verification in the local conditions. In general, these studies are extended to prepare greenhouse gas inventory for the country.

A preliminary inventory of GHG emission for Nepal was worked out in 1997 under the United States Country Study Program (Basnyat, 1997). It was found that CO_2 emissions in 1990/91 from energy consumption in the form of fossil fuels and the cement production were respectively 912.74 Gg and 82.91 Gg respectively. Likewise, methane emission from flooded rice cultivation was 550.59 Gg, from livestock 370.07 Gg and from bio-mass burning 84.87 Gg. Similarly N_2O emission from use of fertilizers was estimated to be 803.13 tons. An institutional mechanism for improving and updating the inventory is however lacking. One time exercise of this nature has become unable to provide adequate basis for continued monitoring and mitigation activities. Furthermore, as the single exercise was based on certain models, checking of their accuracy and reliability all needed continued further studies that are again missing.

Meanwhile, other attempts have also been made to estimate the GHGs emissions. A national GHGs inventory based on some of the recently published data (MoPE and ICIMOD, 2000) is presented in Annex 2. The given figure for CO_2 emission from fuel wood is estimate based on another study (Sharma, R.R., et.al., 1998) and includes the fuel wood used in industrial and transport sectors.

3.2 Climate Change Scenarios and Impact Assessments

Development of climate change scenarios is essential in assessing the vulnerability and the sensitivity of the various national socio-economic sectors to climate change and in identifying and undertaking proper adaptation measures and mitigation strategies. Some initial studies were also carried out under the United States Country Studies Program towards the development of such climate change scenarios (Shrestha, M.L., 1999). Although the spatial resolutions of General Circulation Models (GCMs) in general were not found appropriate for the topographical features of Nepal, two models viz. Canadian Climate Centre Model (CCCM) and Geophysical Fluid Dynamics Laboratory R-30 Model (GFD3) were found to perform better than others. Climate change scenarios were developed in terms of temperature and precipitation changes under the condition of doubling of the CO_2 content in the atmosphere. With the doubling of CO_2, the models indicate temperature changes to be greater at higher altitudes varying from a change of 0.84^oC at lower altitudes to 7.05^oC at higher altitudes. The temperature changes were further found to be small during the peak rainy season (July-August). Likewise, with the doubling of CO_2, the models predict increase of precipitation during summer months varying from an increase of 72 percent at lower altitude to that of 205 percent at higher altitude. A pattern of decrease of precipitation during winter months and a typical tendency of decrease in the change in precipitation from the western to the eastern parts of the country were also noted for the entire region.

By utilizing the climate change scenarios, initial studies were also undertaken to assess vulnerability and possible impacts of the climate changes on the agriculture (Pradhan, R.B., 1999) and the water resources (Gurung, 1999). Likewise, a linear programming model known as MARKAL was used to study mitigation options for GHG emissions in the energy sector (Acharya, 1999).

3.3 Land use and Land cover Dynamics

Topographical survey, aerial photography, satellite imagery, etc. have been utilized to study the land use and land cover dynamics in the country. The data however go back at the most to only the later half of the past century

From recent study on the change in land cover it is estimated that agricultural land has been increasing annually by 0.40 percent. The increase seems to vary with altitude with high values in the plane Terai and Siwalik watershed. Through the area as well as cropping intensity has been increasing (145 percent in 1981/82 to 175 percent in 1991/920), productivity on the average for all the grains are on decline due to inadequate plant nutrient replacement. The gap between the demand and supply of food has been increasing due to rapid growth in population (2.1 percent per annum) thus the increase in agricultural production (1.8 percent). This has been an area of major concern from the point of view of food security.

Compared to 6.4 million hectares of forest in 1964, the present forest area is estimated to be 4.27 million hectares (Khanal, 1999). The forest area, which was 45 percent of the country's total areas in 1996, has reduced to 29 percent in 1999. The per capita forest has declined from 0.63 ha in 1964 to 0.442 ha in 1997 and further declined to 0.198 ha in 1998. In spite of certain programs, which have shown an exemplary works towards conserving the forest resource, excessive demands are responsible for the dwindling forest resources in the country.

3.4 Crop response to elevated CO_2

In collaboration with other South Asian countries, Nepal has been participating in the APN project on the study of crop response to elevated CO_2 by using the Open Top Chamber (OTC) system. Researchers at the Nepal Agricultural Research Council (NARC) and the Institute of Agricultural and Animal Sciences (IAAS) of the Tribhuvan University have recently set up the OTC facilities in their respective premises and have initiated their experiments on different varieties of rice under two different climatic conditions.

3.5 Studies on aerosols

As a result of the growing concern about the air pollution particularly in the urban areas, a number of institutions and organizations are engaging in the aerosol studies in the urban as well as in some remote areas. Such studies deal with the concentration, composition and size distribution of the aerosols. However, such studies are in general confined to spot data and snap observations. The Institute of Engineering and the Department of Meteorology of the Tribhuvan University as well as the Department of Hydrology and Meteorology of HMG/N have been studying aerosol concentration and composition by using various experimental techniques.

In collaboration, with the University of New Hampshire, the Department of Hydrology and Meteorology of HMG/N has also established a few experimental sites for sampling aerosols for studying major ions, particulate matter, and organic and inorganic carbon (Shrestha,A.B., 1999). The results have thrown some light on the seasonal composition of the aerosols as well as their transport mechanism and thus contributed towards understanding the Himalayan atmospheric chemistry and monitoring background air pollution.

3.6 Sediment Transport

The Ganges-Brahmaputra and the Indus rivers are among the most sediment-laden rivers of the world, contributing about 20 percent of the global sediment flux to the oceans. A few computational exercises have been carried out at the Department of Hydrology and Meteorology, estimating sediment delivery to ocean from the various rivers of South Asia (Sharma, K.P. 1999). The Ganges-Brahmaputra and the Indus rivers turn out to be among the most sediment-laden rivers of the world, contributing about 20 percent of the global sediment flux to the oceans.

4. Future Research Prospects

It is likely that global change impacts will be felt most severely in regions already under stress. Regional assessments and the extreme situation arising in same regions must therefore play a key role in the process of estimating global change impacts. Mountain regions with its unique ecological features provide valuable opportunities to study and monitor the global change impact assessments under the human interventions within the imperatives of the mountain specificity. In the context of the sustainable socio-economic development of the mountain regions, such impact assessment could focus in particular on food security and other socio-economic activities.

Global environmental change is a complex process consisting of 'system change' and 'cumulative change' (Turner et.al.1990). While, there is still lack of sufficient information and uncertainties associated with the predicted systemic changes, the 'cumulative changes', in regions can be fully captured in an identified ecosystems, e.g. mountain ecosystem, in the context of which man nature interactions and their consequences can be understood more easily (Jodha, 1992). Global change and environmental risks in mountain ecosystem can be assessed by treating in terms of circumstances that disrupt the basic biophysical process and natural flows, which in the ultimate analysis, determine the health, productivity and stability of environmental resources-land, water, vegetation etc. and their interaction.

Meanwhile, alpine plant lives with exposure of organizations to dramatic climate gradients over a very short distance also provide fascinating opportunities for the plant scientists to explore functional plant ecology of high mountain ecosystems. The combined effects of rising atmospheric CO_2 and global warming are likely to cause more pronounced changes in alpine vegetation them in most, if not all other, natural biomes. High altitude plants are therefore particularly suited for early warming components of a comprehensive global monitoring effort on vegetation change. Likewise, the pristine atmosphere of the high altitude provide unique opportunities to study and monitor global atmospheric changes effectively in a sustained manner.

Similarly, the Himalayas play a central role in the regional circulation pattern in Asia and they also provide idle location for studying ambient atmospheric aerosol for ambient troposphere. Hence it is proposed to carry out means most of aerosol concentration and composition on a continuos basis for studying their spatial, temporal and altitudinal.

Thus, while the study of global change impacts on the Himalayas and the high mountain regions are very crucial in the context of their high vulnerability, they also provide valuable prospects and opportunities for studying spatial, temporal and altitudinal variations of the global change parameters as well as their impacts on natural and socio-economic systems on a continuous basis.

5. Issues

Some of the confronting issues for the promotion of global change research in the country are:

- Lack of awareness and priority settings
- Lack of institutional framework
- Lack of integrated and multidisciplinary approach
- Inadequate laboratory infrastructure and physical facilities
- Lack of encouragement and motivational support
- Rugged topography and hardship in collection of data and information
- Limited access to relevant information on global activities

6. Identified measure:

Some of the measures identified to resolve the issues are:

- Symposia to promote awareness and exchange of knowledge as well as information

- Workshops to foster well coordinated research activities with long term visions as well as short term strategies
- Develop well conceived and targeted project proposals for external and internal funding
- Recognition and incentive measures for achievements and dedications
- Provide enabling rules, regulation and environment for healthy competitive, research and innovation.

7. Capacity Building

In spite of individual efforts, global change research activities in Nepal are thus all scattered and sporadic. Hence there is a need to consolidate the ongoing activities and strengthen them by further networking with those both within the country as well as abroad. Integrated and multidisciplinary approaches need to be encouraged and promoted. Similarly, the institutional framework for researches that is virtually non-existent at present needs to be developed and actively liked with international network. Likewise, the national development strategy needs to outline a policy and research program for sustainable economic development, which addresses the implications of possible global change including climate change effects of greenhouse gases.

Both from technical as well as socio-economic considerations, continued collection, compilation and analysis of reliable data and information on global change are essential for formulation and implementation of effective adaptation strategies and mitigation measures. Necessary infrastructures for such activities need to be established and sustained. Human resource development to undertake and promote such activities demands equal priority. For all these, the world communities including the scientific ones have a primary responsibility to establish much stronger programs of education and research on global changes in the developing countries. Obviously, regional collaboration and international interaction can contribute greatly in enhancing capacity and capability of the developing countries in general, and the least developed countries in particular, to actively participate in the global endeavors for human development on a sustainable basis.

Annex 1

Major Institutions involved in Global Change Studies in Nepal

Topics	**Institutions**
Climate change, Hydrology, Meteorology, Snow, Ice and Glaciers, Sediment transport	Ministry of Science & Technology, Department of Hydrology & Meteorology
Land use/cover	Ministry of Forest & Soil Conservation, Ministry of Agriculture, Tribhuvan University
Ecosystem, Biodiversity	Ministry of Population & Environment, Ministry of Forest & Soil Conservation
Watershed and Water Resources	Ministry of Water Resources
Particulate & Gaseous Emissions & their effects	Tribhuvan University, NGOs, Nepal Agricultural Research Council, Department of Hydrology and Meteorology

Annex 2

Nepal's National GHG Inventory

(in tonnes)

Greenhouse gas sources and sinks	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	SO_2
1. Agriculture					27	7.1	67
a. Enteric fermentation			585,600				
b. Manure management							
c. Rice cultivation			459,600				
d. Agricultural soils			133,200				
e. Burning			22,800				
f. Others			2,400				
2. Residential					12972		25870
a. Fuel wood use (1985)#	$4.54*10^6$						
3. Industrial					3643	18890	7781
4. Transport					7696	21435	808

References

Acharya, L. M., 1997. "Mitigation Options of Green House Gases Emissions in Energy Sector, Nepal", Proceedings of Workshop on Climate Change in Nepal, page 65-73, US Country Study Program, Department of Hydrology and Meteorology, HMG/N, Kathmandu.

Basnyat, M.B. 1997. "Inventory of Greenhouse Gases Emission in Nepal", Proceedings of the Workshop on Climate Change in Nepal, op.cit., page 1-15.

Gurung, T.M., 1997. "Vulnerability and Adaptation Assessment of Water Resources to Climate Change in Koshi Basin ", Proceedings of Workshop on Climate Change in Nepal, op.cit., page 33-44.

Jodha N.S., 1992, "Global Change and Environment Risks in Mountain Ecosystems"ICIMOD, MFS Series No. 23, Kathmandu.

Khanal, N.R. 1999. "Land Use Land Cover Change Dynamics in Nepal ", Himalayan Review, Vol. 30, page 71-83, Nepal Geographical Society, Kathmandu.

MoPE and ICIMOD, 2000. “State of Environment Report: Nepal”, Ministry of Population and Environment, HMG/N and ICIMOD, Kathmandu.

Pradhan, R.B., 1997. "Vulnerability and Adaptation Assessment of Agriculture Sector to Climate Change in Nepal", Proceedings of Workshop on Climate Change in Nepal, op.cit. page 45-64.

Sharma, K.P. 1999. "Regional Sediment Delivery Pattern on the South Asian River Basins to the Coastal Areas", START/LOICZ/IGBP Workshop, Colombo.

Sharma, R.R.et.al.1998. "Deforestation and its Impact in Atmospheric Carbon Dioxide", Forest Survey Division, Forest Research and Survey Center, Kathmandu.

Shrestha, A.B. 1999. "Aerosol Research in Nepal Himalayas: Present Status and Future Prospects", Scientific World, 1(1), Ministry of Science and Technology, HMG/N, Kathmandu.

Shrestha, M.L. 1997. "Development of Climate Scenarios with Reference to Nepal" page 16-32

Turner, B.L. et al. 1990. "Two Types of Global Environmental Change Definitional and Spatial-scale Issues in Their Human Dimensions". Global Environment Change, 1(1).

NATIONAL PRIORITIES FOR GLOBAL CHANGE RESEARCH AND CAPACITY BUILDING NEEDS IN PAKISTAN

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Introduction

Global warming and the resulting climate changes in different parts of the world are currently the focus of attention of the scientific community and the policy makers of all the countries. However, it has been established that developing countries are likely to be most vulnerable to the effects of climate change mainly due to the extent of their dependence on agriculture and economic use of natural resources

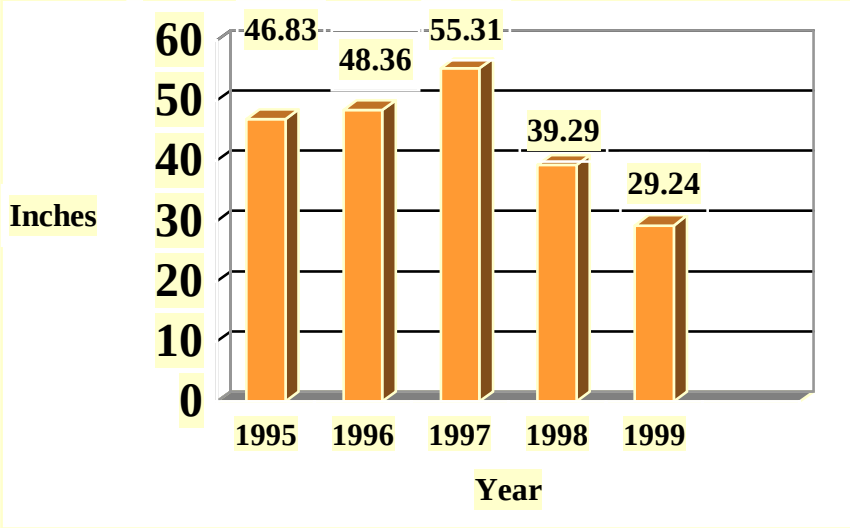
Pakistan is primarily an agricultural country Basic facts about the country are given in table 1

Table1: Fact Sheet of Pakistan

Total land	**88.2 million hectare**
Land for agriculture	**20million hectare**
Population	**130 million**
Per capita income	**$ 483 per year**
Rural/urban ratio	**65/35**
Rural/urban migration	**4.5%annually**
Water availability	**1200 cu.m/person/year**
Vehicle population	**4 million**
Literacy rate	**35%**

The consequences of climate change are of great importance to Pakistan both from the point of view of human habitation and economic prospects especially its impact on agriculture. The Pakistan Meteorology Department has formulated climate change scenarios using a synthetic model guided by Global Climate Model (GCM) outputs from a variety of GCMs. According to their findings, a temperature increase of 1-40C is anticipated by year 2100 while the change in precipitation is projected to be ±1.0% per decade for Pakistan. The average rainfall in most parts of Pakistan has been showing a decreasing trend for the last few years as shown in figure 1 where the average rainfall for Islamabad is given

Figure 1: Average Annual Rainfall in Islamabad, Pakistan



The main cause of global warming is considered to be the emission of greenhouse gases (GHGs). Considerable work has been done in Pakistan to collect data about GHG emissions. The average emission of CO2 in Pakistan is still quite low as compared with several developed countries and selected countries in Asia (Table 2)

Table 2: Carbon Emissions from Fossil Fuel Use Causing Greenhouse Effect*

Country	**C- Emissions** (tons /capita)	**Total Emissions** (mln tons)	**% of Global Emissions**
USA	5.4	1,340	22.3
China	0.6	655	10.9
Russia	3.8	570	9.5
Japan	2.7	330	5.5
Germany	3.1	250	4.2
India	0.2	175	2.9
UK	2.8	160	2.7
Pakistan	0.2	19	0.3

A brief overview of the implications of climate change on sectors that are most likely to be affected is given below.

Agriculture: The impacts on the agriculture and livestock sectors will be considerable. There is expected to be a shift in spatial boundaries of potential cropping areas and possible changes in productivity. Water and land use for the sector will also be influenced especially due to the change in availability of water for agriculture. The livestock sector will be influenced economically due to changes in livestock feed grains availability and prices. Climate driven impacts on rangelands and livestock will be shifts in rangeland vegetation and boundaries changes in forage and water quality and quantity influences on livestock productivity and the length of growing season. The ecological impacts on the livestock sector are closely

linked with the impacts on the forestry sectors as the grazing area and habitat of livestock is affected by these changes.

Forestry and Ecology: The effects on the forestry sector include changes in the location and size of optimal growing areas of different forest types, changes in productivity alterations in the make up of forests e.g. Changes in productivity, alterations in the make up of forests e.g. changes in the amount of stored carbon, nutrient retention and literacy rate. There is expected to be an impact on forest phonology such as bud breaking or flowering and on the spread and severity of forest pests, diseases and weeds. . Due to the expected changes in climate some of the responses of ecosystems and natural communities include increase in the rate of photosynthesis, early growth and flowering, reduction in photorespiration, changes in plant-plant and plant –animal interactions, changes in decomposition rate and in the community composition. Marine ecosystem, mangroves, Indus riverain wetlands, mountains are all areas that are expected to be largely affected by the expected changes in the climate.

Mangroves: Significant impact of climate change is expected on the mangroves:

- Sea level rise: Unlikely to adopt quickly, Reduction in sedimentation, Increase in erosion, Reduction in photosynthesis, Increase in salinity
- Higher temperatures may affect the composition, distribution and productivity
- Elevation in carbon dioxide may increase productivity
- Low rainfall will contribute to salt stress
- Frequency and severity of storms may impart detrimental impacts

Water Resources: For the water resources sector, there are expected to be impacts on the operation of Indus basin system and changes in extreme events, which in turn will influence the water resources of the country. Alterations in evaporation, groundwater, and glacier events such as increased risks of storms and of drought and desertification, heavier more sustained rainfall, increased moisture in the air and changes in the monsoon patterns will be impact the water resources sector.

Energy: Energy sector is not as vulnerable to influences of climate changes as some of the sectors discussed earlier, as it does not solely depend on natural resources. However, here will be impacts on the infrastructure and changes in the power generation requirements.

Although other sectors will be also affected, the above sectors have been discussed due to their relatively higher vulnerability to change in the climate.

Priority Areas for Future Emphasis

Pakistan has a very modest infrastructure to study the impact of global changes on the environment and national economy. It is important that public awareness about various aspects of global change is increased through publications and media. The socio-economic impacts of climate change are likely to be very significant and there is an urgent need to systematically study the climate change scenarios and their socio-economic impact in order to devise mitigative measures for the anticipated changes.

Pakistan is mostly an arid to semi-arid country. The impact of global change on the overall water availability situation is therefore of prime importance for the survival of the human population and socio-economic development. This year the water level in the country's two major water storages-the Tarbela and Mangla dams has been lowest ever due to a failure of the summer monsoons and very low winter rainfall. This is already threatening the current *rabi* crop and increasing the likelihood of a sever wheat shortage in the coming year. Pakistan, therefore needs to study the impact of global changes on rainfall, glacier melting and water requirement of crops very carefully. With increase in global temperature, the possibility of recurring draughts in an already arid to semi-arid country like Pakistan will increase considerably. It is therefore essential that effective planning may be done for draught monitoring and emergency arrangements to meet the draught situation.

Atmospheric aerosols and environmental pollution is another area of great concern in Pakistan. With a rapid increase in motor vehicles, especially diesel vehicles, and an emphasis on industrialization, the extent of aerial pollution, especially in the large urban centers has increased a great deal. It is essential to regularly monitor the air quality in different parts of the country and to take mitigative measures to meet the challenge of increasing air pollution, especially to human health. The impact of air pollution especially increasing haze due to smoke and other particulate matter, to agriculture needs to be studied urgently since it adversely affects photosynthesis in crops resulting in reduced crop yields.

Pakistan is an energy deficient country and has to import most of its oil requirements. The impact of global changes on the energy requirements especially on increasing import bill has therefore to be studied carefully so as to have an economically viable strategy. This will also necessitate further research on energy efficiency and on devising the most economical and efficient means of transport so as to minimize environmental pollution and the use of imported fuel.

Institutional Imperatives of Global Change

At present there is no systematic institutional mechanism in Pakistan to deal with various aspects of climate change. There is an urgent need to have focal point for studying various aspects of global change and undertaking research on priority areas of special importance to Pakistan. It is recommended that initial a National Cell for Global Change Research may be established in one of the existing research organization e.g. PARC where already considerable research is going on in different sections relating to different aspects of impact of global change on agriculture. Eventually such a cell could grow into an independent research institute dealing with all aspects of global change including modelling of anticipated changes and impacts on environment, human health, agriculture and national economy.

Since climate change is such an important subject for Pakistan, a cell may be established in the Ministry of Environment to study all aspects of climate change in collaboration with the Pakistan Meteorology Department, Space and Upper Atmosphere Research Commission (SUPARCO), Pakistan Agricultural Research Council (PARC), Pakistan Council for Research in Water Resources (PCRWR) and thr Water and Power Development authority (WAPDA).

For any meaningful development of capability in forecasting, monitoring and mitigating the impact of global change, it is essential to develop properly trained manpower at undergraduate and graduate level specializing in a study of the comprehensive global change phenomenon. Since Pakistan is taking several measures to monitor and mitigate global change effects, it is important that properly trained manpower is employed to work on these projects. It is therefore essential that initially a post-M.Sc diploma course is instituted at one of the universities or government departments where training is imparted in various aspects of global change. Such a diploma course could gradually be upgraded to a degree course when the need for trained manpower increases substantially.

Global Change Research in Sri Lanka: Current Status and Future Priorities

J. RATNASIRI
Chairman, IGBP National Committee, Sri Lanka, Colombo

1. Country Profile

Sri Lanka has a land area of 65,610 sq km, bounded by a coast line of approximately 1,585 km. Most parts of the country comprise lowlands with an elevation below 100m. The south-central region comprises highlands having two broad levels at 500m and 2000m levels and rising to a peak height of 2,524 m.

The mean annual temperature of the lowlands is 27.5^{o} C, while in the highlands it is 18^{o} C. The relative humidity in the low country is generally high, while it is relatively low in the hill country. The monthly mean temperature has only a small variation throughout the year, with the mean temperature of 25.0^{o}C during the coolest months November to February in the lowlands being only 2.4^{o}C lower than that during the warm months April and May (1).

The rainfall in Sri Lanka is governed by the two monsoons, the South-West received during May-September, and the North-East received during December-February. Most parts of the country receive an annual rainfall within 1000 and 5000 mm. The south-west quadrant, referred to as the wet-zone, receives more than 2500 mm of rainfall annually. A greater portion of the rest of the country receives less than 2000 mm and is known as the dry zone. A narrow strip in between, known as the intermediate zone, receives rainfall between 2000 and 2500 mm annually. The extreme north-west and south-east corners receive below 1000 mm of rainfall annually and are known as the arid zones.

The closed-canopy forest cover has depleted from about 45% in 1956 to about 24% in 1992 (2). The percentage arable land is about 30%, as estimated in 1992. The area under rice cultivation is about 11%. The other crops of economic importance are tea, rubber and coconut, which occupy 2.9%, 2.4% and 6.8% of total land area, respectively, as estimated for 1998 (3).

The mid-year population for 1998 has been estimated to be 18.80 million. The Colombo District is the most densely populated district, with a density of 3,374 persons per sq. km, while the country average is 300 persons per sq. km (4). The rate of growth of population has been brought under control to about 1.3%. It is estimated that only about 21% of the people live in urban areas.

The GNP for 1998 has been US $ 823 per capita (5). Its major share of 53% came from the services sector, while the agriculture and manufacturing sectors contributed 21% and 17%, respectively. The rate of growth of GDP for 1997 has been 6.4% at real terms.

The indigenous sources of primary energy in the country are biomass and hydro-electricity. No fossil fuels are available and all petroleum products are imported. The topography of the country with central hills and several perennial rivers has made hydro-power the major source of electricity, supplying about 70% of energy generated to the national grid. In the total energy scenario in Sri Lanka, on an average, biomass contributed 70%, petroleum 25% and hydro-electricity 5%, during 1994 (6). Electricity is available to only about 50% of the households, and the annual per capita electricity consumption in 1998 was about 240 kWh.

2. Climate Change Studies

Only a few studies have been carried out in Sri Lanka on the impacts of climate change. The first major coordinated study was carried out during the period 1992-93 as part of a regional study, sponsored by the Asian Development Bank, and conducted by a local team under the direction of the Climate Institute in Washington (7). The second study was undertaken by a team of scientists, co-ordinated by the Ministry of

Forestry and Environment, under the US Country Studies Program (USCSP) (8). Sri Lanka was not included in the ALGAS Project that was initiated by UNDP in other South and SE Asian countries.

Among the study elements supported by the USCSP were the preparation of the Greenhouse Gas Inventory, Mitigation Options, Impacts and Vulnerability Assessment and Awareness Activities. Under mitigation options, the emission of methane from rice fields under different water management systems, fertilizer use and varieties was investigated, and it was found that with proper water management, methane emission could be reduced by about 36% without affecting the yield (9). Under impacts and vulnerability, three studies were undertaken: the potential impact of climate change on forest distribution, using Holdridge classification of life zones under different climate conditions (10); the impact on beach erosion and inundation of coastal land along the south-west coast line under different scenarios of sea level rise (11); and the impact of climate change on the incidence of malaria, particularly the sensitivity of the potential transmission factor and the vectorial capacity (12, 13).

Several researchers attached to the Universities and other Institutions, on their own initiative, have undertaken various studies that are related to global change. Among these are: land use changes in the biotic environment and the anthropogenic nature of droughts and desertification in Sri Lanka (14); economic appraisal of social/agro forestry systems in Sri Lanka, with special reference to soil fertility improvement (15); vulnerability of Sri Lankan tea plantations to global climate change and adaptations to dry environments (16,17); impact of climate change on paddy production in two major paddy growing districts (18) and rehabilitation of degraded land using early-successional plant species for sequestering carbon (19).

Under the Mahaweli Project, the country's major river Mahaweli was partially diverted to a relatively drier area, resulting in the conversion of large extents of forest land into agriculture land during the last two decades. A detailed mapping of the land cover/use, biodiversity and land degradation in the project areas has been undertaken with a view to studying changes that had taken place from the inception of the project. A study on the long-term climate variability on water resources and environment management in the project area has also been undertaken (20).

There are two on-going APN supported studies, one on the impact of CO_2 elevation on rice productivity carried out in collaboration with India, Bangladesh and Nepal (21) and the other being a study on rehabilitation of degraded land for sequestering carbon, carried out in collaboration with Indonesia (22).

According to a recent study undertaken by the Department of Meteorology, the annual mean air temperature over the entire island has increased by about 0.16 ^{o}C per decade, particularly during 1961-90 period (23).

3. Policy and Institutional Support

The Government of Sri Lanka has recently formulated several policy documents related to climate change. Among these are the Forestry Sector Master Plan (2), the National Water Resources Policy and Institutional Arrangement for Comprehensive Water Resources Management (24), the National Policy Framework in Agriculture and Forestry (25), the National Environment Action Plan 1998-2001 (26), the Coastal Zone Management Plan (27), and the draft Energy Policy for Sri Lanka (28). However, none of these policy documents have incorporated any climate change considerations in them. Currently, the Ministry of Forestry and Environment is preparing the country's initial National Communication on Climate Change (NCCC) with assistance from the Global Environment Facility, for submission to the UN Climate Change Secretariat.

There are several agencies, which channel funds for research, with money coming from both internal and external sources. These are the National Science Foundation, the National Research Council, the Council for Agricultural Research Policy, and the University Grants Commission. However, climate change studies is not a priority area for the granting of awards. Recently, the Government has established a Centre for Climate Change Studies within the Department of Meteorology with a Technical Advisory Committee drawn from other relevant organizations. The Ministry of Environment has also initiated action to establish a Secretariat for Climate Change, within the Ministry for taking measures to comply with the requirements of the Framework Convention on Climate Change.

4. Recent Programmes

The National Committee of IGBP has in recent years organized several activities to provide a forum for scientists to present their climate-change related work and to sensitize policy makers on climate change issues. These included the National Symposium on Climate Change held in March 1997 and the National Workshop on Impacts of Climate Change for Policy Makers held in June 1998, both with financial assistance from the USCS Programme. The Committee also organized two regional activities with the objective of capacity building and networking of coastal scientists in the South Asia region. These were the Regional Workshop on Estuarine Modelling and Coastal Zone Management held during 28-30 April 1999 with financial assistance from START and LOICZ, and the Regional Training Workshop on Biogeochemical Budgeting and Socio-Economic Modelling held during 18-22 September 2000 in association with LOICZ and financial assistance from APN and START. A special activity on Capacity Building and Networking Workshop for Scientists in Bangladesh, Nepal and Sri Lanka was held on 23 September 2000 with assistance from APN and SASCOM.

The objectives of the Coastal Modelling Training Workshop were to: improve the capability of modelling of sediment dynamics and biogeochemistry of coastal systems; assess the economic and social impacts of global change in coastal systems and how mitigation measures would affect the human population; assess the impacts of human activities on the coastal environs and ecosystems, and on the BGC budget; and to integrate the natural sciences with the socio-economics for proper coastal zone management. The main outcome of the Workshop was to formulate a project proposal to: identify, assess and share existing studies related to material fluxes, their origins and impacts on the functions of coastal systems; develop a system of classification of the river basins and coastal areas and make an assessment of the fluxes and their impacts in selected systems; identify critical gaps in information and knowledge of processes and develop proposals for detailed studies to address these needs; study the links between government policy, socio-economic factors and the material fluxes and their impacts in the region; and to establish a network of researchers and institutions engaged in research, policy formulation related to fluxes of material to the coastal zone, and their training. The proposal was submitted to APN last September.

The special Capacity Building and Networking Workshop was held with the objective of: exposing the scientists in South Asian countries to the latest information regarding global change issues pertaining to land use/cover, terrestrial ecology, agriculture, forestry and climate variability; discussing issues pertaining to above areas that need to be investigated on a regional basis; building capacity of the scientists to undertake projects concerning above areas on a regional basis in collaboration with scientists and organizations in other countries; and identifying areas to develop project proposals for submission to APN and other Agencies for funding.

5. Priority Research Areas

5.1. The Capacity Building Workshop identified several areas for developing into project proposals for submission to APN seeking funds. These were: a regional study on impact evaluation of the quality of resource base and improvements in agricultural productivity brought about by irrigation command projects, including land use changes that had followed after introduction of major irrigation schemes in the participating countries; studies on methane evolution from paddy lands and management strategies for reducing the intensity of evolution for verifying the emission factors and examine mitigation options; regional study on the greenhouse gas emission factors in the agriculture, forestry and land use sectors applicable to the region, as recommended by an IPCC Meeting held recently in Ghana; regional study on the impact of carbon dioxide elevation and climate change on the productivity of tea (on which a pre-proposal has already been cleared by APN); and a regional study for the analysis of trends in climate extremes and synthesis of climate variability data in South Asian region which is subject to monsoon weather patterns and their correlation to agricultural productivity.

5.2 The draft National Communication on Climate Change has identified several priority areas for undertaking research in various sectors (29). Among these are:

Coastal Zone

- Salt water intrusion into fresh water intakes and agriculture land
- Impact of sea level rise on erosion and inundation
- Impact of sea level and temperature rise on coral reefs

Agricultural Sector

- Crop response forecasting
- Develop draught/salinity resistant varieties of crops
- Low impact cropping systems

Forestry Sector

- Climate change and forest ecosystem links
- Quantify sinks and sources of carbon
- Estimate biomass for different types of vegetation

Water Resources Sector

Impacts on river flow regimes

Impacts on ground water table

Human Health Sector

- Dynamics of vector-borne diseases
- Thermal environment management strategies

Human Settlements

- Map flood prone areas
- Map areas vulnerable to land slides.

5.3 The Centre for Climate Change Studies has also identified several areas for undertaking research at regional level (30). Among these are:

- Develop temperature and sea level rise scenarios for the South Asia region
- Monitor sea level rise and study its impacts in the coastal systems
- Synthesize data on water resources and study their vulnerability to climate change
- Synthesize climate variability data and study impact on the Asian Monsoon system
- Study impact of climate change on the occurrence of vector borne tropical diseases and mitigation measures

6.Conclusion

The scientific community in Sri Lanka is much concerned about the climate change and its adverse impacts. Consequently, several research studies have been initiated recently by scientists both in the Universities and Government organizations. A separate Centre has also been established recently for undertaking climate change research However, there is still complacency among policy makers in giving climate change concerns its due consideration when formulating various sectoral policies as well as in implementing associated plans. It is therefore essential that scientists be given support to arm themselves with adequate

information acquired through country specific research, enabling them to apprise the policy makers on these issues. It is expected that such measures would at least result in policy makers giving priority for climate change concerns when formulating policies and action plans in the future, particularly in sectors vulnerable to climate change.

REFERENCES

Department of Census and Statistics (1999), Statistical Abstracts of the Democratic Socialist Republic of Sri Lanka, Ministry of Finance and Planning, Colombo, pp. 9-10.

Forestry Planning Unit (1995), Sri Lanka Forestry Sector Master Plan, Ministry of Agriculture, Lands and Forestry, Battaramulla, Sri Lanka, p. 20.

Department of Census and Statistics (1999), Statistical Abstracts of the Democratic Socialist Republic of Sri Lanka, Ministry of Finance and Planning, Colombo, pp. 82,90.

Department of Census and Statistics (1999), Statistical Abstracts of the Democratic Socialist Republic of Sri Lanka, Ministry of Finance and Planning, Colombo, pp. 31-32.

Central Bank of Sri Lanka (1999), Economic and Social Statistics of Sri Lanka 1999, Central Bank of Sri Lanka, Statistics Department, Colombo, p. 1.

CEB (1996), Report on Long Term Generation Expansion Planning Studies 1996-2010, Generation Planning Branch, Ceylon Electricity Board, Colombo, p. 2.4.

ADB (1994), Climate Change in Asia: Sri Lanka Country Report, Asian Development Bank, Manila.

Ratnasiri, J. (1998), Final Report of the Sri Lanka Climate Change Country Study submitted to US Country Studies Program, Washington DC, Ministry of Forestry and Environment, Colombo.

Namaratne, S.Y. (1997), Studies on Methane Emission from Paddy Fields in Sri Lanka and Options for its Mitigation, Final Report submitted to the US Country Studies Program on Climate Change, Washington DC, Ministry of Forestry and Environment, Colombo, p.57.

Somaratne, S. and Dhanapala, A.H. (1996), Potential Impact of Global Climate Change on Forest Distribution in Sri Lanka, in: *Climate Change Vulnerability and Adaptation in Asia and the Pacific*, Erda, L., Bolhofer, W.C., Huq, S., Lenhart, S., Mukherjee, S.K., Smith, J.B., and Wisniewski, J. (Eds), Kluwer Academic Publishers, pp129-135

Weerakkody (1997), Potential Impact of Accelerated Sea Level Rise on Beach Erosion and Inundation of the South-west Coast of Sri Lanka, Final Report submitted to the US Country Studies Program on Climate Change, Washington DC, Ministry of Forestry and Environment, Colombo.

Dhanapala, A.H., Mendis, K., Wickramasinghe, A.R., Fernando, W.P., de Soyza, A.P.K., Chandrapala, L. (1998), Potential Impacts of Enhanced Greenhouse Effect on Malaria in Sri Lanka, Final Report submitted to the US Country Studies Program on Climate Change, Washington DC, Ministry of Forestry and Environment, Colombo.

Dhanapala, Andra H. (1998), Sensitivity of Malaria Potential Transmission to Climate Change in Sri Lanka, *Asian Profile*, Vol. 26 (4), pp. 283-292.

Wickramasinghe, Anoja. (2000) Anthropogenic Nature of Droughts and Desertification in Sri Lanka, Paper to be Presented at the International Conference on: *Sustainable Development of Water Resources - Socio-Economic, Institutional and Environmental Aspects*, Institute for Resource Management and Economic Development, New Delhi, 27-30 Novermber, 2000.

De Soyza, Mangala (1995), Social Forestry in Sri Lanka: An Economic Appraisal, *Transactions of the Japanese Forestry Society*, No. 106, pp. 5-10.

Wijeratne, M.A. (1996), Vulnerability of Sri Lanka Tea Production to Global Climate Change, *Water, Air and Soil Pollution*, Vol. 92 (1/2), pp. 87-94.

Wijeratne, M.A. (1996), Some Adaptations of the Tea Plant to Dry Environments, *Adapting to Cliamte Change: Assessments and Issues*, Springler, New York, pp. 174-187.

Fernando, T.K. (2000), Impact of Climate Change on Paddy Production in Sri Lanka, *Global Environmental Research*, Vol. 3 (2), pp. 169-176.

Wanniarachchi, S.D. (2000), Private Communication.

Manthithilake, H. (2000), Private Communication.

Uprety, D.C. (2000), Details of the Regional Network for Elevated CO_2 Rice Research being set up for Joint Experimentation in South Asia including OTCs and Mid-FACE Facilities, Paper presented at the APN-SASCOM Workshop on *CO_2 Enrichment Rice Research and Policy Interaction*, 18-20 February, 2000, Dhaka.

Wanniarachchi, S.D. (2000), Private Communication.

Department of Census and Statistics (1999), Statistical Abstracts of the Democratic Socialist Republic of Sri Lanka, Ministry of Finance and Planning, Colombo, p. 10.

Water Resources Secretariat (2000), National Water Resources Policy and Institutional Arrangement for Comprehensive Water Resources Management, National Planning Department, Colombo,

National Policy Framework in Agriculture and Forestry, Ministry of Agriculture, Lands and Forestry, Battaramulla.

National Environmental Action Plan (1998-2001), Ministry of Forestry and Environment, Battaramulla, 1999

Revised Coastal Zone Management Plan, Coast Conservation Department, Ministry of Fisheries and Aquatic Resources Development, Colombo, 1997.

Energy Policy for Sri Lanka, Ministry of Irrigation, Power and Energy, Colombo, 1997.

Initial National Communication under the United Nations Framework Convention on Climate Change - Sri Lanka (Final Draft), Ministry of Forestry and Environment, Battaramulla.

Director, Department of Meteorology, Colombo (2000), Private Communication.

NATIONAL PRIORITIES FOR GLOBAL CHANGE RESEARCH

The national priorities were discussed extensively in the discussion on national and regional priorities for global change research. It was agreed that agriculture and water- related issues were of highest priority for the region in the context of global change. The economy of all the countries of South Asia region is intimately linked to agriculture production, which in turn is dependent on availability of irrigation supplies in most parts of the region. The group therefore decided that while other aspects of global change are also very important, this workshop should concentrate on the highest priority issues dealing with agriculture and water.

BREAKOUT GROUPS

The participants divided into two groups to deal with issues related to agriculture and water. The breakout groups had in-depth discussion about the impact of global change on various aspects of agriculture and water sectors. After extended discussions, the groups prepared priority lists of research topics in these two main areas. The groups also discussed measures for strengthening networking and capacity building in future and prepared list of such measures for considerations in the plenary session.

RECOMMENDATIONS

The last session of the workshop was devoted to preparation of recommendations regarding priority research projects in the two main areas dealing with agriculture and water. Lists of research topics considered to have high priority for almost all the participating countries were prepared for consideration of the SPG and IGM of APN in the forthcoming 6th IGM to be held on Cheju Island in South Korea in March 2001. Measures for strengthening the networking and capacity building efforts were also discussed at length and a set of recommended measures agreed for submission to the IGM for final decision.

a. General Recommendations

1. The over-riding theme of the projects seeking funds from APN or other agencies/mechanisms concerning global change research in water and agriculture sectors should be "Vulnerability assessment of water resources and agriculture systems and development of corresponding abatement strategies."

2. The Indo- Gangetic Plain should be the focus for assessing impacts of global change on the agriculture systems, considering its role as the food basket of the region. For water issues, specific watersheds be taken up on national or regional basis for comprehensive study of different parameters related to global change.

b. Promising Project Titles

- Implications of globalization and WTO provisions on institutional aspects of research in post-harvest processing and marketing to safeguard against loss of markets of agricultural products of South Asian countries to other competitors.
- Factors leading to severe draught in parts of South Asia (hydrological cycle, water availability and use, global warming, increased population, overgrazing and desertification) and vulnerability assessment of draught-prone areas in the light of future global change scenarios
- Development of technological packages and policy strategies to increase irrigation efficiency for optimising crop production in South Asia (initial emphasis on rice/wheat rotation).
- GHG emissions, environmental, and socio-economic impacts of large dams in South Asia in light of the recent report of the World Commission on Dams.
- Impacts of future water resource scenario (quantity and quality) on food security and development of sustainability indicators for water resources management in light of anticipated global warming and climate change.
- Effect of increase in CO2 content in ambient air on insect population and plant diseases in relation to crop yields.
- Impact of global warming on land use decision-making at different altitudes in the hilly areas of Himalayan mountains in Nepal, India and Pakistan
- Impact of global change on livestock health and production, and net family income of small farmers.
- Changing consumer pattern due to globalization and their impact on climate change and environmental pollution especially in relation to increased production of GHGs and use of non-degradable packing material.

- Impact of climate change on weed-crop competition and biological control of weeds in relation to rice productivity in South Asia.
- Global change and the increasing incidence of tree dieback in South Asian countries.
- Global change and its impacts on microclimate, vegetation and soil caused by land use/cover changes (forestry, agro forestry) over several decades with special reference to major irrigation schemes and quantification of carbon sinks.
- Impacts of climate change on alpine species in the Himalayan region
- Effect of global change parameters on N-fixing capacity of legumes
- Climate change and invasion of alien species in relation to change in the biodiversity of natural ecosystems.

c. Capacity Building and Networking

- In order to maintain the continued interest of participating scientists of this workshop in formulating projects on the identified issues, the APN Newsletter may include titles of promising projects identified in similar workshops and be distributed widely to all institutions in the region having an interest in global change research.
- SASCOM may update the Directory of Scientists in the region and include the main research interest of the scientists, email and fax numbers for easy communication. Besides national directories, directories of scientists and institutions in the region in major disciplines may also be prepared to stimulate networking among professional colleagues.
- Some of the APN capacity building and networking funds may be set aside to organize scoping workshops to facilitate the development of promising research projects for submission in the APN-Project Cycle, by the scientists from the participating countries (Bangladesh, Nepal, Pakistan and Sri Lanka). The scoping workshops may be organized by April 2001 so that revised projects are submitted to APN by the September 2001 deadline.
- In order to improve the capacity in the region, a web based DIS system needs to be introduced which will contain:

  -a reference list of recently published papers on related issues

  -information on upcoming events

  -links to international project offices of IGBP, BAHC, IHDP, START, APN etc.

  -a meta data directory of related data bases available in the region with links to original source

  Eventually data might be formatted on GIS platform. It is recommended that this DIS system be housed within the SASCOM web page
- The APN Focal points and SPG members may be sensitized appropriately in the forthcoming IGM to motivate them to take up a more active role in dissemination of APN information to concerned policy makers and scientists so that the research scientists can effectively participate in APN activities especially competitive research grants.
- There should be a closer liaison between the APN Focal point/ SPG member and the SASCOM member in APN member countries so that they can collaborate in promoting the common objectives of APN and START within the country.

- Each country may designate a relevant research group in an existing institution as the "National Global Change Research Centre/Cell" in order to provide a focus to the national activities in global change research. Such centre/cell may be entrusted the responsibility of preparing directories of institutions/. Scientists interested in GC research, publish newsletters about national GC research efforts, provide information to interested scientists about opportunities for research support in consultation with APN, START and other similar international agencies, and sensitise the policy makers about need for GC research.
- The recent successful outcomes of the Capacity building and Networking workshops held in Sri Lanka and now in Pakistan, where a large number of scientists working within the respective countries on GC issues have participated, indicate that such meetings greatly stimulate research activity in GC in the respective countries. APN therefore may provide financial support in future for organizing such workshops on national scale in the region where all scientists working on GC projects in different disciplines present their work besides invited lectures from the leading international organizations (IGBP, IHDP, WCRP).
- Promising research scientists in the target countries often do not have information about international organizations that provide financial support to scientists from developing countries for such research and capacity building (e.g. TWAS). START may be requested to develop a list of such organizations with names and contact information of the relevant persons and widely disseminate this information to scientists in the developing countries.
- Curricula at school and university level do not include much information about global change. Besides developing curriculum content for inclusion at various levels, attempts may be made to have at least one university in each of the countries impart post-graduate education in global change aspects.
- A regional centre of excellence for global change research may be identified/established that could serve as a training institution for manpower in the regional countries.

Annex 1: Program

Day 1 *20th November 2000*		
Session 1: Inauguration		
9:00 – 9:15	Welcoming Remarks	Dr. Amir Muhammed, Chairman SASCOM
9:15 – 9:35	APN and the Networking & Capacity Building Program	Dr. Gerhard Breulmann, Programme Manager, APN
9:35 – 10:00	START and its Role in Capacity Building	Dr. Hassan Virji, Deputy Director, START
10.00 – 10:25	IGBP and the Global Change Research Perspective	Dr. Wendy Broadgate, Deputy Director, IGBP
10:25 – 10:45	Inaugural Address	Mr. Omar Asghar Khan, Minister for Environment
10:45 – 11:10	**Tea Break**	
Session 2: International Programs (Chairman: Mr. Mahboob Elahi)		
11:10 – 11:35	IGBP - BAHC Research	Dr. Holger Hoff, BAHC Program
11:35 – 12:00	Greenhouse Gas Emissions and Global Climate Change Perspective for South Asia	Dr. Toufiq Siddiqi GEE-21, Hawaii
12:00 – 12:15	Ongoing Activities and Future Plans of SASCOM	Dr. Amir Muhammed, SASCOM Chair
12:15 – 12:30	Activity Report of the South Asia START Regional Research Centre (SAS-RC).	Dr. Sumana Bhattacharya, South Asia Liaison Officer APN
12:30-13:00	Funding Opportunities for GC Research Projects - APN, EC and others	Dr. G. Breulmann (Programme Manager, APN) and Dr. H. Virji (Deputy Director, START)
13:00 – 14:00	**Lunch**	
Session 3: National Priorities for Research & Capacity Building Needs (Chairman - Dr. H. Virji)		
14:00 – 15:00	Plenary discussion with introductory country presentations by:	1. Dr. Choudhury (Bangladesh) 2. Dr. K.L. Shrestha (Nepal) 3. Mr. Asif S. Khan (Pakistan) 4. Dr. J. Ratnasiri (Sri Lanka).
Session 4: Regional Priorities and Funding Opportunities (Chairman: Dr. G. Breulmann)		
15:00 – 16:00	Regional Priorities for Research and Funding Possibilities	General Discussion
16:00 – 16:15	**Tea Break**	
16:15 – 17:30	Discussion on priority issues in agriculture and water sectors related to global change	Dr. Amir Muhammed

Day 2 *21st November 2000*

9:00 – 11.00	Breakout groups on Agriculture and water issues	Group discussions
11:00 – 11:15	**Tea Break**	
11:15 – 13.00	Break out groups discussion (contd..)	
13.00-14.00	**Lunch**	
14:00 – 14:30	Reports from the break-out groups	
14:30 – 15:30	General discussion	
15:30 – 15:45	**Tea Break**	
Session 5: Identification of Project Titles for Collaborative Research in the Region (Chairman: Dr. A. Mohammed)		
15:45 – 17:30	Possible project titles	General discussion
19:30	**Workshop Dinner**	

Day 3 *22nd November 2000*

Session 5: Identification of Project Titles (Cont)		
9:00 – 11:30	Selected project titles	Discussion
11:00 – 11:20	**Tea Break**	
11:20 – 1230	Workshop recommendations	
12:30 – 13:0	Closing Remarks	
13:00 – 14:00	**Lunch**	

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