SCIENCE & TECHNOLOGY IN ASIA AND THE PACIFIC

Co-operation for Development

United Nations
Educational,
Scientific and Cultural
Organization

This Collection, conceived,
compiled and edited by
Penelope Gobel,
Office of the ADG/SC,
is based on the contributions of
many staff members of UNESCO,
both active and retired, at
Headquarters and in the Field.

Cover photograph: Professor Savitri Gunatilleke of the Department of Botany of Peradeniya University with a group of young villagers training to be tourist guides in Sinharaja Biosphere Reserve, Sri Lanka. Photo by Nimal Gunatilleke

UNESCO 1997

SC-97/WS/44

CO-OPERATION FOR DEVELOPMENT

UNESCO SUCCESS STORIES

FOREWORD

by the Director-General of UNESCO

In a context of increasing globalization with all its inherent complexity, science and technology will inevitably be the key to ensuring that developing countries become effective stakeholders in the future development of the world economy.

In all countries - including those of the Asian and Pacific region - scientific and technological knowledge and know-how are more than ever indispensable for capacity building. This holds good for the entrepreneurs who convert applied science into technology.

It is through science and technology, guided by social and democratic principles, that poverty will be overcome and all Asian and Pacific countries will progress firmly along the path towards sustainable development, thereby laying the foundations for a culture of peace.

Federico Mayor

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BOXES giving a brief overview of on-going UNESCO projects

PREFACE

CAPACITY DEVELOPMENT IN ASIA AND THE PACIFIC

MAURIZIO IACCARINO
Assistant Director-General for Science

The series of regional publications on "Science and Technology: Co-operation for Development" have become familiarly known as the UNESCO Success Stories and began with the Report on the Symposium on Science and Technology in Africa, (Nairobi 1994). The second publication "Science and Technology in Latin America and the Caribbean" was published in March 1996 and I am now pleased to present the third volume in the series: "Science and Technology in Asia and the Pacific".

The Organization's science programme in Asia is mainly covered by two offices: the New Delhi Office for South and Central Asia and the Jakarta Office for Southeast Asia. Other offices such as those in Beijing, in Apia, in Phnom Penh Office and in Bangkok have programme specialists in various science disciplines, and in fact all offices, not only in Asia but throughout the world, are moving towards interdisciplinarity. The Secretariat for the Intergovernmental Oceanographic Commission's Sub-commission for Western Pacific is also housed in Bangkok.

To operate in this continent has been a challenge for the Science Sector: in fact the scientific culture is of European origin and it is therefore difficult to propose activities that are suitable, and acceptable, to a different civilization. For example, Confucianism implies a deep respect for the Authority, while scientific progress requires a continuous criticism of hypotheses. Another difficulty is related to democracy: it is in fact difficult to achieve scientific progress in the absence of respect for civil rights and this in some countries poses problems.

This publication gives examples - albeit far from comprehensive - of UNESCO's action in science and technology throughout the region. They are projects that have contributed to the process of national development, and in some cases regional development, through human resources development, institution building, organization and promotion of research and science education, transfer of technology and management of natural resources.

All these projects have a social, educational and cultural aspect, and collaboration with the other Sectors of UNESCO has been intensive, even if not always apparent. They cover our different fields of action which range from basic and engineering sciences to the environmental sciences: earth sciences, ecological sciences, water sciences and oceanography and marine sciences, and witness the impact of the activities on the local population, be it from the point of view of urban ecology (Hong Kong), disaster prevention such as the earth sciences chapter on Volcanoes in the Philippines, studies on malaria in Iran, vocational and mobile education in Myanmar, or water resources in small Pacific islands. I hope that this volume will give the reader a glimpse of our wide ranging activities and the results we have achieved.

Here I should like to quote from the Preface of my predecessor, Adnan Badran, to the second volume of this series

"Although, of course, UNESCO does not take credit for all this progress, it has been there right from the beginning and has always fulfilled a leading, innovative and inspirational role. And today, no less impressive Success Stories continue to take place: ***UNESCO is "right there in the field".***"

INTRODUCTION

ASIAN DEVELOPMENT AND SCIENCE AND TECHNOLOGY

STEPHEN HILL,
Director, UNESCO Jakarta Office
Regional Office for Science and
Technology in Southeast Asia

The Asia-Pacific region is highly diverse, ranging from some of the very smallest countries such as Nauru in the Pacific and the Maldives in the Indian Ocean, to the very largest, China and India in East and South East Asia; from the richest, Japan, to the poorest, Cambodia and Bangladesh. There is considerable variation in the level of economic drive across Asia and the Pacific, with the economic miracles of Japan and the "Asian Tigers" contrasting strongly with the highly constrained economic activity of Laos, Burma and peasant sectors across the whole region. Nevertheless, as a region, the Asia-Pacific has become more cohesive, with strongly increasing intra-regional trade and associated political/trade forums - the Asia Pacific Economic Co-operation from, APEC, the Association of South East Asian Nations, ASEAN, and the Pacific Forum, backed by the South Pacific Bureau for Economic Co-operation, SPEC.

The emerging spirit of co-operation offers considerable potential for mutual learning and development assistance as the region crosses into the 21st Century. However, the environmental legacies of overheated and single-mindedly development oriented strategies, the socially distortive strains of inequality in access to development opportunity, and the lack of access to knowledge and technological capability through all sectors behind the leading edges of global participation - together present a series of walls to the sustainability and distribution of regional economic vitality. In particular, there are serious problems with the *linkage* of fast-growing modern sectors with lower technological orders of production through the economy out to village levels, problems that specifically follow from lack of distribution of scientific and technological capacity, and which yield continuing threat to maintenance and growth in sustainable livelihoods. And there are serious problems in the adequacy of human resource capacity to capture global technological flows to national advantage, and to understand and balance development enterprise against sustainable use of physical and biological resources.

In other words, behind the apparent optimistic growth scenarios that Asia presents when compared against Africa or poorer regions of South America, there are serious strains on sustainability, even in the countries that appear so successful - but where, not far below the surface, barriers of serious environmental degradation or continued inequitable access to sustainable livelihoods, could well threaten both regional and global order. At the heart of sustainability in Asia and the Pacific is the knowledge required to participate and to balance growth against human and environmental priorities. Yet, across the whole region, all science and technology organizations and infrastructures are in transition, in most cases from prior relatively unproductive public sector dependency to more application oriented commercial enterprise.

There is not one Asia story however, but a complex web of different science and technology stories, each reflecting differences in national culture, history and current development status. UNESCO is confronting these different cultures of science and technology through broad-ranging programmes that stretch from support of the basic sciences to the assistance of Member States in their policies and planning of science and technology, and which increasingly cross the bridge between sectors, science to culture and education, for example. Whilst movement towards an integrated action strategy is desirable, UNESCO fully realises that implementation of such strategies in any national context must be quite specific to endogenous need.

1. BASIC SCIENCES

PILOT SCALE PRODUCTION OF BIOLOGICAL INSECTICIDES

I. INTRODUCTION

Malaria, the most deadly of all tropical diseases, still kills more than one million people annually world-wide and causes more than 100 million new clinical cases, many of whom are children.

In the southern part of the Islamic Republic of Iran, the southern slopes of Zagros and along the littoral areas of the Persian Gulf and the Sea of Oman, malaria transmission occurs in villages and among nomads who live around villages.

The development of the main vector *Anopheles stephensis* and the exophagic and exophilic tendencies in the secondary vectors, *A. superpictus*, *A. fluviatilis* and *A. dthali* in the hilly area of the Zagros slopes have turned the southern areas into a problematic zone for malaria control. *P. falciparum* and *P. malaria* have been recorded as the most prevalent type agents of malaria in humans prior to implementation of the malaria control programme.

Further information on this project can be obtained from the Project Officer, Edgar DaSilva, Chief, Life Sciences Unit, Division of Basic Sciences, UNESCO, 1 rue Miollis, 75732 Paris, France. Fax: 01 45 68 58 15/16; e-mail: e.dasilva@unesco.org

II. BACKGROUND

Some 2.2 billion people, or 40 percent of the earth's population, are exposed to the risk of malaria in 95 nations in Africa, Asia and Oceania, Latin America and the Caribbean. About 90 percent of people carrying the malaria parasite are found in tropical Africa.

In Iran, there have been small-scale studies, since 1984, on the development of biological insecticides against malaria. The current study has been carried out as a joint project between the Iranian Research Organization for Science and Technology, the United Nations Development Programme (UNDP) and UNESCO.

III. OBJECTIVES

The project objectives were:

a) Establishment of a Pilot Plant.

b) Pilot scale production of *Bacillus thuringiensis Moazami H14*.

c) Application of microbial insecticide in the southern part of Iran.

d) An economic feasibility analysis of how production of *B. thuringiensis Moazami H-14* should be organized in Iran.

IV. SUMMARY OF ACTIVITIES

A. Establishment of a Pilot Plant

The pilot plant facilities have been in full operation since April 1992. During 1990, the Iranian Research Organization for Science and Technology purchased two fermenters, (one of 75 and the other of 750 litre-capacities); centrifuges, and spray dryers. The total contribution from the Iranian Research Organization for Science and Technology under direct costs was US$ 700,000 and Rials 300,000,000. The premises, as well as the necessary funds for raw materials consumption and operational costs, and maintenance of supporting facilities were provided by Iranian Research Organization for Science and Technology.

Financial support from UNDP/UNESCO facilitated the purchase of a 15 litre bio-reactor and biological laminar flow hoods in order to put the biotechnology laboratories into full operation for the pilot scale production of the biological insecticides.

This is the only pilot plant in biotechnology which has been developed and expanded in Iran with UNDP/UNESCO support in collaboration with the Government of the Islamic Republic of Iran. It opened up research facilities to different fields of biotechnology (i.e. agriculture, industry, environment and medicine) for solving problems in Iran's food, energy and health sectors.

National Project Staff with the Director-General of UNESCO in front of equipment purchased with the assistance of UNDP and UNESCO

B. Pilot Scale Production of High Yield Spore-Crystal

In the survey for mosquito larval pathogens conducted in 1986-1988, several hundred spore-forming bacteria were isolated and assayed out of a total of 200 samples collected from the edges of drying rainpools containing mosquito larvae in different parts of the Hormozgan, Baluchistan and Lorestan provinces.

A strain of *B. thuringiensis* was isolated in 1988 from a breeding site of mosquitoes in a pond of approximately 3 x 6.5 m. with a maximum depth of 25 cm. A high concentration of dead and decomposing mosquito larvae was present. The identity of the bacterium was confirmed biochemically and with antiserum donated by Professor H. de Barjac of the Institut Pasteur, Paris, France. This strain was named *B. thuringiensis Moazami H-14* and was used throughout the experiments. In addition, IPS-82, a tentative international standard prepared by the Institut Pasteur was also evaluated.

Production was carried out in a culture medium with the formulation incorporating predominantly locally available substrates such as molasses and cornsteep liquor. These were assessed as media for large-scale production of *B. thuringiensis Moazami H-14.*

Toxicity of the product was determined by bioassay against larvae of *A. stephensis.* A slow release floating formulation was produced for field studies. The granules were evaluated against a population of larval *Anopheles* and *Culex* in Qeshm Island.

During the period from March 1991 to June 1992, the *B. thuringiensis Moazami-H-14* granular formulated preparation against mosquito larvae was field-tested in two villages of the Hormozgan province covering a population of 500 families.

All the private and government water tanks and water reservoirs were treated with *B. thuringiensis Moazami-H-14*. A marked effect of the treatments was noted one hour after application with 80% mortality of the mosquito larvae, 100% mortality was obtained 24 hours after treatment with this insecticidal agent. Granular formulations of *B. thuringiensis Moazami-H-14* have shown excellent activity against malaria vectors. On the basis of these results, the field feasibility study was extended to Qeshm Island from March to July 1993.

V. FINDINGS AND LESSONS LEARNED

In the present investigations, a strain of *B. thuringiensis* obtained from the mosquito breeding site in the Lorestan province area, was used for large-scale production and formulation. The isolated strain was identified by a series of morphological and biochemical tests and confirmed with the antiserum kindly donated by Professor H. de Barjac of the Institut Pasteur, Paris, as mentioned above. Further serotyping indicated that the isolated strain is *B. thuringiensis serotype H-14* which was named *B. thuringiensis Moazami-H-14*.

Various preparations and formulations of *B. thuringiensis Moazami-H-14* have been field tested against *A. stephensis* and *Culex pipiens*. Among the tested formulations, slow release formulation in the form of granules with high toxicity was obtained which showed a strong action against malaria mosquito vectors.

A total of 1.5 tons of *B. thuringiensis Moazami-H-14* was produced and applied in the Hormozgan province. Field work was performed in the Hormozgan province during March 1991 to July 1992 and in Qeshm Island from March to July 1993.

Slow release formulation has provided excellent control (100%) of larvae at the application rates of 1.6 kg/Ha.

In the malaria control programmes carried out in Qeshm Island, about 10 gms slow release formulated product were packed and distributed locally. Social workers trained the women and children of each house in the use of slow release formulated product as soon as the product was made available by the Island's Health Centres.

VI. OUTPUTS

As a result of the project activities, highlights and outputs were as follows:

1. The first Regional Conference on Biotechnology was organized in 1992. During this Conference, more than 56 papers were presented by different experts from all over the world.

2. The agencies and authorities benefiting from the project are:

a) The Ministry of Health and Medical Education;

b) Asian and African countries were there is a high occurrence of malaria with a high mortality rate and which have expressed interest in the bio-insecticidal preparation.

3. The project has been instrumental in establishing an awareness of the impact of biotechnology in the region. Scientists from the Commonwealth of Independent States (former Soviet Union) have been involved in the training activities of the project.

4. A Division of Biotechnology Engineering has been established at Amir Kabir University, Teheran.

5. The Red Crescent Society has provided facilities for the establishment of a multi-purpose pilot plant.

6. The bio-insecticidal product has been approved by the Biological Control Section of WHO and the International Reference Centre of *Bacillus* affiliated to WHO at the Pasteur Institut, Paris, France.

Annex

UNESCO CONSULTANT

John F. Thorley, U.K. Senior Fermentation Processor 8 - 23 June 1992

NATIONAL PROJECT STAFF

Dr N. Moazami, National Project Director
Eng. M. Heydarian, Biotechnology Centre
Mr S. Ghavami, Biotechnology Centre
Mr F. Hormozi, Biotechnology Centre
Mr M. Azin, Biotechnology Centre
Mr S. Mirdamadi, Biotechnology Centre
Dr K. Rostami, Biotechnology Centre
Dr M. Mazaheri, Biotechnology Centre
r M. Kiani, Biotechnology Centre
Ms P. Samadi, Biotechnology Centre
Ms H. Motavaselian, Biotechnology Centre
Ms M. Ramazani, Biotechnology Centre
Ms M. Tabatabai, Biotechnology Centre
Dr R. Movahedzadeh, Biotechnology Centre
Ms F. Shokri, Biotechnology Centre
Mr F. Esfandyari, Biotechnology Centre

LIST OF EQUIPMENT SUPPLIED

Non-expendable Equipment

1 6-Channel Dot Printer
1 PH Measuring Amplifier Digit Display
1 Comb. Measuring Amplifier
1 P02 Measuring Amplifier Digit Display
1 Semi-automatic Sterilization Unit
2 Spiral Reflux Cooler
1 Bioreactor 15 Ltr. W Control & Measuring System
1 Laminar Flow Clean Bench
1 IBM PS/VP W. 14Ó SVGA Colour Monitor, Scanjet, HP Deskjet 500 & Acc.
1 Canon Copier CLC10
Electrophoresis Equipment

Expendable Equipment

- Manual of Industrial
- Microbiology & Biotechnology
-Manual of Clinical Microbiology
-Manual of Clinical Immunology
- Phosphate Metabolism in Micro-organisms
- Basic Biotechnology
-Biotechnology: A Textbook of Industrial Microbiology

STUDY TOURS

Name	Field	Duration/Year	Country/Host Institute
Tabatabai Adnani, Mina	Production Techniques	2 weeks/1992	France/Institut Pasteur
Samadi, Pershia	Production Techniques	2 weeks/1992	France/Institut Pasteur
Moazami, Nasrin	Maintenance Schemes	2 weeks/1991	Germany/University of Bonn
Rostami, Khosro	Biotechnological Research	3 months/1994	Canada/University of Waterloo

INTERNATIONAL COLLATION OF TRADITIONAL AND FOLK MEDICINE

For centuries, widespread folk and traditional medicines have been used for the treatment of various kinds of diseases, especially in the oriental regions of the world. This more often resulted from observations by local people that certain plants have certain effects on certain illnesses; people found that in different countries, the same plant could be used to treat different diseases, which implies that extracts from different parts of the plant, *i.e.* root, stem, leaves, skin or seeds, could have different medicinal functions. Even more interesting, however, was the fact that many plants are used in the different countries to treat similar diseases; these experiences and practices tend to indicate that the plants must indeed have medicinal properties.

But the reasons "why" remain widely unknown, and hence this has encouraged scientists to explore the phenomena further through a series of modern scientific means. For some plants, research has been undertaken; however, for most plants, nothing has been done. In order to identify the active principles of plants and discover their mechanism of action, researchers need a basic instrument such as a catalogue of traditional and folk medicines. A book which systematically summarizes the uses of folk and traditional medicines, indicates the differences and similarities in their utilization, as well as a collection of papers of scientific research on the nature of the existing medicines would obviously promote the comprehension of folk and traditional medicines throughout the world, and guide the further development of new drugs and medicines

The idea of organizing such a project was first raised by Professor Byung Hoon Han, the National Point-Contact Representative of Republic of Korea for the UNESCO Regional Network for the Chemistry of Natural Products in Southeast Asia at the 1990 Board Meeting of the Network. This idea was strongly supported

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Further information on the activities of this project may be obtained from the Project Officer, Fumin Zhang, UNESCO Jakarta Office, UN Building, 2nd Floor, Jalam Thamrin 14, Tromolpos 1273/JKT, Jakarta 10012, Indonesia. Fax: +(62-21) 315 0382

by UNESCO and all the board members. There were, however, no funds available at that time. Professor Han sought support from Korea and eventually the Korean Ministry of Education provided UNESCO with a Funds-in-Trust contribution (amounting to US$20,000 per year since 1993) to support the implementation of this project within the framework of activities of the UNESCO Regional Network for the Chemistry of Natural Products in Southeast Asia. A part of the funds also came from UNESCO's Regular Programme budget.

The project is implemented by the UNESCO Jakarta Office. A collaborative group, which was formed in early 1993 and composed of editorial and managing board members from China, Hong Kong, Japan and the Republic of Korea, has been working on the project. Traditional and folk medicines were collected and catalogued in China, Hong-Kong, Japan and the Republic of Korea.

Volume I of the catalogue published in 1996, (*cf* pp 12 and 13) presents 200 plant species classified by plant family and by individual species within a plant family. For each of them the book gives information on the botanical and local names of the various species, their similarities and differences, the use made of fruit, leaf and root, special methods of processing involved, apparent folk medicinal efficacy in each country, possible contra-indications and side effects, scientific research (in chemistry and pharmacology) and a list of related literature. It aims at assisting phytochemists to identify the plant species which most likely contain bioactive components of interest and which may warrant further investigation.

Volume II has also been completed and is currently being published. Volume III (as well as a series of publications on traditional medicines in tropical and oceanic areas) is in preparation. Both Volumes II and III are a continuation of Volume I and will each include 200 plant species. In order to carry out the work on Volume III, the collaborative group will mainly rely on the royalties from sales of the previous volumes.

Overall, the catalogue is expected to provide guidance to the scientists working in the fields of pharmacology, phytochemistry and traditional medicines in finding new drugs and mechanisms against illnesses such as cancers and AIDS.

From the implementation of the project, we can note the following:

- As a regional co-operative project, it is jointly supported by the Member States concerned and UNESCO; the project is expected to become self-supportive through the income received from the royalties (12%) paid by the Publishing Company;

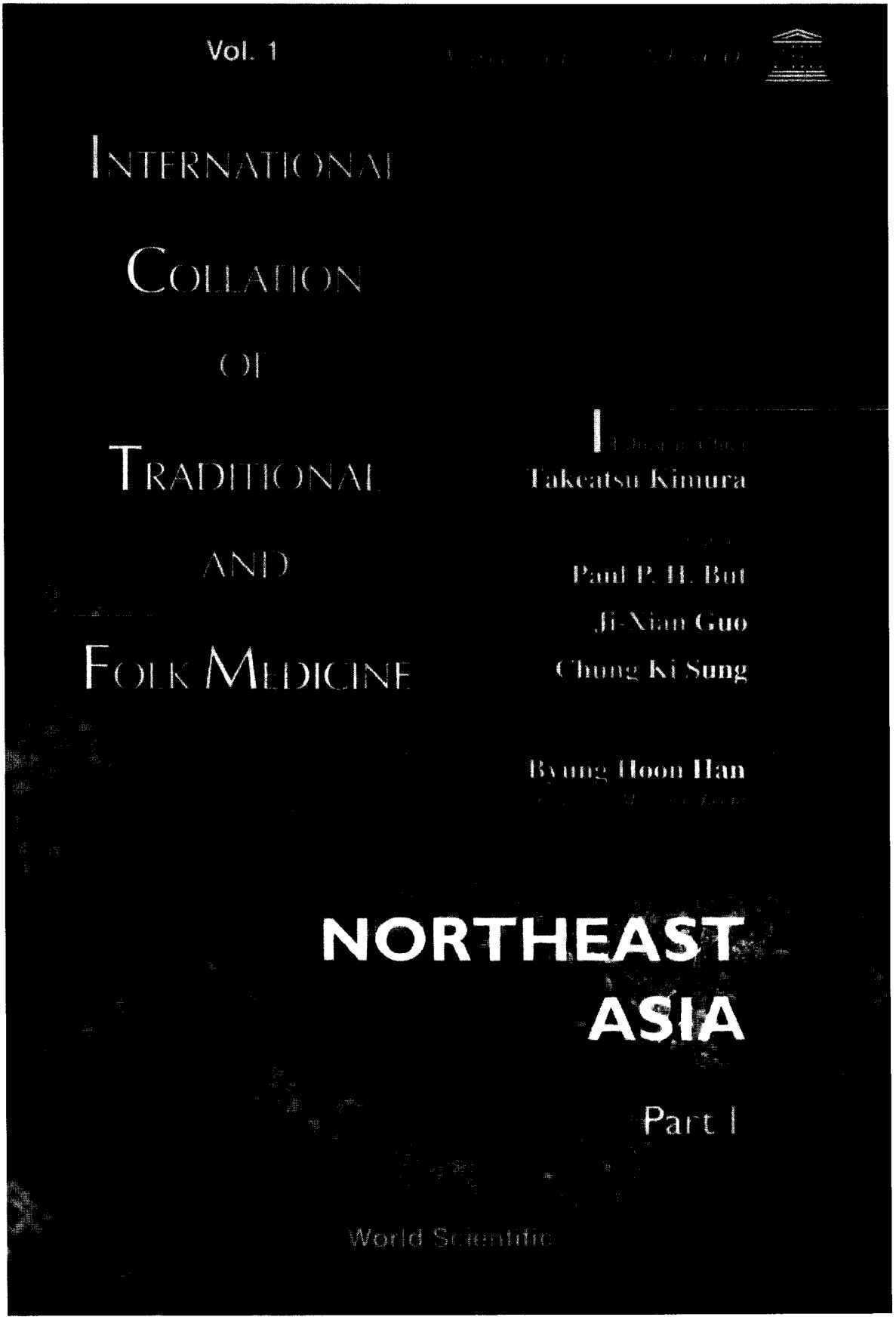
- Its implementation has created a very co-operative spirit among the Member States involved;

- Korean scientists have requested that the project to be extended from 3 years to 5 years and expanded from three to five volumes. The publications will also cover animal and mineral resources, besides plant resources, and include fungi, algae, etc. s well. This request has been gladly accepted by all the members of both editorial and managing boards of the project. Thus, Volume IV of "International Collation of Traditional and Folk Medicines in Northeast Asia",

including medicines derived from sources other than plants, such as algae, fungi and animals will be prepared.

- Volume V will expand this work to the tropical areas of Asia, especially including those medicines which are traditionally used in tropical regions .

Achyranthes aspera L.



EXTRACT FROM VOLUME I OF THE
INTERNATIONAL COLLATION OF TRADITIONAL AND FOLK MEDICINE

EXTRACT FROM VOLUME I

Achyranthes aspera L. (Amaranthaceae)

Tu-niu-xi (C), Do-kou-cho (H), Indo-inokozuchi **(J)**

Root

Local Drug Name: Dao-kou-cao (C), To-ngau-chui (H).
Processing: Herb: Dry under the sun (C). Root: Use in fresh (C),
Method of Administration: Oral (decoction: C, H).
Folk Medicinal Uses:

1) Fever due to common cold (C, H).
2) Headache due to summer-heat (C).
3) Malaria (C, H).
4) Dysentery (C, H).
5) Urethral calculus (C, H).
6) Chronic nephritis (C, H).
7) Tonsillitis, mumps (H).
8) Rheumatoid arthritis (H).
9) Traumatic injury (H).
10) Nephritic edema (H).
11) Dysmenorrhea (H).
12) Amenorrhea (H).

Scientific Researche:

Chemistry
1) Saponins: asperasaponin A, B [1].
2) Alkaloids: achyanthin [2].
3) Aliphalic ketones: 36,47-dihydroxyhentacontan-4~one [31].
4) Steroids: ecdysterone [41].

Pharmacology
1) Protein assimilation (cedysterone) [5].
2) Raising blood pressure, stimulating respiration (alkaloids) [6].
3) Antispasmodic effect on intestine (alkaloids) [6].
4) Antiduretic effect (alkaloids) [6].
5) Contraceptive and absortifacient effect [7, 8].
6) Antifungal effect (volatile oil) [9].

Literature:

[1] Hariharan, V. et al.:*Phytochem.* **1970** ,9,409.
[2] Ratra, P. S.: *Curr. Treuds Life Sci* **1979**, 4, 81.
[3] Mista, T. N. et al.: *Phytochem.* **1991,** 30, 2076.
[4] Banerji, A. et al.: *ibid,* **1971,** 10, 2225.
[5] Otaka, T. et al.: *Chem. Pharm. Bull.* **1968,** 16, 2426; **1969,** 17, 1352, 1883.
[6] Kapoor, V. K. et al.:*Ind. J. Pharm.* **1967,** 29, 285.
[7] Wadhwa, V. et al.:*Planta Med.,* **1986,**231.
[81 Pakrashi, A. et al.: *Ind. J. Exp. Biol.* **1977,** 15, 856.
[9] Misra, T. N. et al.: *Phytochem.* **1992,** 31, 181 1,

[J.X. Guo]

C: China, H: Hong Kong, J: Japan, K: Korea.

ADVANCED STUDIES IN BIOCHEMICAL ENGINEERING AND BIOTECHNOLOGY AT THE INDIAN INSTITUTE OF TECHNOLOGY

I. INTRODUCTION

Biochemical engineering and biotechnology deal with the application of biological, physical, chemical and engineering principles to the processing of materials by biological agents in order to provide useful products and services. The biological agents include microbial, plant and animal cells, cell organelles and enzymes produced by these cells. An essential feature of this discipline is an integrated study of a number of basic and engineering sciences.

Biotechnology has generated several techniques that hold great promise for application in the chemical process industries, food pharmaceuticals, health, agriculture, environment and energy. The spectrum of application is extremely broad. Engineering these technologies has created novel industries which rely on renewable and inexpensive resources, operate near ambient conditions, consume little energy and provide cleaner environment.

The Government of India has recognized the need to develop home grown technologies and to transfer and adapt them to Indian bioprocess industries such as health care, energy, agriculture etc. This activity requires a critical mass of biotechnologists and bioprocess engineers. In 1989, a project was set up at Delhi's Indian Institute of Technology which, along with five other such institutes, was created as a Centre of Excellence for higher education with contributions from the Government and UNDP and with UNESCO as the executing agency.

II. OBJECTIVES AND RESULTS

Objective 1: To strengthen research and development capabilities of Indian Institute of Technology, Delhi, in biochemical engineering and biotechnology so that it can undertake development oriented research programmes and technology transfer and adaptation.

Further information on these activities may be obtained from the Director, UNESCO New Delhi Office, 8 Poorvi Marg Vasant Vishar, 11057 New Delhi, India (Fax: + 91 11 6873351; e-mail uhndl@unesco.org)

- The **Department of Biochemical Engineering and Biotechnology** was inaugurated in 1993. It had begun as a Biochemical Engineering and Research Centre in 1976, was renamed Department of Biochemical Engineering and Biotechnology and elevated to the status of a full fledged department only three years ago.

- The Department of Biochemical Engineering and Biotechnology has been running a five year integrated Master of Technology programme in Biochemical Engineering and Biotechnology (since 1989) and offers programmes for Ph.D and post-doctoral research. Its earlier three-semester Master of Technology programme was phased out in December 1992.

- The Department is closely interacting with industry, research organizations, user agencies in the form of training students for industrial work, joint research projects, sponsored and consultancy services; it conducts short-term courses, workshops, seminars and symposia. The academic programme for manpower training in this field has developed into a model of its kind.

- The Department maintains its own documentation unit. It houses books, dissertations and reports of the Department, technical reports, user manuals and audio-visual aids and duplicating facilities.

- A Biotechnology Information Data Bank has been set up.

- As executing agency, UNESCO helped in setting up the Centre by procuring sophisticated equipment as well as over a hundred highly specialised books. This was part of the overall UNDP contribution of US$1.2 million towards the project. The government of India's contribution was Rs 12.2 million (US$3.5 million).

- The major focus of research activities has been identified as microbial and enzyme engineering and bioseparation to enable an effective integration of new biology with engineering sciences. The Department boasts a committed faculty with research interests in bioprocess and enzyme engineering and metabolic regulation, molecular biology and recombinant DNA technology.

- Practical work during the last semester of school is designed to develop students' ability to apply the knowledge of biochemical engineering they have acquired to the problems of industry. Their work at the school is expected to accelerate professional development.

- The Indian Institute of Technology has established a Foundation for Innovation and Technology Transfer to speed up the growth of industry-institute interaction. Its terms of reference are to add commercial value to academic knowledge and to market the infrastructural and intellectual resources of the Institute. The Department of Biochemical Engineering and Biotechnology is actively associated with this Foundation for the commercialisation of biotechnology.

Objective 2: To meet the expanding and long term requirement for qualified and trained human resources in biotechnology and biochemical engineering by the year 2000.

- The Department of Biochemical Engineering and Biotechnology has created excellent facilities to conduct research in frontier areas; hi-tech equipment has helped to concentrate on different fields such as cell culture, microbiology, DNA technology, downstream processing etc.

- The Master of Technology programme equips students with the ability to innovate, analyse, design and operate processes in which biochemical catalysis has a fundamental and irreplaceable role.

- Graduates of the Institute are expected to provide leadership to bioprocess industry in the country.

- Research activities are planned in process engineering aspects of animal and plant cell culture.

- Five senior faculty members of the Department of Biochemical Engineering have gone on study tours to some of the best institutes in different parts of the world. These tours were very beneficial in helping to identify priority research areas and decide the kind of infrastructure that could be developed at Indian Institute of Technology.

- Although facilities need to be constantly updated and expanded, the Department of Biochemical Engineering and Biotechnology has the potential, with what is already in place and with faculty support, to help neighbouring Asian countries.

III. HIGHLIGHTS

The conclusion of this UNESCO-implemented project leaves the Department of Biochemical Engineering and Biotechnology at the Indian Institute of Technology, Delhi, well equipped, in terms of trained staff and laboratory apparatus, to conduct degree courses and research at internationally accepted standards. The training provided by this Department renders its graduates some of the most sought after young professionals by private sector industries in India and overseas. Most significantly, this project anticipated by several years the rapid industrial expansion which is now taking place in India, and is producing some of the highly-trained biotechnologists required to service the new industries.

UNESCO-UNIVERSITY FOUNDATION COURSE IN MODERN PHYSICS

One of the major obstacles facing university science teaching in the developing world has been the dearth of text-books which relate to the environment and day-to-day experiences of undergraduates in those countries. The few available texts have in the main been those produced immediately after the colonial era; they tended to be drab, completely outdated and held little appeal for students who learned from the media of the dramatic developments in the fields of electronics and the information technologies. The sternest indictment of these texts has been however that they rarely provoked independent, creative thinking and almost never were apt to prepare students for employment in industry or agriculture. It was as a response to this situation that the Division of Basic Sciences initiated a project to develop ***UNESCO University Foundation Courses in the Modern Sciences.*** *It was decided that this project would be commenced by selecting small groups of scientists from each region of the world to develop their own courses in modern physics, chemistry, biology and mathematics in order to better equip graduates for employment in industry. The courses were intended to give the first year undergraduate a bird's eye-view of the discipline -superficial yet extensive - so that he/she could make enlightened choices regarding areas for study in the ensuing undergraduate years. The courses would also serve to instil an appreciation of the discipline in students who would not be reading it beyond their first year in the university. The rationale was that for instance, a mother would give a better education to her child if she understood the rudiments of biology and chemistry. The courses were to illustrate scientific concepts with examples drawn from the students' home region and would, wherever possible, attempt to 'bring science out of the class room and into the real world.*

The production of the foundation course in physics was the first to be undertaken by UNESCO New Delhi Office. A group of four experienced physics teachers from the University of Poona in Maharashtra State in India were mobilized to compose the text. Besides the group's teaching experience, a factor which influenced the selection of Poona for this assignment was the existence on its campus, of a multi-medium education centre which routinely produced video clips and computer-aided teaching materials.

Over a two-year period, the Poona Group composed a 350-page core unit containing what was perceived as essential physics knowledge for first year undergraduates. Specialized topics are to be presented later in much smaller, optional units. The core text attempts primarily to convey concepts and principles in an accessible and attractive style without overburdening them with mathematical detail. It cites examples which are likely to be familiar to students in South Asia and frequently makes reference to the everyday applications of physical principles, particularly in industrial processes. A video-package of laboratory experiment demonstrations and some computer simulations of experiments were also developed.

An international group of physicists met in Beijing, China, in August, 1994, to review progress on the Physics Foundation Courses being developed by UNESCO in the various regions of the world. The one co-ordinated by the UNESCO New Delhi Office was found to have progressed farthest; the Poona Group was the only one with a completed 'core' unit. After the review meeting the Poona group began revising the draft text and are currently inserting references to the corresponding laboratory exercises. Tutorials are also being included at the ends of chapters. A Laboratory Handbook and Teachers' Guide will accompany the text. The experiments described in the Laboratory Handbook will be complete with anticipated approximate readings. The video clips and computer simulated experiments are expected to be particularly helpful in institutions lacking adequate laboratory facilities.

The multi-medium Physics Foundation Course is expected to be ready for teaching trials by January 1997. The trials will be conducted in two South Asian countries and the experience of teachers and students will be evaluated before the course is finally made available to universities in the Region. The multi-medium ***UNESCO University Foundation Course in Modern Physics*** *is expected to be the first of a series which will revolutionise the teaching of university level science in South Asia. In a region which includes five Least Developed Countries, the lack of standard science text-books is commonplace and the teachers' knowledge is often the only, though frequently outdated, repository of scientific information. The availability of such a package represents a leap into the world of information technology-based science education which these Member States would not otherwise have been able to acquire in the foreseeable future*

Further information on the this project may be obtained from the Director, UNESCO New Delhi Office, 8 Poorvi Marg Vasant Vishar, 11057 New Delhi, India (Fax: + 91 11 6873351; e-mail UHNDL@unesco.org

COST EFFECTIVE SCIENCE EDUCATION IN DEVELOPING COUNTRIES

I. INTRODUCTION

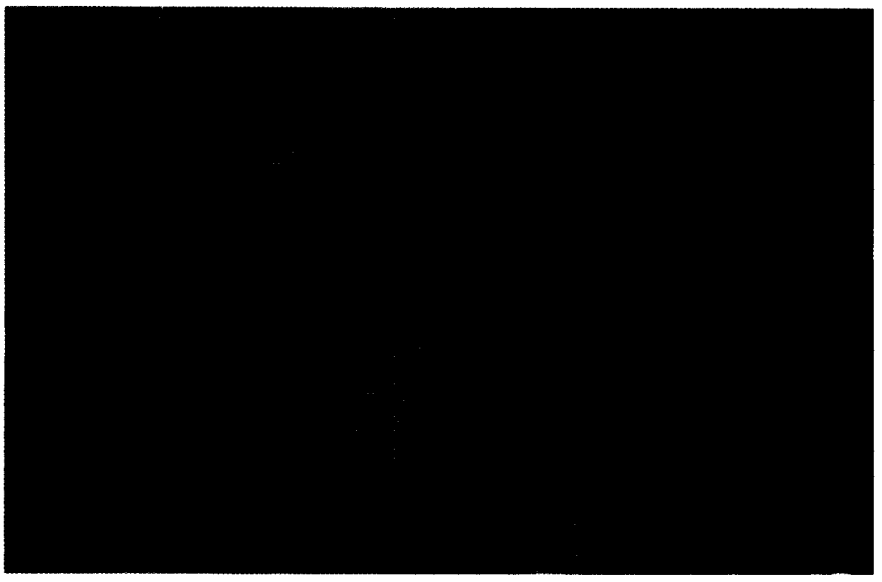
Science education in many developing countries has been hard hit because of declining facilities in laboratories. The reasons for this are twofold: (a) a steady rise in the cost of equipment and chemicals and (b) poor maintenance of laboratory instruments. Equipment for the teaching of science poses problems for the simple reason that too few educators see its development as an essential part of curriculum development as a whole. Such neglect not only obstructs the learning of manipulative skills, it also leads to sub-standard laboratory work and risks producing poorly trained scientists for research, training and industry.

One of the keys to upgrading science education is the availability of simple, efficient and affordable low cost equipment. Commercial instruments are not only expensive, they are often designed for the multipurpose needs of industry and research. The needs of a student, however, can be met with a far simpler type of fabrication. Luckily, modern technology, particularly in electronics and materials, offers many products which as well as being cheap, are versatile, durable and reliable. These are now made or available in developing countries and can be used as building blocks for the design of simple equipment.

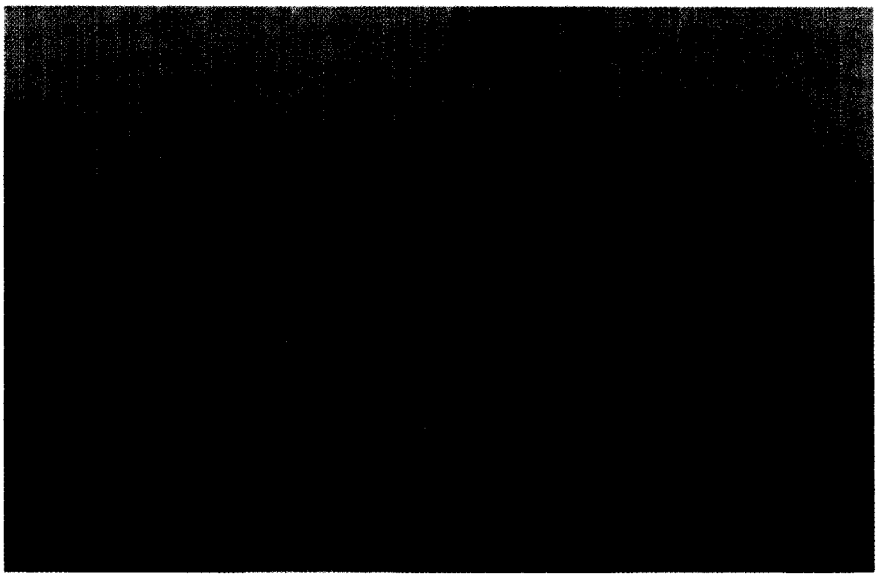
However, technology must go hand in hand with methodology if low cost equipment (i.e., equipment low in cost but sound in quality) is to become a means for improving science education. Teachers and students need to be involved in the design, fabrication and the testing of prototypes.

Further information on these activities may be obtained from the Director, UNESCO New Delhi Office, 8 Poorvi Marg Vasant Vishar, 11057 New Delhi, India (Fax: + 91 11 6873351; e-mail: uhndl@unesco.org)

This is what led UNESCO New Delhi, in association with the Committee on the Teaching of Chemistry of the International Union of Pure and Applied Chemistry, to find solutions to the problem using locally available materials and electronic components. A project was initiated in 1979 at the Department of Chemistry in Delhi University for the manufacture of such equipment.



Colorimeter



Spectrometer

II. OBJECTIVES AND RESULTS

Objective 1: The production of reliable, low cost, equipment that is easy to make and maintain and to find experiments compatible with it.

The Department of Chemistry in New Delhi has manufactured the following equipment: pH meter; conductance meter, colorimeter, polarimeter, thermometer, polarograph, nephelometer, reflectance meter, oxygen meter.

A low-cost **interface package** has been developed for coupling the equipment to either a personal computer or to a microprocessor. The package is designed to provide training in modern methods of data-acquisition and data-processing.

A **simulation package** for potentiometry, colorimetry and conductometry has been designed for Computer Assisted Learning.

Carbon rods have been used to construct very low cost electrodes and conductance cells; a glass electrode from soft glass test tube and a variety of simple ion-selective electrodes and biosensors are being investigated to extend the versatility of the pH meter.

Accessories such as magnetic stirrer, timer, thermostat, minicentrifuge have been designed to complement the equipment.

Objective 2. To facilitate maintenance in student laboratories

A test package (continuity tester, transistor tester, in circuit (I.C.) tester, AVO[1] meter, AVO source) has been made using similar circuits as the main equipment to ensure compatibility of cost and performance.

Objective 3. Find experiments compatible with the equipment.

Suitable experiments have been identified and standardized. They blend traditional and applied science. Agricultural, biochemical, clinical, environmental and industrial applications are highlighted.

The Delhi University Group, known as the Edutronics Group, has published a monograph entitled **"Locally Produced Low Cost Equipment for Teaching of Chemistry".** It describes step by step the fabrication, use and maintenance of the equipment developed by them.

Objective 4: Train chemistry teachers in design and manufacture

Over 25 hands-on workshops have been held throughout the world, particularly in the developing countries: dozens have been held in India and selected teachers trained. A textbook entitled **"Low Cost Chemical Instrumentation"** has been published. These workshops have also led to the formation in nine countries of core groups which are adapting the UNESCO approach to suit their local needs.

[1] AVO is a trademark of AVO International (Amps, Volts and Ohms)

An international network for locally roduced low cost equipment has been created with UNESCO's assistance. It consists of independent groups around the world which operate alone similar lines.

Objective 5: Dissemination

This has been achieved through the holding of conferences and seminars.

Objective 6: Social relevance

A notable feature of the Indian programme is the involvement of 'handicapped' persons and school dropouts in the manufacturing process and of students and teachers in quality control.

A manufacturing/marketing unit has been set up which has supplied over 3000 pieces of equipment to student laboratories.

III. HIGHLIGHTS

a) The setting up of a 'low overhead' production unit managed by socially disadvantaged persons such as disabled youths and school dropouts, whose initial remuneration demands were more modest and by purchasing low cost raw materials. This unit is supplying locally produced low cost equipment items at prices only 10-15% above the cost of components; the items are 10-50 fold cheaper than commercially made equipment. It also usefully employed persons who may have otherwise had difficulty in finding gainful employment.

b) A publication unit managed by women. This unit provides hands-on training in desk to publishing empowering young women to become self employed. Their training involves the preparation of educational material which are then sold at nominal prices. For example, the American Chemical Society publication "Modern Experiments for Introduction Chemistry", originally priced at US$18, has been reprinted with permission from the American Chemical Society for US$2.

c) Low cost equipment has other uses as well. These include small scale and cottage industries, rural health centres, soil testing, environmental monitoring etc. For example, a hospital-based evaluation of the Edutronics colorimeter carried out over a 3-month period, has shown the instrument to be satisfactory for estimations of routine biochemical parameters such as albumin, bilirubin, cholesterol, glucose, haemoglobin, total protein and urea.

d) Preliminary tests have also given encouraging results for soil analysis and pollution monitoring.

e) fabrication and trouble shooting of low cost equipment has been found to be useful in training technicians to repair corresponding chemical equipment. A one-week trial workshop in Delhi was successful in servicing idle commercial equipment worth nearly Rs 100,000.

f) the coupling of social and educational objectives is not only one of the more gratifying features of the Delhi University Project; its benefits can be enjoyed by both individuals and institutions.

2. *ENGINEERING AND TECHNOLOGY*

STRENGTHENING TECHNICAL, AGRICULTURAL AND VOCATIONAL EDUCATION

INTERNATIONAL CO-OPERATION FOR
TECHNICAL, AGRICULTURAL AND VOCATIONAL
EDUCATION DEVELOPMENT IN THE UNION OF MYANMAR
IN CO-OPERATTON WITH UNDP AND THE ORGANIZATION
OF PETROLEUM EXPORTING COUNTRIES (OPEC)

I. INTRODUCTION

Although the Union of Myanmar, previously the Union of Burma, is basically an agricultural country with a diverse production of agricultural products, it has a long history of technical education. Its first technical institute was established as early as 1904, while the country, which gained independence in 1948, was still under British rule. But it was following the Second World War, when the Union of Myanmar had to concentrate its efforts on the rehabilitation of the country, that the education system first introduced a policy of technical education in line with social and development needs. Until then, the educational system had encouraged its youth to pursue an education which led to clerical, junior administrative positions and other academic professions within the civil service. Technicians and skilled workers required to man the existing industrial establishments were, to a great extent, brought in from India. Thus, the country found itself short of skilled workers, craftsmen, middle-level technicians and engineers and this, once recognized, led to a complete change in the technical education policy of the country.

This story was contributed by C. S. Hakansson, Chief, Asia and Pacific Operational Acitivities Unit (retired). Further information on the project may be obtained from the Project Officer, Vefa Moustafaev, Division for Policy Analysis and Operations, Science Sector, UNESCO, 1 rue Miollis, 75732 Paris, France. Fax: + 33 1 45 68 5824; e-mail: v.moustafaev@unesco.org

In the 1950's only the artisan training centres, a technical institute at Insein and a faculty of engineering at the University of Yangon under the Ministry of Education were responding to the manpower needs of the country. Even then, teaching staff for the institutions had to be brought in from abroad on a contract basis. The Government of the Union of Myanmar recognized the need to develop and strengthen engineering and technical education at all levels to enable the country to develop and benefit from its rich natural resources and to accelerate its economic and social development in general. However, the high cost of education in general, and of technical and agricultural education in particular, limited the Government's possibilities to equip all the various institutes and schools to meet the needs of a rapidly changing and developing industrial sector of the country. Teachers and instructors must be continuously trained and upgraded in new technologies in industrial production and processes. Also, equipment for such new technologies must also be provided to at least keep abreast, if not ahead, of the industry.

In 1972, therefore, the Department of Technical, Agricultural and Vocational Education was established and all technical, agricultural and vocational education in Myanmar comes under the responsibility of this Department, which is one of the seven departments of the Ministry of Education. It is responsible for the education and training of technicians, skilled and semi-skilled workers and has developed into an active and still expanding department with no less than 70 Institutes and schools under its responsibility. At present there are 11 government technical institutes, 7 state agricultural institutes, 16 technical high schools, 10 agricultural high schools, 3 commercial schools, 2 machinery repair and maintenance schools, 11 handicraft schools, 6 schools for home sciences, 2 fishery schools, 1 industrial training centre and 1 technical teachers training institute.

To further assist the youth of the country to obtain technical education and training, the Department now offers, in addition to the full time educational institutions mentioned above, special courses in different technical trades as follows:

(a) Engineering technology evening classes of three years duration at selected government technical institutes and technical high schools;

(b) Evening trade courses of three months duration at selected government technical institutes and technical high schools;

(c) Computer operator courses.

II. BACKGROUND

Following a review of the Education Sector carried out in July/August 1989 by UNESCO and UNDP and based on the broad educational objectives of the Government, UNESCO, through UNDP and the Fund for International Development of the Organization of Petroleum Exporting Countries was requested to assist the Governnent of the Union of Myanmar in upgrading the teaching standards and equipment of 21 of the institutes and schools under the Department of Technical, Agricultural and Vocational Education.

These broad educational objectives were:

a) to lay down a firm foundation for basic education.
b) to promote basic education to international standards.
c) to make basic education accessible to all citizens.
d) to develop an advanced educational system including science and technology.
e) to train technicians and skilled workers.
f) to develop an education system conducive to production.
g) to strive for the perpetuation and development of national and indigenous literature.
h) to train workers for all-round development.
i) to provide opportunities for attaining higher education.

It became apparent that it was not only necessary to strengthen the existing technical courses, but also to introduce new subjects and technologies at the government technical institutes and the technical and agricultural high schools to meet the demand for skilled middle-level technical and scientific manpower (in areas such as computer controlled machine tools, electronics, electricity, plastics technology, chemical and food technology, communications, civil engineering, mining engineering, agricultural mechanization, animal husbandry and veterinary science) and to raise the level of qualifications of the students graduating as craftsmen and tradesmen.

III. THE PROJECT

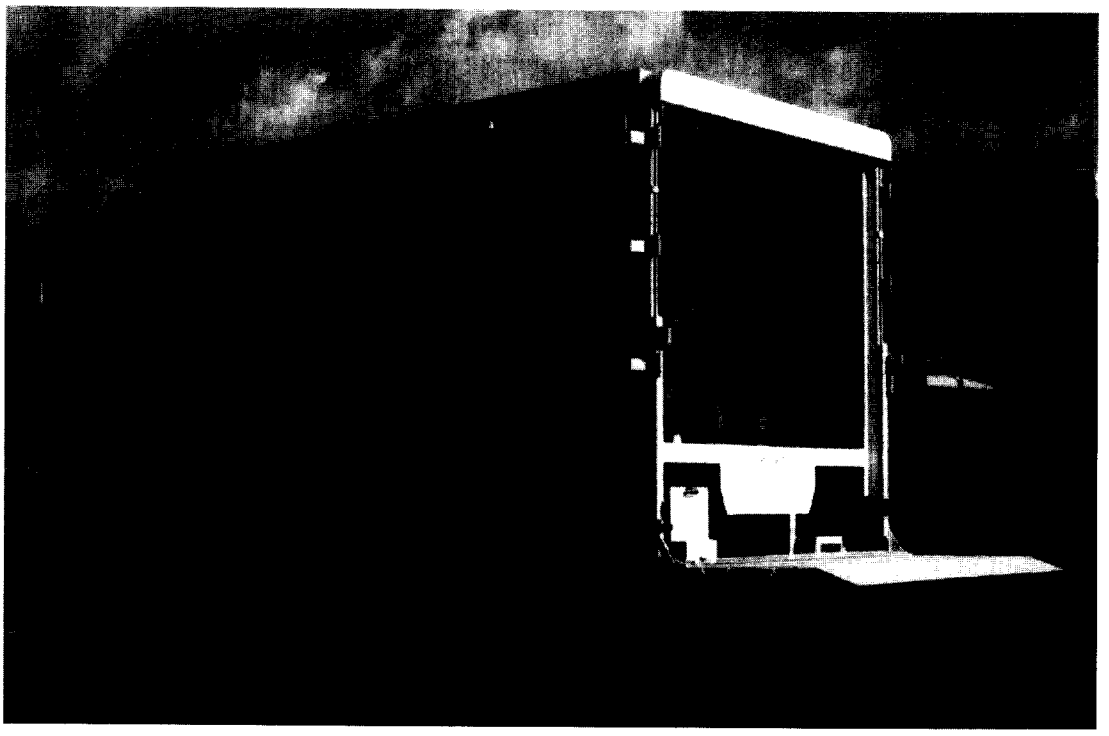
Twenty one institutions, including technical and agricultural institutes and high schools, were selected to participate in the Project on "Technical, Agricultural and vocational Education Development in the Union of Myanmar". Many of these institutes and schools were established in the early 1950's and 1960's, shortly after the country's independence. In many instances, practical training was still undertaken with the same equipment initially provided, but due to difficulties in obtaining spare parts and accessories for much of the equipment, close to 40 years old, many machines were unserviceable and the practical aspects of training and education were seriously affected. Likewise the efforts to up-grade the skills of the teaching staff could not be implemented satisfactorily. Even the better equipped government technical institutes were seriously lacking in modern teaching and training equipment in the new and emerging technologies.

As a consequence, the technical and vocational education system could not produce adequately trained man-power, which, in turn, had serious repercussions on the implementation of the Government's policy of developing the industrial sector of the economy.

The project was scheduled to be implemented over a period of three years (1990-1993); the final total amount provided by UNDP through UNESCO was US $ 826,141 while the OPEC Loan Agreement was US $ 7,300,000. Over this period, the funds earmarked by the Organization of Petroleum Exporting Countries for the various activity areas were adjusted from time to time to meet the needs of the Department as closely as possible, while remaining within the set framework of US $ 7.3 million. With a project of this magnitude and with so many institutions and subjects involved, flexibility, from the UNDP/UNESCO side, the loan agency and the recipient department, was essential for smooth and timely implementation

In line with the general policy of international donor agencies to co-ordinate development assistance to one and the same institution, it was proposed by the Department of Technical, Agricultural and Vocational Education to co-operate with the United Nations Development Programme in Myanmar for implementation of the project. Over the three-year

project period, the UNDP grant increased from US$626,900 to US $ 826,141 to include mobile training facilities used in remote border areas and parts of the country where technical schools are not available.



The specially designed truck to transport instructors and equipment for the mobile training system offered by the Department of Technical, Agricultural and Vocational Education. (The photo was taken at the Coach Builder in Leicester, UK)

The project had three immediate objectives which can be summarized as follows:

1. Development of existing curricula relevant to modern technical, agricultural and vocational education and new technologies to meet the demand of the industrial sector and public services.
2. Upgrade and update the technical skills and knowledge of the technical staff and instructors of Institutes and Schools under the Department of Technical, Agricultural and Vocational Education.

3. Selection, installation, commissioning of new machine tools and laboratory equipment needed for new subjects and technologies, introduced into the technical, agricultural and vocational education programme for Myanmar.

The long-term development objectives of the project stated, *inter alia:*

- To improve the quality of instruction in technical, agricultural and vocational subjects at the Government Technical Institutes, State Agricultural Institutes, Technical High Schools and the Technical Teachers Training Institute.

- To contribute towards the economic development of the country through the appropriate training and education of skilled technicians and craftsmen for the existing industries and for future industrial development.

Equipment:

Based on a request from the Government and a detailed report prepared with the assistance of UNESCO outlining the equipment requirements for the 21 institutes and schools included in the project, the contribution of the Organization of Petroleum Exporting Countries reserved for the equipment component of the project, was designed. The 21 institutions involved were: the 11 government technical institutes, 2 state agricultural institutes, 7 technical high schools and the technical teachers training institute. Although only 21 of the 70 institutes and schools were the primary beneficiaries of project, most of the other institutes and schools also benefited indirectly from the project through transfer of certain old, but operational, equipment and through the availability of better trained teachers and instructors. To best meet the needs of the Department of Technical, Agricultural and Vocational Education, it was agreed that the combined project would support the following main areas:

- Renovation work to existing educational facilities and buildings.

- Workshop and laboratory equipment and materials for technical, agricultural and vocational education and training.

- Didactic material consisting of technical books and literature, audio-visual materials and equipment for classroom use and teacher training.

- Project supervision.

Training:

The training component in a project involving such large quantities of sophisticated machine tools and laboratory equipment is vital, as equipment alone cannot, in itself, guarantee an improvement in the quality of teaching and training.

- Short-term technical expertise was be recruited for the various new technologies which were introduced into the teaching process. In all, six short-term consultants for a total period of 22 man-months, including a part-time Chief Technical Adviser, assisted the Department of Technical, Agricultural and Vocational Education.

- Two high-level study tours for a total of 4 man-months and 78 man-months of individual fellowships for teachers and instructors from various institutes and schools were also provided. This technical assistance programme ensured that the large quantities of workshop machine tools and laboratory equipment provided to the Department of Technical, Agricultural and Vocational Education through the OPEC Fund were properly utilized and maintained.

- In addition to the overseas training of 26 senior and junior staff members, in-country training of 120 teachers and instructors were carried out by the UNESCO consultants and returning fellows.

Project Implementation Unit:

A primary factor for the successful implementation of the project and which probably contributed more than any other single factor is that it was decided at the onset of the project to establish a project implementation unit. The Unit was a permanent committee; its chairman was the National Project Director and the members consisted of various national specialists in technical, agricultural and vocational education as well as specialists in procurement, data processing and school architecture. The Director-General of the Department of Technical, Agricultural and Vocational Education and the UNESCO Chief Technical Adviser were also members.

The composition of the Project Implementation Unit varied somewhat during the period of project implementation due to transfers, promotions and retirements. However, efforts were always made to ensure that competent and dedicated specialists were included in the project implementation unit to facilitate a timely and smooth implementation of the project.

The establishment of a Project Implementation Unit was considered a necessity in view of the fact that the project had a part-time Chief Technical Adviser who visited Yangon only twice a year, or for a total of 15 months. This arrangement worked well and it is felt that it has been cost effective.

III. RESULTS

In broad terms, upon completion of the project, the technical core staff and workshop instructors of the country's 11 government technical institutes were trained in the use and operation of newly acquired equipment and teaching aids. Their technical skills and knowledge were broadened; new technologies were introduced and existing ones strengthened. In particular, the courses in electrical power, electronics and communications, plastic technology, mechanical power, machine tool engineering, and mining engineering received new modern equipment for education and training, to meet the demand for appropriately trained and qualified technicians.

Two of the country's 7 agricultural institutes received new and improved mechanization systems for rice production, and improved farm implements, and new laboratory equipment for animal husbandry and veterinary courses were provided.

Seven technical high schools received new and modern equipment, hand tools and teaching material for building trade, electric and electronic trade courses, vehicle mechanics, machine tools, welding, fitting and plumbing trade courses. Basic aids to improve teaching methods were furnished to the schools along with training in the use and maintenance of such equipment, as well as equipment for the preparation of educational materials (software and slides for overhead projectors, video films and written materials etc).

Through loan of the Organization of Petroleum Exporting Countries, sophisticated workshop equipment, such as automotive engineering equipment, machine tools technology equipment, plastics technology equipment, civil engineering equipment, computer-aided training systems, etc. for an amount of US$7 million, were provided.

IV. HIGHLIGHTS

Through the provision of up-to-date equipment for teaching purposes, teaching aids, good basic training in the use and maintenance of this equipment, it was possible to introduce revised curricula and in this way ensure higher standards in the qualifications of both teachers and students. Thus, in retrospect, the Department of Technical, Agricultural and Vocational Education of the Union of Myanmar and the donor agencies can look back at a well designed and well executed project which has successfully assisted the country in strengthening its Technical, Agricultural and Vocational Education and Training Programme, to meet the challenge of the ever increasing demand for trained manpower for the industrial and agricultural sectors of Myanmar's economy.

The smooth co-operation between the UNDP/UNESCO and the Organization of Petroleum Exporting Countries ensured that the immediate objectives of the project could be successfully met and that the long term development objectives are likely to be met in the not too distant future. Last but not least, the competent leadership of the national counterparts and the Director-General of the Department of Technical, Agricultural and Vocational Education contributed significantly to the success of the project.

SCIENCE AND TECHNOLOGY MANAGEMENT INFORMATION SYSTEM FOR INDONESIA

Following a period of increasing activity and interest in developed countries in the late 1970s and early 1980s, which declined in the later 1980s and early 1990s, science and technology management is again becoming recognized as an important aspect of national development planning. This world-wide change is reflected in the developing, industrializing countries of the Southeast Asian region, where there is a particular interest in science and technology management as one of the most important engines of national development, and where the link between science, technology and development exists in a broader management context. This is vividly illustrated in the development of the newly industrializing countries in Southeast Asia, and the model of development of these countries is now advocated by many international development agencies and followed by most Southeast Asian and other developing countries..

The Science and Technology Management Information System project

The three-year Science and Technology Management Information System project was initiated in 1991, funded jointly by UNDP and the Government of Indonesia (contributing US$690,000 and US$300,000, respectively), executed by UNESCO and implemented by the Indonesian Institute of Sciences in conjunction with UNESCO. It terminated in 1994, by which time the need to continue and expand the project and related activities in Indonesia and the wider Southeast Asia region was recognized.

The overall objective of the Science and Technology Management Information System project was to assist the Government of Indonesia to rationalise science and technology management planning by developing and establishing an Science and Technology Management Information System for policy makers, planners and decision-makers in the public and private sectors. Specific objectives included the design of a computerized science and technology management information system database, enhancing networking capability, upgrading institutional capacity for science and technology management information systems, and science and technology management in Indonesia. The project provided intensive training in aspects of science and technology management and published 17 manuals relating to all aspects of science and technology management information systems.

The Science and Technology Management Information System Project is regarded as a pioneering initiative that also serves as a basis for integrating science and technology into broader socio-economic policy and planning. The project is also a useful model for similar activity in other countries of Southeast Asia, where significant support and interest have already been expressed, and elsewhere in the world.

Further information on the project may be obtained from the Project Officer, Tony Marjoram, Programme Specialist in Science, Technology and Informatics, UNESCO Jakarta Office, UN Building, 2nd Floor, Jalam Thamrin 14, Tromolpos 1273/JKT, Jakarta 10012, Indonesia. Fax: +(62-21) 315 0382

Further information on the activities on the following page may be obtained from Yasuyuki Aoshima, Division of Engineering Sciences and Technology, UNESCO, 1 rue Miollis, 75732 Paris Cedex 15, France, Fax: + 33 1 45 68 58 19; e-mail: y.aoshima@unesco.org.

UNIVERSITY-INDUSTRY-SCIENCE PARTNERSHIP PROGRAMME -- UNISPAR

University-Industry-Science Partnership Programme - UNISPAR was launched in 1993 with the following goals: (i) adaptation of university engineering education to industrial needs, (ii) continuing Engineering Education, (iii) university-industry joint R&D and (iv) setting up university-industry co-operation mechanisms.

In Asia, which is the most dynamic region for economic development at present, technology-led industrialization has become a major issue and the Asian branch UNISPAR Programme is encouraging the technical universities of the region to play an important role in the process of industrialization in a country, in particular, for human resources development and technology transfer. To this end, the following national, regional and international conferences on the topic of university-industry co-operation were organized in the region; "International Conference on Engineering Education - An Indian Perspective", Visakhapatnam in India on 21-23 November 1994, "The 1995 International Congress of Engineering Deans and Industry Leaders", Sydney in Australia on 3-6 July 1995, "Colloquium on University-Industry-Government Co-operation in Quality Engineering and Technology Education for Southeast Asia in the 21st Century", Nakhon Ratchasima in Thailand on 27-28 July 1995, "AUPELF-UREF (Agence francophone pour l'enseignement supérieur et la recherche) VIèmes Journées Internationales de Technologie", Phnom Penh in Cambodia on 23-25 January 1996 and "National Conference and Workshop on University-Industry Cooperation", Lae in Papua New Guinea on 9-11 April 1996.

As a results of these conferences, UNISPAR working groups have been established in India, Papua New Guinea and China. The working groups consist of representatives of local universities and private companies, and will identify and implement action-oriented university-industry joint projects.

INDUSTRY-SPONSORED UNESCO CHAIRS

The UNISPAR Programme also assists the establishment of industry-sponsored UNESCO Chairs. The UNITWIN/UNESCO Chairs Programme established in 1991 is an international plan of action for strengthening higher education in developing countries, through inter-university co-operation. UNESCO Chairs are considered complementary to fellowships and expected to be cost-efficient with a wider impact. Since the activities are mainly undertaken in developing countries, the brain drain effect may be minimized. Within the UNISPAR Programme, Chairs are established at technical universities in developing countries and are sponsored by industry of developed countries. The holders of UNISPAR UNESCO Chairs are eminent experts, often professors, researchers or industry experts from industrialized countries, and are appointed by the host university in close consultation with UNESCO and the donors. The length of their stay in the developing country is variable and during this time they train students and university staff or organize seminars and training courses for the intention of practising specialists. The potential subjects of the UNISPAR Chairs include but are not limited to: environmental technologies (cleaner production and waste management); infrastructure; renewable energies; total quality management; and food industry. Currently, 16 UNESCO Chairs sponsored by Japanese private firms are under negotiation.

CLEAN COAL TECHNOLOGY

A UNESCO Chair on Clean Coal Technology is being established at the Clean Coal Engineering & Research Centre of the Coal Industry in the partnership of the E7 Network of Expertise for Global Environment (8 major electric power companies are the members). A similar chair on Clean Coal Technology is already established at Moscow State Academy of Chemical Engineering and the UNISPAR Programme has been assisting the two Chairs in establishing a network. Coal is the one of the most important sources for heat and electric power generation and major branch of technological sources for chemical industry. Roughly 40% of the world electricity supply is based upon coal. Coal is the most abundant and available fossil fuels and represents 87% of global energy resource. China is the greatest coal producing and coal consuming country and 78% of its national energy is produced by coal (1.21 billion tons in 1994). The development and utilization of Chinese coal has not only a major effect on the continuous development of national economy but also on the environment. R&D on clean coal technology and its application to coal industry are urgent needs. A training course on "Clean Coal Technologies Environment Protection" was organized in Beijing on 18-22 December 1996 at the Clean Coal Engineering & Research Centre of the Coal Industry.

THE "EYE OF KALIMANTAN"

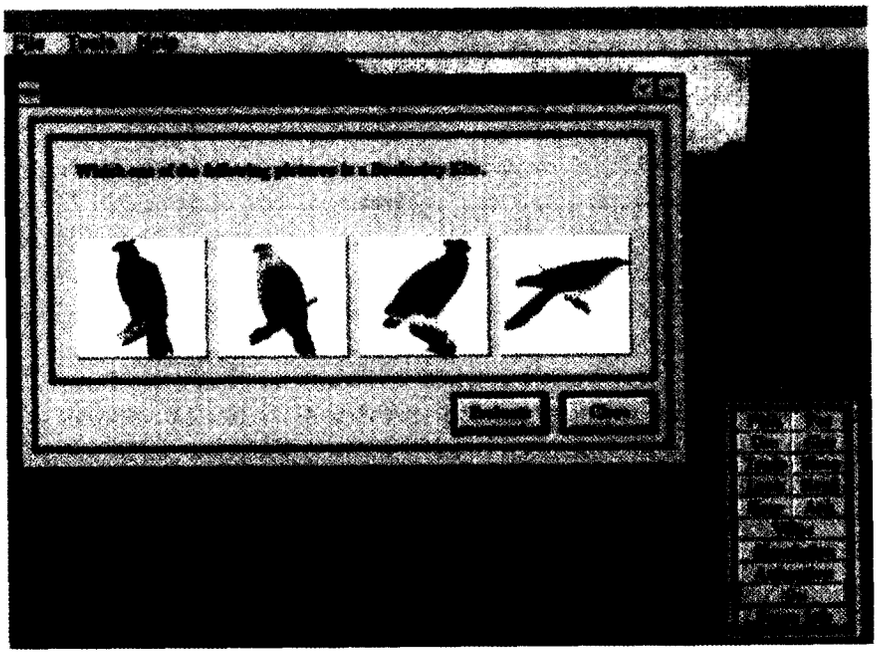
A COMPUTER-BASED ADVENTURE GAME FOR ENVIRONMENTAL EDUCATION

The "Eye of Kalimantan" is a computer-based adventure game for environmental education designed for young people (12-17 year olds), using the island and rain forest of Kalimantan, a large tropical island (formerly Borneo which includes the Malaysian provinces Sabah and Sarawak and Brunei Darussalam) as a model. The idea underpinning and reflected in the game is that the best atmosphere for learning is in an atmosphere of fun, challenge, achievement and positive feedback. The adventure game is a structured learning process regarding the environment, ecology, society and culture of Kalimantan, designed to maximise interactivity and user involvement. The goal of the game is to discover, in "Indiana Jones" fashion, the legendary "Eye" of Kalimantan by exploring Kalimantan for various clues and artefacts. While performing this task the player is introduced to the people, society, culture, geography, flora and fauna of Kalimantan, and develops an understanding of the role and ecological importance of rain forest in local, regional and global ecology. The courseware is in PC format, on diskette and CD ROM, and contains still black and white and colour images (see illustrations), computer animation, audio and various other simulations. The total budget of developing the courseware to date is US$16,500.

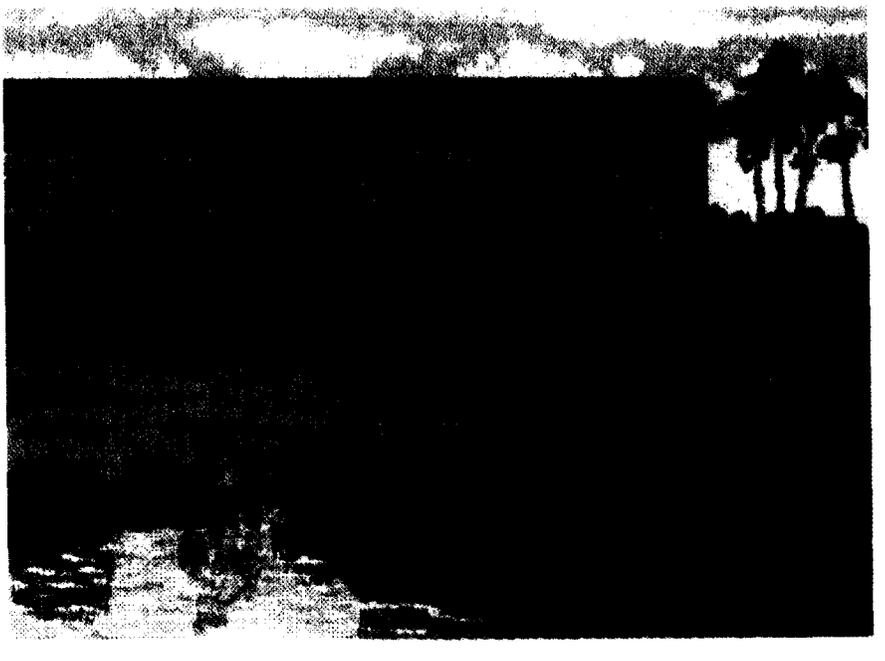
Prior to work on the computer game "Eye of Kalimantan" itself, a computer authoring tool editor programme, KAL-edit (named after the computer game) was designed and developed. KAL-edit was developed as an exercise in itself, that would be necessary in the subsequent development of the courseware package and subsequently other adventure-based courseware, and also because a tool of such specification was not available in Indonesia. It performs the function of a compiler and editor of multimedia elements such as text, image, sound, video, animation and simulation and uses the Visual Basic programming environment on Windows systems. KAL-edit is intended to be simple enough to be used by non-specialists with no programming experience, such as teachers. KAL-edit is also supplemented by KAL-script, a scripting language designed to cater for experienced KAL-edit users.

KAL-edit and "Eye of Kalimantan" were produced by a team of staff and students of the Computer Science Centre of the University of Indonesia and is now at an advanced pre-production stage. The next step will be the commercialization of the game. The students were involved as part of a final year undergraduate exercise. It is interesting to note that these students are now developing a computer software company in Indonesia, which is another notable achievement in a developing country, characterized by a severe shortage of computer specialists.

Further information on the project may be obtained from the Project Officer, Tony Marjoram, Programme Specialist in Science, Technology and Informatics, UNESCO Jakarta Office, UN Building, 2nd Floor, Jalam Thamrin 14, Tromolpos 1273/JKT, Jakarta 10012, Indonesia. Fax: +(62-21) 315 0382



Scenes from the video screen of the computer game "Kalimantan"



POSTGRADUATE COURSES IN COMPUTER SCIENCE, SRI LANKA

The objective of this UNESCO/UNDP project was to upgrade the existing one-year postgraduate Diploma Course in Computer Application at the University of Colombo, Sri Lanka, into a two-year M.Sc. course, intended for professional data processing managers and system analysts who have been initially trained in other disciplines and need to gain a sound professionally recognized knowledge of current computing practices, and insights into future trends in this rapidly changing field of technology. ***This has been achieved.***

The project has, in an informal manner, initiated a link between the Department of Statistics and Computer Sciences of Colombo University and industry. This has come about more by the enthusiasm generated by the student, rather than by the employer. This aspect needs to be further developed with the department undertaking research and development of local relevance.

It was planned that postgraduate students would be trained abroad. For this reason, University College Cardiff was selected as a twin university. The equipment provided within the framework of the project for research staff at the University of Colombo was similar to that installed in Cardiff, so that postgraduate students returning home could start to work immediately and train other students without difficulty.

The main objectives were to develop within the Department of Statistics and Computer Sciences a team of suitably qualified staff supported by appropriate computing equipment, who could run the Postgraduate Degree course as well as to develop the research potential of the Department and to consolidate the computing teaching infrastructure in the Sri Lankan universities.

The success of this activity has exceeded expectations. In addition to the minicomputer that was originally planned with project funds, several networks of computers have been established. These include a network of 11 state-of-the-art SUN workstations (also funded by the project) which are used by the M.Sc. students for their project work. Apart from this, 4 other networks of personal computers exist, comprising approximately 100 machines.

Further information on this project may be obtained from the Project Officer, Vefa Moustafaev, Division of Policy Analysis and Operations, Science Sector, UNESCO, 1 rue Miollis, 75732 Paris Cedex 15, France. Fax: + 33 1 45 68 5824; e-mail: v.moustafaev@unesco .org

LOW COST RURAL HOUSING FOR SOUTH ASIAN COUNTRIES

I. INTRODUCTION

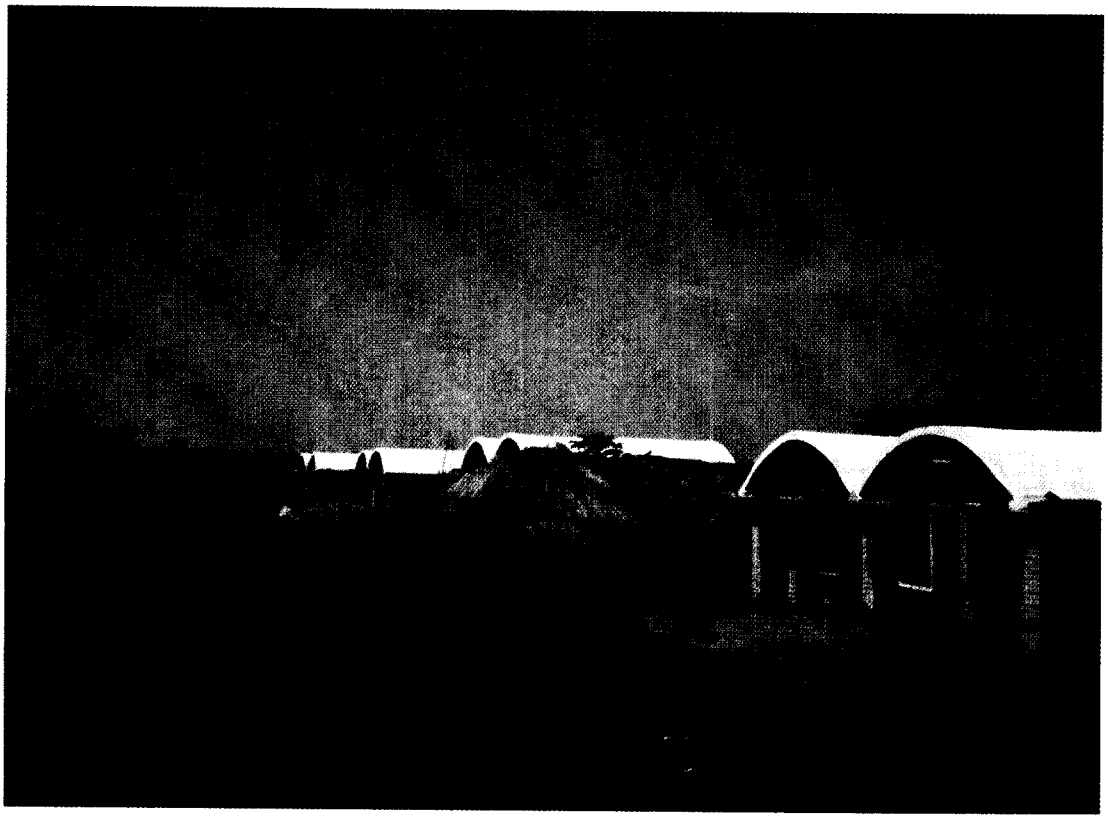
In several developing and high population countries, housing shortage is an endemic problem. In rural areas, shelters belonging to the poorer sections are dilapidated and shabby and most likely to become the first victims of floods, hurricanes, earthquakes and other natural calamities. On the one hand, construction costs have continued to escalate, and on the other, the industrial building materials such as steel, cement and baked bricks are always in short supply. And everywhere, the problem is compounded by capital and energy constraints and population pressure.

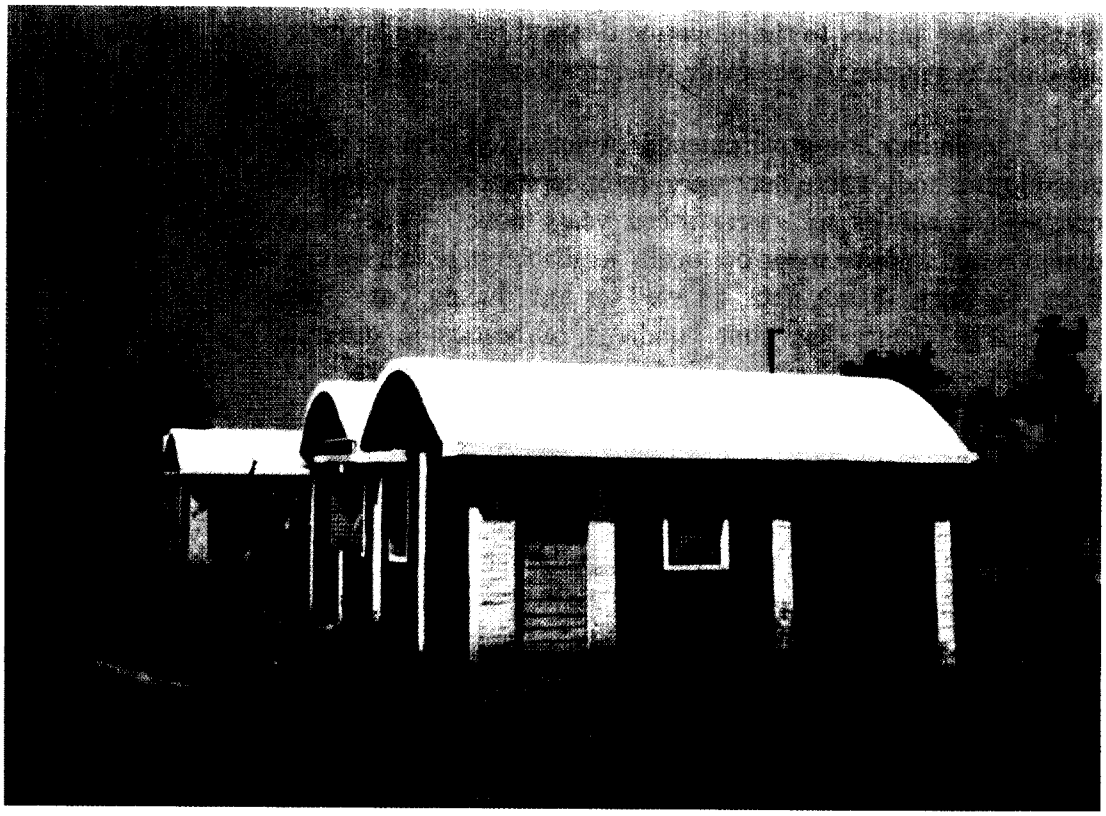
Nor can the ecological aspects of the problem be ignored. It is widely known that the pace of population growth could irreparably damage nature's balance. Therefore, a large part of the answer to the mounting demand for more housing must lie outside the use of these modern materials especially when responding to the needs of the rural poor.

The Indian non-governmental organization, Centre of Science for Villages, has been exploring and, where necessary, re-understanding, the merits of locally available and renewable alternatives for over fifteen years now. They have devised corresonding innovations and improvement on locally available materials readily found in the area, such as bamboo, mud, thatch, etc., as well as introducing cost-effective techniques in rural housing. The Centre has built hundreds of houses in different regions of India and transferred these techniques through the training of volunteers.

During a visit to the Centre of Science for Villages in Wardha district of Maharashtra, India, in March 1992, the Director-General of UNESCO, Mr Federico Mayor agreed to support an innovative venture in low cost housing, esteeming that other countries in the region should benefit from the experiences of the Centre of Science for villages. This venture had been receiving financial support from the non-governmental organization, Wardha Development Association, in France.

Further information on the this project may be obtained from the Director, UNESCO New Delhi Office, 8 Poorvi Marg, Vasant Vishar, 11057 New Delhi, India (Fax: + 91 11 6873351; e-mail: uhndl@unesco.org)





Views of the housing built under the low cost rural housing scheme

II. OBJECTIVES AND RESULTS

Objective 1: Sharing the understanding of locally available renewable structural materials.

- Involvement in the building of a new village (skills were taught by master artisans) using local materials and appropriate low cost technologies developed by the Centre of Science for Villages. This was done during a UNESCO-sponsored training course for participants from countries of the South Asian Association for Regional Co-operation (Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri lanka.).

Objective 2: Transferring technologies

- This includes understanding the nature of organic building materials *vis à vis* their intended application.

- It also includes understanding the science behind traditional construction and adapting it to the context of present day needs and conditions.

- Following the first training course, UNESCO organized a Regional Workshop on Low Cost Housing in Kathmandu, Nepal. The Centre of Science for Villages provided the resource person and background materials. Nine countries of the region participated and prepared country action plans for regional collaboration. The Centre of Science for Villages has already begun executing the plans and is currently in the process of transferring its technologies to a school building programme in Nepal.

Objective 3: Building up confidence in the trainees through construction experience

- During the UNESCO training course an entire village was literally built by the 19 participants from countries of the South Asian Association for Regional Co-operation region and local people (4 October to 12 November 1993). During the practical session in the course of the workshop, the participants involved themselves in the whole process of fabricating materials and constructing 10 houses. Initially, they were very surprised that they really had to build with their own hands, but in the end they agreed that this was the best way to learn.

Objective 4: Dissemination

- An important component of the course is the discussion with participants of resource problems of individual countries. The Centre of Science for Villages does not wish to set up a one-way process of handing out the techniques it has elaborated.

- It is seen as a special opportunity for each participating agency to share its experiences in the field. The Centre hopes to build a network of such agencies which can later be expended and/or strengthened.

111. HIGHLIGHTS

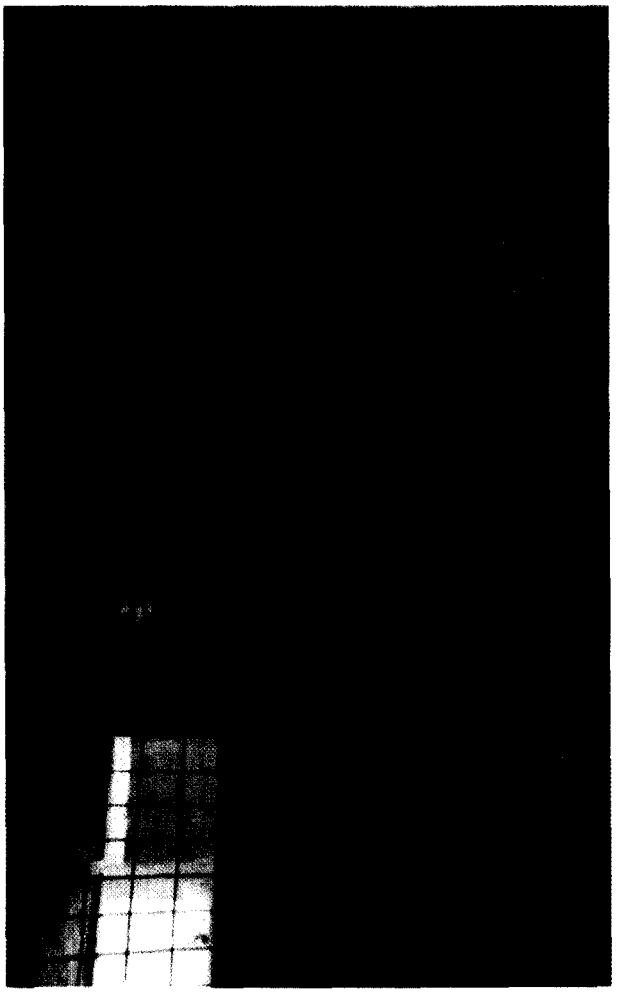
1. In general, the new houses are made of mud with thin tiles attached to the outside walls. This way, the houses give the impression of being made of brick. Villagers prefer this because of their perception of progress in living conditions is to move from a mud house to a brick house. Tiles are also used to protect mud structures from rain.

2. The roof is made of clay pots which fit into each other. Their round structure provides an arch effect. This reinforces the roof which receives additional support from brick pillars.

3. An additional element is two cement storage shelves.

4. Since wood is scarce in the Wardha region, its use is avoided wherever possible. The Windows, for instance, do not have wooden frames.

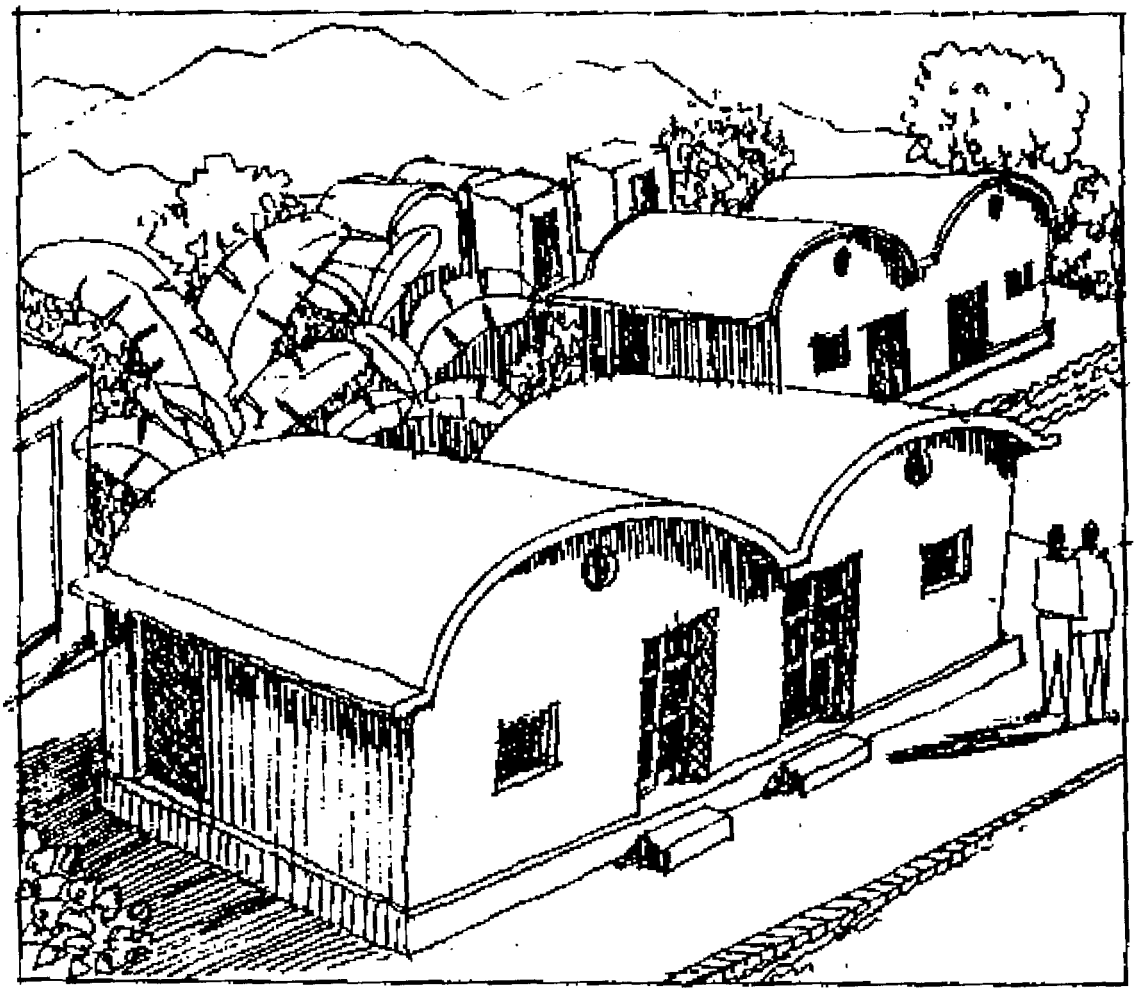
5. Toilets made of cement are so constructed that very little water is needed to flush since water, too, is a scarce commodity in this area.



Roof seen from the interior of a low cost rural house

6. Bathrooms are also made of cement. All toilets and bathrooms are privately owned by villagers so that they feel responsible for their cleanliness. Aspects of health and sanitation education are therefore inherent to the scheme.

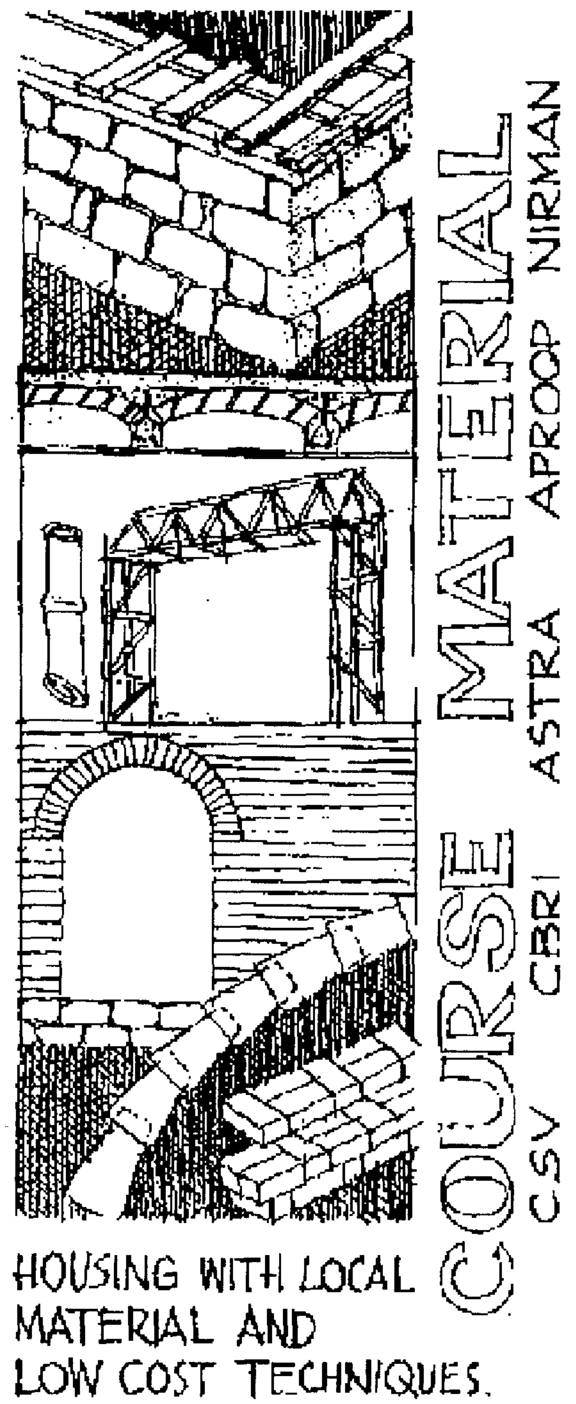
7. Normally, when water is pumped from a well, some is inevitably lost due to spillage. This led to both waste and muddiness. The spilled water is now caught and led through a filtration canal with stones and gravel. The water is then collected in a drinking trough for cows.



A REPORT

TRAINING COURSE ON LOWCOST RURAL HOUSING FOR SOUTH ASIAN COUNTRIES


A PRESENTATION
SRILANKA BANGLADESH PAKISTAN NEPAL INDIA
NGOS' PARTICIPATION
IN HOUSING THE POOR


COURSE MATERIAL
CSV CBRI ASTRA APROOP NIRMAN
HOUSING WITH LOCAL
MATERIAL AND
LOW COST TECHNIQUES.

3. EARTH SCIENCES

DECADE VOLCANOES IN THE PHILIPPINES

Natural hazards may be called a household concept to the Filipinos. From typhoons, flooding, draught, landslides, tsunamis to volcanic eruptions - everything is there. As the Philippines have a population density of 220 habitants per square kilometer and half or more of the land area is too inhospitable for human habitation, it is not possible for everyone to occupy 'hazard free' zones.

The largest island in the Philippines is Luzon Island (see Fig. 1) on which the capital, Manila (the greater metropolitan area has a population of approximately 10 million) is situated has several active volcanoes of which the most notable are Mayon (Photo 1), Pinatubo (Photo 2) and Taal (Photo 3) all situated in rather densely populated areas with important lifelines.

In view of the above-mentioned vulnerability to people and property in the Philippines, UNESCO initiated collaboration on the issue of prevention and mitigation of the effects of natural hazards in earnest in the early nineteen seventies with a regional project on improvement of seismic networks funded by UNDP. The countries concerned were: Indonesia, Malaysia, the Philippines and Thailand; in the initial phase Hong Kong was also included. Subsequently UNESCO, in collaboration with United States Geological Survey and various universities in Australia, Japan and New Zealand, increased the efforts within the broader realm of natural hazards aiming, through enhancement of the individual country's capacity - both in terms of equipment and skilled manpower - by holding regional seminars and workshops commencing in 1982.

Further information on this project may be obtained from Soren Malling, Division of Geological Sciences, UNESCO, 1 rue Miollis, 75732 Paris Cedex 15, France. Fax + 33 1 45 68 5822; e-mail: s.malling@unesco.org
Photo credit: Philippine Institute for Volcanology and Seismology, Quezon City, Metro Manila, Philippines.

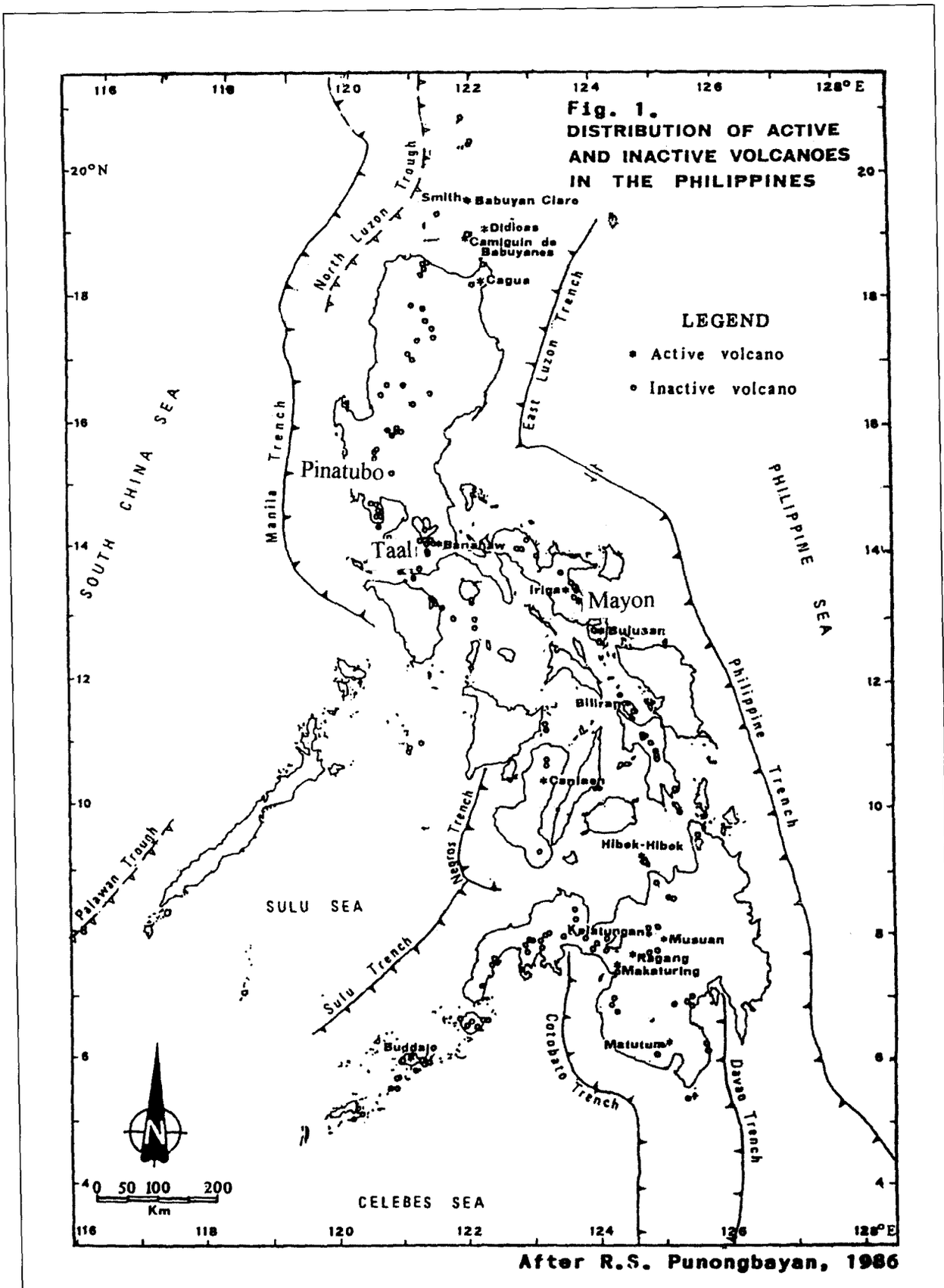


Figure 1: Distribution of Active and Inactive Volcanoes in the Philippines

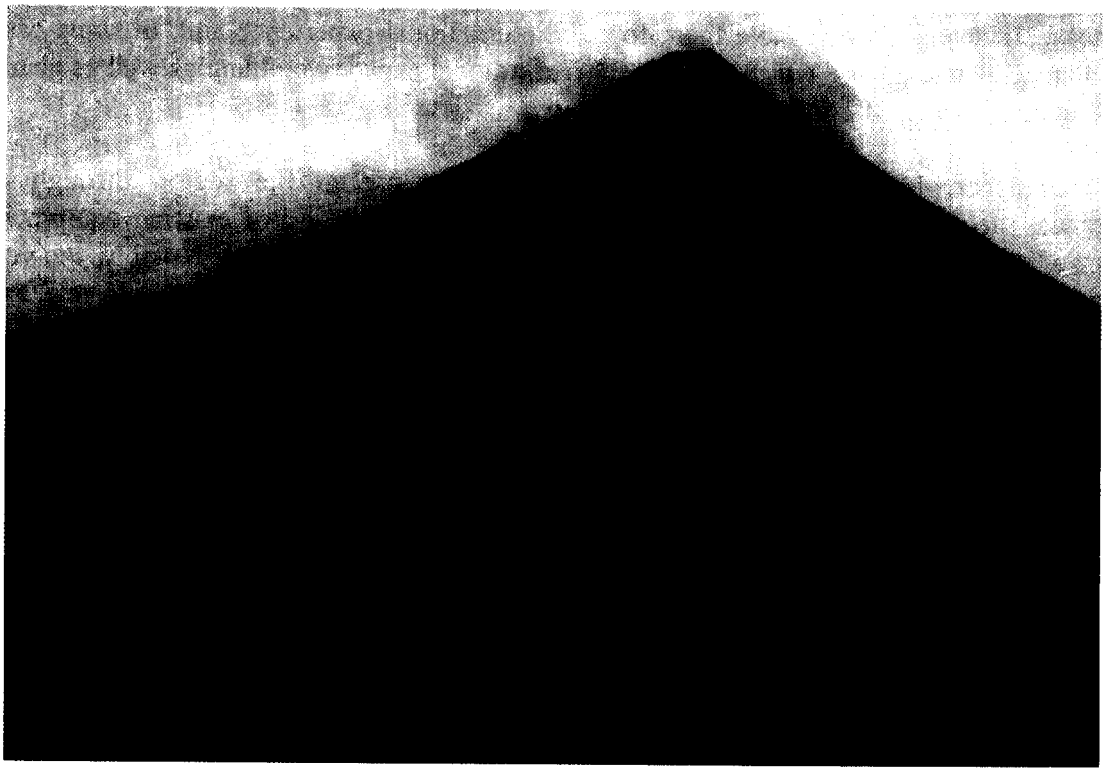


Photo 1: Mayon (southeast face)

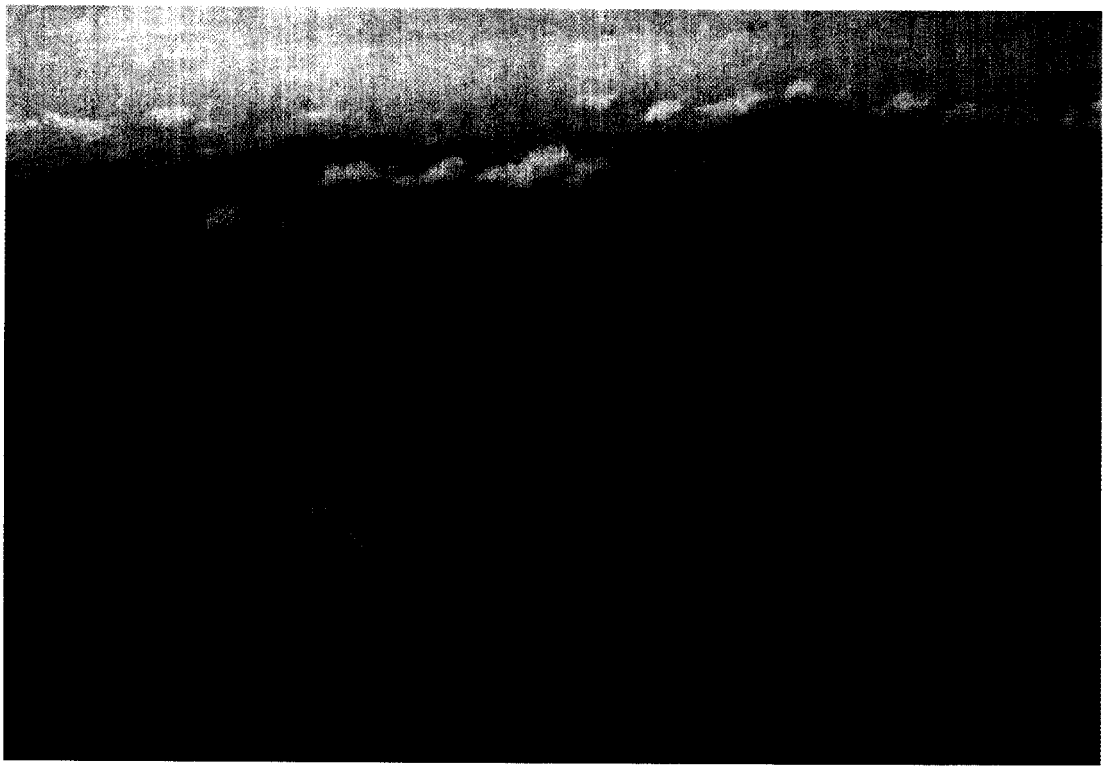


Photo 2: Pinatubo, after eruption, looking south

In addition to the regional events, UNESCO supplied grants to scientists from the southeast Asian region to enable them to gain international experience and, in some cases, to obtain an academic degree which assisted the institutional capacity building as well as generating a certain amount of self-confidence in the region.

Further, UNESCO facilitated emergency response in the region through expert assistance, the provision of urgently needed equipment or updating of existing equipment and organized seminars and workshops both during and after the emergencies. Notably, the volcanic eruptions of Galungung, Indonesia (1982) and Mayon, Philippines (1984 and 1986 respectively) were addressed prior to the declaration of 1990-99 as the United Nations International Decade for Natural Disasters Reduction.

At a meeting of volcanologists, held in Japan under the auspices of the International Association of Volcanology and Chemistry of the Earth's Interior it was decided to select "decade" volcanoes worldwide which were considered dangerous and prone to erupt during the Decade with the aim of making detailed studies and monitoring of these volcanoes and to instigate collaboration between the teams not only in the case of an emergency, but also on a regular basis. It is hoped, that this will further strengthen the capacity of the countries concerned to deal with volcanic emergencies. Five volcanoes in southeast Asia were selected namely: Merapi (Indonesia), Sakurajima and Unzen (Japan) Taal (the Philippines) and Ulawun (Papua New Guinea). Of these only Unzen has, up until the end of 1995, had an eruption of consequence when it erupted towards the end of 1993 after a period of several years of unrest, an eruption which caused the death of 44 people and substantial damage to property.

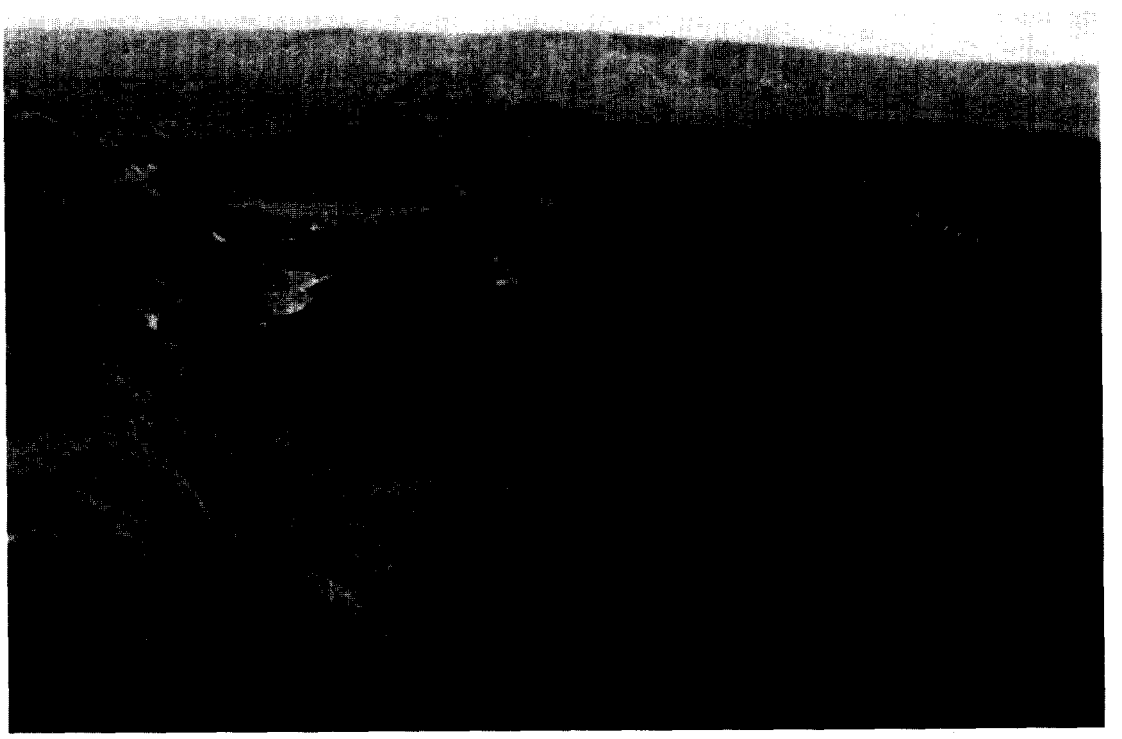


Photo 3: Taal Crater Lake

Very shortly after the declaration of the Decade two major natural disasters befell the Philippines: first an earthquake of magnitude 7.8 (Richter's scale) which occurred at Nueva Ecija on July 15, 1990 and subsequently volcanic eruptions from Pinatubo volcano in mid June 1991 which combined formed the largest eruption so far in this century (volume of the ejected material was estimated to 10-15 km^3). The earthquake claimed more than 1600 victims as a direct result and severe damage to property and lifelines.

In the case of the eruption of Pinatubo, the past investment in capacity strengthening of the Filipino volcanologists demonstrated the beneficial value.

In the month of April 1991 local residents observed steam emanations from the hitherto quiescent Pinatubo and the Philippine Institute for Volcanology and Seismology was alerted. The staff of the Institute made a preliminary survey and, as the volcano continued to be restless, a more complete monitoring was commenced. Since the Taal volcano was also showing signs of unrest at the this time, the Philippine Institute for Volcanology and Seismology requested and obtained help from the Volcano Crisis Assistance Team of the U.S. Geological Survey. The team arrived in the Philippines late April 1991.

This monitoring comprised, *inter alia*, seismic, temperature, gas emanation and ground deformation. Although considered active, Pinatubo had not erupted during the past 500 years and its stratigraphy was poorly known; therefore a detailed mapping of the extent of previous eruptions was performed.

Such mapping enables the volcanologists to establish likely scenarios as well as worst case scenarios. The mapping concentrates in particular on the pyroclastic (hot debris) flow's area coverage from the individual past eruptions and their specific geographical location.

In the Philippines, the scientists and the authorities, in particular the civil defense then collaborated in making evacuation plans for the likely scenarios. As evacuation is a traumatic experience for the people concerned, it is naturally important to implement evacuation only when a near certainty of an impending eruption exists. An arbitrary scale from one to five is used and once the volcanologists expect, that the volcano will erupt within the next 24 hours (step 4) evacuation is undertaken. The final warning is given to commuters and air traffic when imminent eruption is expected.

On the 7th of June 1991, the Philippine Institute for Volcanology and Seismology decided to issue alert 4 (meaning that an eruption was possible within 24 hours), based on the seismic signals which showed an increased frequency, indicating that the magma was mowing closer to the surface. This movement was not accompanied by a corresponding ground deformation as would normally be expected in case a large eruption is impending. Thus, the people living on the flanks of the Pinatubo volcano were evacuated.

Subsequently, on the 9th of June 1991, alert 5 was issued by the Philippine Institute for Volcanology and Seismology, following which the population living in the presumed danger area (cf. above) was evacuated.

photo 4: Pinatubo - 15 June 1991 - View from the South

On the June 15, 1991, following a few small eruptions, the largest eruption of this century took place (Photo 4). The areas affected by pyroclastic flows and lahars (mudslides) were pretty much those predicted on the hazard maps produced in the previous few months. However, as the typhoon Yunya hit the area around Pinatubo at the same time as the eruption occurred this unfortunately meant that the ash accumulated on the roofs became water saturated and hence heavy. The sad implication of this was, that the bulk of the people killed succumbed from collapsing roofs (about 180). About 70 people died from various other causes.

Other small eruptions occurred through to beginning of September 1991 and to date Pinatubo has shown a gradual waning of activity.

In retrospect one may argue, that the alert system was not sufficiently flexible with regard to evacuation, which confused some of the local officials and generated some credibility problems. On the whole, however, the action can be deemed successful or in other words, the long term investment in enhancing the capability of the Filipino volcanologists had paid off. UNESCO and its partners can claim some of the credit for this outcome.

REFERENCES

Bautista, B.C., Bautista, M.L.P., Rasdas, A.R., Lanuza, A.G., Amin, E.Q., and Delos Reyes, P.J., 1991, The 16 Julv 1990 Luzon earthquake and its aftershock activity, in *The July 161990 Luzon earthquake: A technical monograph*: Manila, Department of Environment and Natural Resources, p. 8 I- 118.

Blong, R.J., 1984, *Volcanic Hazards: A Source book on the Effects of Eruptions*: Sydney,Academic Press, 427 p.

PHIVOLCS, 1988, Distribution of active and inactive volcanoes in the Philippines: PHIVOLCS, Quezon City, *Educational poster, I sheet.*

Punongbayan, R.S., 1987, Disaster preparedness systems for natural hazards in the Philippines: an assessment, in *Geologic Hazards and Disaster Preparedness Systems*, Philippine Institute of Volcanology and Seismology, Quezon City, p. 77-101.

Punongbayan, R.S., Rimando, R.E., Daligdig, J.A., Besana, G.M., and Daag, A.S., 1991, The July 16, 1990 Luzon earthquake ground rupture, in *The July 16, 1990 Luzon earthquake*: A technical monograph: Manila, Department of Environment and Natural Resources, p. 1-32.

Punongbayan, R.S., Sincioco, J.S., and Newhall, C.G., 1993, Pinatubo Volcano Observatory: *WOVO News, Quarterlv Newsletter*, no. 1, p. 9-1 1.

Ramos, A.F., and Isada, M. G., 1990a, Emergency Investigation of the Alleged Volcanic Activity of Mount Pinatubo in Zambales Province. *Letter to Gov. Amor Deloso, Zambales Province*, 1 p.

Ramos, A.F., and Isada, M. G., 1990b, Emergency Investigation of the Alleged Volcanic

Activity of Mount Pinatubo in Zambales Province. *PHIVOLCS Memorandum Report*, 2 p.

Sabit, J.P., 1992, Pinatubo Volcano's 1991 eruptions. Paper presented at the *International Scientific Conference, on Mt. Pinatubo*, 27-30 May, 1992, Manila, 34 p.

Simkin, T., 1993, Terrestrial volcanism in space and time: *Annual Reviews Earth Planetary Science, v. 21*, p. 427-452.

Tilling, R.I., 1989, Volcanic hazards and their mitigation: Progress and problems: *Reviews of Geophysics, v. 27, no. 2*, p. 237-269.

UNDRO/UNESCO. 1985, *Volcanic emergency management*: Geneva, United Nations Disaster Relief Office/UNESCO, 86p.

GEOSCIENCES AND SOCIETY

Examples of results of the International Geological Correlation Programme Projects in Asia

I. INTRODUCTION

The International Geological Correlation Programme (IGCP) was created in 1972 by UNESCO in order to facilitate worldwide collaboration between geoscientists working on vital problems concerning the earth and its resources. The Programme was specifically designed to promote the exchange of ideas, data and techniques, to encourage and assist the training of geoscientists, and to enhance quality control of the world's geoscientific information.

The IGCP is managed jointly by UNESCO and the International Union of Geological Sciences. Several thousand scientists from more than 150 countries have participated in the Programme over the past twenty five years. Like all dynamic scientific undertakings, it evolves continually in response to new discoveries and concepts and to the changing emphases and demands arising from social needs. The scientists whose freely-given efforts have made the IGCP the most successful international programme of its kind have made fundamental contributions to understanding earth systems and relating these findings to real-life problems ranging from the search for, and utilisation of, natural resources to the investigation of global warming. For example, the modest "seed money" provided by UNESCO and IGCP led to the development of a global model of essential commodities such as phosphates. Similar successes can be claimed for work on the presence of toxic chemicals in the vital natural resources of soil and water. Soil and rock chemistry also has a bearing on

This account was prepared by Margarete Patzak and Vladislav Babuska, Division of Earth Sciences, using material provided by Professor E. Derbyshire (Great Britain) Chairman of the International Geological Correlation Programme Scientific Board, from scientific information in a review by Mr M. Brown, Nature and Resources, vol. 30, No. 3 & 4 (1994) and from annual project reports, prepared by project leaders Ms N. Petit-Maire (France), Mr Yuan Daoxian (China), and Mr A.K. Signhvi (India). Further information on the IGCP may be obtained from the IGCP Secretariat, Division of Earth Sciences, UNESCO, 1 rue Miollis, 75732 Paris Cedex 15, France.

human health, as shown by an increasing number of geochemical epidemiological studies around the world. A number of IGCP projects have also shown that the more recent sediments on the Earth's surface contain a detailed record of climatic change against which can be set the evidence of human-induced changes over the past century. These and many other IGCP investigations have involved hundreds of geologists from the developing world, and many have included advanced training components in line with the scientific, educational and cultural aims of UNESCO.

The three IGCP projects outlined below show in a little more detail how the results of IGCP research contributes to an improved understanding of the earth's environment in the continent of Asia. They have established important facts about the evolution of deserts, demonstrated the value of studies of the cave and underground drainage systems of many limestone regions (called "karst" systems) in the reconstruction of former earth environments. They have left no doubt about the importance of research in the "Quaternary" era (the period from about 2.5 million years up to the present) in many areas bearing upon the wellbeing of humankind including, for example, land-use and environmental planning in South-East-Asia. Moreover, much of the information on the nature and extent of past climatic changes is now of sufficient detail to make it possible to predict future climatic and environmental changes.

II. PAST CLIMATIC CHANGES IN EAST CHINA

The current debate about global climatic change has thrown into sharp relief the need for a better understanding of the way deserts have evolved within the known range of climatic change in recent geological time.

During the Quaternary, the generally consistent pattern of atmospheric circulation throughout the low latitude zone extending from West Africa to East China led to climatic variations of similar amplitude and type. The annual precipitation, largely derived from the summer monsoon, showed significant variations, while the changes in the mean temperatures were much less marked. Geological analysis has yielded valuable data on environmental change across this vast area over the last 130,000 years, much of it dated by isotopic methods. A significant amount of such data has been provided by members of IGCP project 252 on "Past and future evolution of deserts". Geochronological analysis of sediment series, including those left by ancient ponds, pools and lakes, and the evidence of ancient life forms (palaeo-biological proxy data) has proved a fertile source of information on past environmental change.

These changes affected the global hydrological system, its properties, circulation and distribution, as well as the type and distribution of the vegetation and fauna including the development of humans and their settlements along the Afro-Asian arid/semi-arid belt. They confirm conceptual models of regional humid/arid alternations, which are roughly in phase with the warm/cold global variations. Realistic geological records of past global changes show that, for the area investigated so far, periods of global cold coincide with regionally dry phases, whereas globally warm periods correspond to regionally wet phases. The evolution of CO_2 and CH_4 in the atmosphere may be related to these major environmental changes.

The recent climatic history of the earth is now known in fair detail, and the main periods and conditions are summarised below.

- The climate reached a peak in humidity at around 125,000 years ago (during the last Interglacial phase).

- The period from 55,000 to 24,000 years ago was marked by two wet episodes (55,000-42,000 and 38,000-22,000).

- The Last Glacial Maximum (ca. 20,000-15.000 years ago), was characterised by severe arid phases which extended the arid/semi-arid zones in North-East China some 900 km southward of their present positions (Figure 1). There was a significant decline in mean annual temperatures (of about 12'C), in response to enhanced influence of polar air masses, a factor that further served to enhance aridity.

- The warming trend in the Holocene (CA 10,000 years ago to the present) led to a new and significant increase in the precipitation/evaporation ratio across the whole region. Subsequent major environmental changes allowed the Neolithic civilisation to appear, including a distinct northward shift in the semi-arid/semi-humid margins in India and China. These changes began between 10,000 and 9,500 years ago, optimal climatic conditions occurring between 9,000 and 6,500 years ago. However, climatic deterioration followed, with an irregular pattern of drier/wetter episodes, until the general termination of the humid conditions (triggering enhanced wind action) between 4,000 and 3,000 years ago.

- Since the climatic optimum (9,000 - 6,000 years ago) the arid zone has extended some 200-250km further south in North West India and North East China.

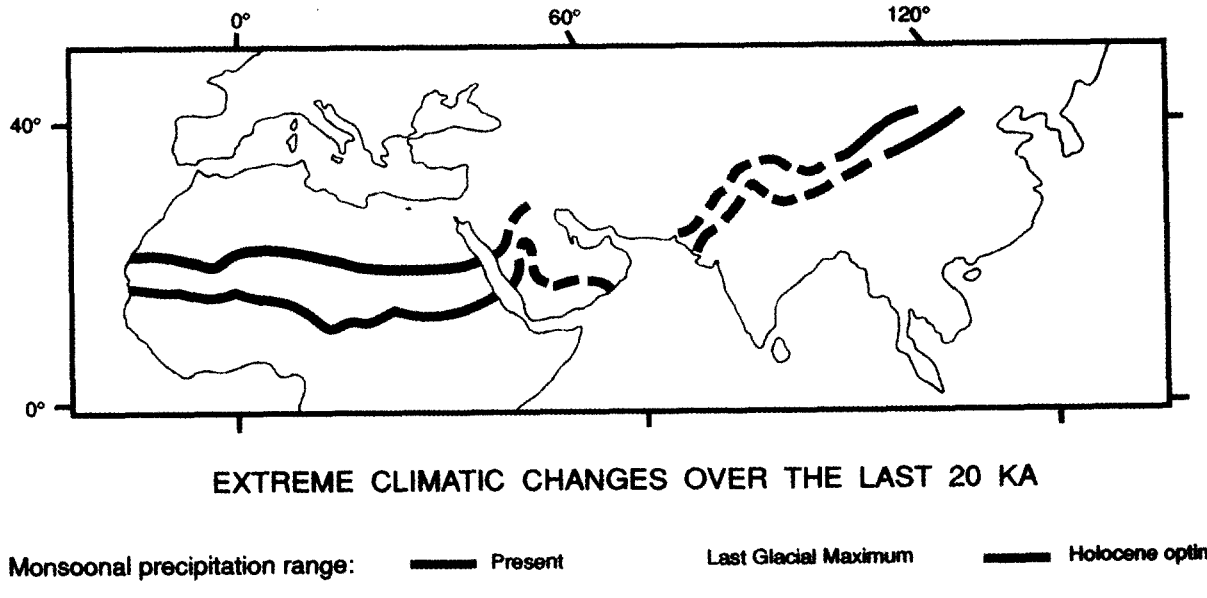


Figure 1 Temporal movements of the semi-arid transitional zone (West Africa to Northeast China). Associated with global palaeo-climatic changes and attendant summer-monsoon precipitation levels. (From: N. Petit-Maire)

Glaciers, ice sheets and deep-sea sediment cores also record such changes. For example, along with some renewed advance by the glaciers (the "Neoglacial" period) since ca. 6,000 years ago, there occurred a renewed extension of the tropical arid zones towards the Equator, as expressed by desert expansion.

The area affected by successive shifts between the two extremes of cold and warm (and specifically from semi-arid to sub-humid environments and back again, involving extension and diminution of the deserts) is estimated to have been about 14,000,000 km2 in Africa and Asia.

What is the relevance of these data to the climatic conditions prevailing today? Natural global cooling (-0.01°C per century) over several millennia will induce continued aridification of the desert transitional zones currently experiencing highly variable summer monsoonal rainfall. Man is a powerful agent in the enhancement of this trend, adding desertification to climatic change. However, the man-made increase in atmospheric radiative gases will probably enhance the natural greenhouse effect (without which the earth's atmosphere would be at lease 18 degrees C cooler) to induce an artificial component of global warming. The geological record provides us with no analogue for such a situation. In the northern hemisphere, globally warmer conditions can be expected to re-activate former monsoonal patterns and a general favourable set of environmental changes. However, if not quickly mastered, desertification could nullify any such natural benefits.

III. LIMESTONE KARST, CLIMATE AND GROUNDWATER

"Karst", in the simplest terms, refers to landscapes made up of carbonate rocks, such as limestone, dolomite or carbonatite which are characterised by sinkholes and caves largely formed by the dissolution of calcium in the rocks. As a result, karst terrain has a well-developed subterranean drainage system instead of surface streams.

Some recent highlights of IGCP Project 299 on "Geology, climate, hydrology and karst formation" illustrate this theme. The broad objectives of this programme were

- to identify global differences in surface and sub-surface karst forms;
- to study relationships between karstification processes and geological, climatological and hydrogeological conditions;
- to use geological evidence to reconstruct palaeo-geographical , and especially palaeo-climatic conditions;
- and to apply these results in the prediction, evaluation and exploitation of mineral resources, and environmental protection, in various karst areas of the world.

From the viewpoint of earth science, the karst process is part of the global carbon cycle, which expresses the continued exchange and reaction of carbon in the biosphere, atmosphere, hydrosphere and lithosphere by the movement of carbon (Figure 2).

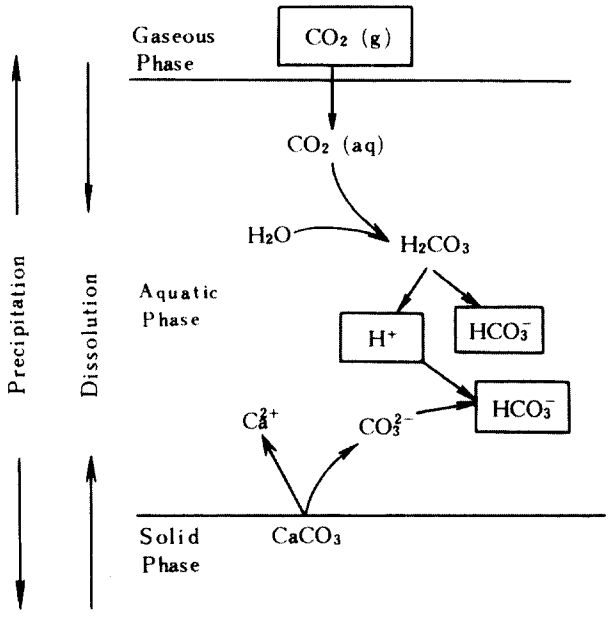


Figure 2 Carbon transfers in karst dynamic systems. (From: Yuan Daoxian)

Workers on the project have examined karst dynamic systems within the Earth's various ecological divisions. Each region exhibits its own characteristic properties, related to environmental conditions. For example, tropical karst is characterized by tower karst (Figure 3), numerous dolines (sinkholes), red soils and giant caves with abundant speleothems (e.g. stalagmites). Arid karst areas show aeolian deposits, limestone scree (broken rock fragments lying on or mantling a slope) and small caves with little speleothem development.

Within the general scientific area of global climatic change, karst studies have made a number of important contributions. The first of these is an improved understanding of the 'greenhouse effect' of carbon dioxide in the atmosphere. The karst process can act as either a sink or a source of such $C0_2$ depending on whether carbonate dissolution or carbonate precipitation (with $C0_2$ degassing) is the predominant process in a particular environmental

region. The broad global expanse of carbonate-rock is a significant influence upon 'greenhouse gas' fluctuations. In karst regions, this is associated with the deposition of calcareous sinter at the outlet of geothermal springs, the volume of calcareous sinter providing a measure of temperature, pH and HCO_3 and $C0_2$. Every tonne of deposited sinter requires the release into the atmosphere of 120 kg of carbon in the form of $C0_2$ gas.

A second contribution relates to palaeoenvironmental reconstruction. Being particularly sensitive to environmental change, the karst dynamic system provides very high-resolution records of environmental change on the scale of centuries, decades, or even single years. A detailed study of a stalagmite (1.22 m long) from a cave in South China (Figure 4) has revealed remarkable details of changes in climate from the last glaciation to the present, as well as many rapidly changing events in the local region. Among the various karst features, speleothems are certainly one of the most important recorders of palaeoenviromnental changes. In East China, for example, it has been found that speleothem growth shows obvious regularity, development having occurred mainly at the time of 1st, 3rd, 5th and 7th warm periods and the 2nd 4th and 6th glacial stages. The development of speleothems in North China is less intense than in the south, reflecting environmental differences that have persisted since the Late Pleistocene. North China has been dry and cold, even though there have been several warm and wet periods, whereas the south was much warmer and more humid. The data reveal that, even though the climate has not changed much in the period 4,000-12,000 years before the present, there have been remarkable changes in the ecological environment because of deforestation associated with the rise of human civilization.

A third contribution has been to knowledge of groundwater management in different karst ecosystems. It is generally considered that the underground water-drainage systems typical of karst are detrimental to agricultural development. However, in Siberia the karst system has been found to be a positive asset because it naturally drains excess water from swamps in the Taiga forest region. Other environmental problems are being investigated, such as groundwater versus landfill use in karst areas, where an intervening impermeable rock-layer is necessary if pollution is to be avoided.

The Karangbolong karstic limestone district of central Java captures and retains rainwater, acting as a kind of natural water tank. The surface of the hills are covered by dense forest, retaining rainwater in the rainy season and thus enlarging the volume of water which penetrates the limestone to be saved within the natural reservoir below the surface. The limestone here is used as a building material because of its high quality. However, recent studies have shown that such economic exploitation causes a negative impact on the hydrological system, so that conservation of the limestone is now recommended.

The plan to create a huge reservoir by damming the Seven Gorges area of the Yangtze River in China provides another example of human interference in karst terrains. When the Yangtze Gorges reservoir is full of water, the hydrodynamic, hydrochemical and water-temperature conditions will change and so will the karst environment. Caves are abundant in

this area, occurring at seven distinct altitudes within the limestone. Those caves in the lower three zones will be partly or completely inundated as the reservoir level approaches its maximum, and the dry caves at higher levels will change from air-filled to partially saturated

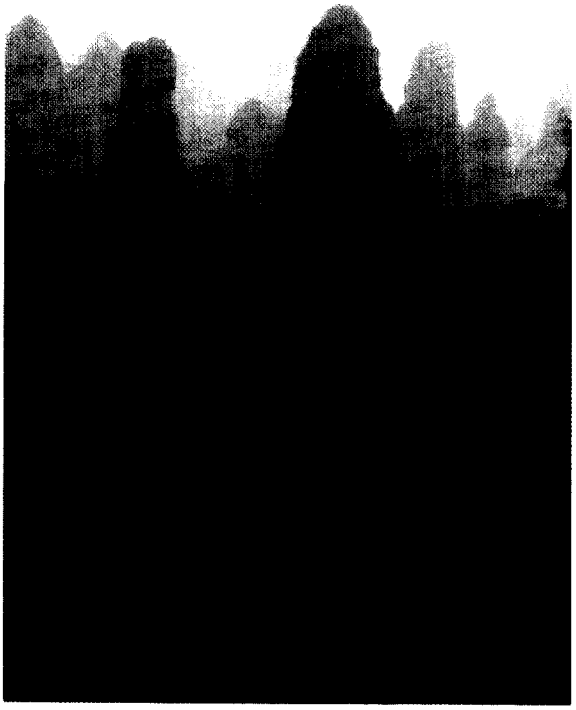


Figure 3 Tower karst, typical of tropical environments, in Guilin, South China (Photo: Yuan Daoxian)

Figure 4 Section of a stalagmite (1.22m high) from Panlongdong cave, Guilin, South China. Oxygen isotope measurements have shown marked climatic changes during its growth over 40,000 years. (Photo: Yuan Daoxin)

conditions This will stimulate further cave development and the hazard of cave collapse because of the renewed solution and mechanical water action. About ten large karst springs and outlet of the subterranean stream near the river bank will become inundated, and a new karst drainage network will form, altering the hydrodynamic and hydromechanical conditions in the region. Because of the backing up of the drainage, the amount of groundwater chemical runoff will increase and its dissolution capacity will rise by about 10 percent, so enhancing the karstic processes.

The construction of underground dams across subterranean streams in the karst regions of China has gained momentum in recent years because less engineering is required and such a process yields quicker results in supplying irrigation water and electrical power. The underground dams include full dams, half dams, underground reservoir, surfaced reservoir (cockpit storage) and others. Their construction must be based on regional data and planned subterranean stream systems, with due attention being given to leakage prevention, dam foundations, flood control and water supply at both upstream and downstream sites. Hundreds of underground dams have been built in recent years in South China, many of which have solved problems of irrigation within the framework of local conditions.

IV. DESERT MARGINS AND PALAEOMONSOONS SINCE 135,000 YEARS AGO

The IGCP Project 349 on "Desert margins and palaeomonsoons" has been investigating wind blown sediments as clues to improved understanding of the sensitive interfaces between atmosphere, oceans and the land over the past 135,000 years. This is providing valuable information not only on shifting desert margins but also on changes in these relationships within a global context. The investigation of dryland sediments has proved to be keystone providing a fuller understanding of the Earth's climate has changed during the Quaternary.

Within the past decade, however, two terrestrial sources of high-resolution data on climatic change have attracted particular attention, namely cores from ice sheets and detailed sample series from thick wind-blown deposits. Blown sand, loess (wind-deposited silts) and associated dust mantles have proved to be a rich source of information. Indeed, the pace of research has accelerated and taken on a sharper focus in recent years for a number of reasons. These include the recent improved accessibility to the huge deposits of loess in both China and the former Soviet Central Asia (Figure 5).

The high quality information obtained in these studies was obtained by using a wide range of complementary techniques including mineralogy, micromorphology and particle size analysis, magnetic susceptibility and thermoluminescence dating (using the last exposure of sediment grains to light prior burial). Other techniques include scanning electron microscopy artifact typology, palaeontological analysis, radiocarbon dating and amino acid analysis. Considerations such as particle origins, sedimentation rates, palaeosol development and type, comparative stratigraphy, archaeology, and the use of other climate-proxy measures have been instrumental in establishing palaeoclimatic gradients, palaeo-rainfall patterns and a range of other palaeo-climatic reconstructions.

In order to answer specific questions about climatic changes at different times in the past, it is essential to determine the age of sediment layers in addition to, for example, using the grain size and origin of its constituent particles as a guide to former about wind directions and air mass dynamics in both glacial and interglacial times when the material was deposited (Figure 6). Project 349 provides an example of IGCP's focus on particular geoenvironmental issues of current concern. It focused deliberately upon changes in the environment of present-day deserts over the past 135,000 years, and the implications of these changes for

both past reconstructions and prediction of future changes e.g. alternation of dry and wet periods, warming and cooling trends in response to changes in solar radiation, variations in sea-surface temperatures and shifting trade winds as expressed in the intensity and range of the monsoonal rains that delimit the critically important borders between desert (arid) and semi-arid zones.

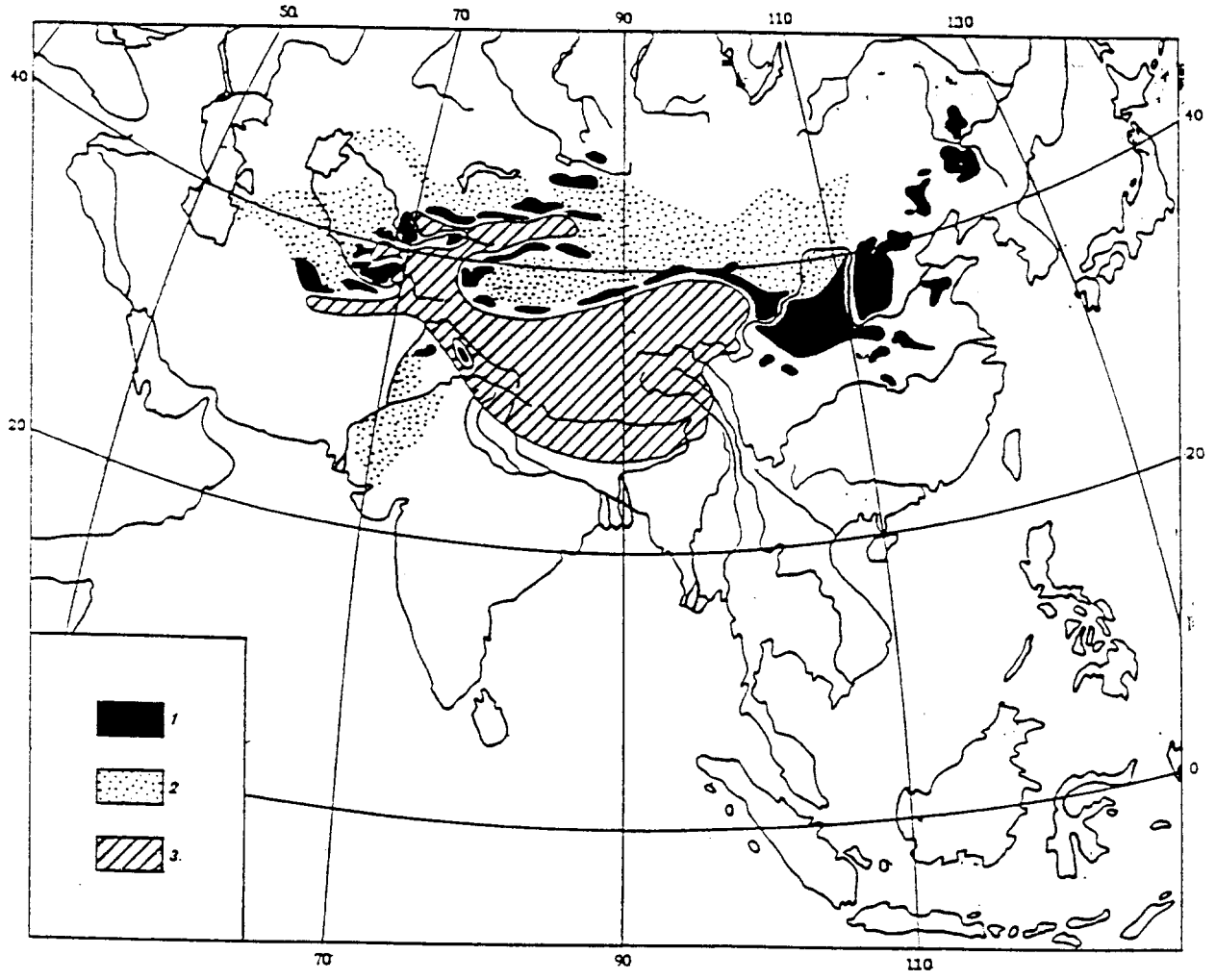


Figure 5 Loess in the region of High Asia (from Alekseev and Dodonov, 1989), (1) Loess cover, (2) Sandy deserts; and (3) Mountains uplifted to a height of more than 3000m. Note the inticate relationship between the loess, the uplifted region and the Yellow River.

The great loess successions of central and eastern Asia are a fine example of a young formation providing a rich source of palaeoclimatic information. These deposits contain many interbedded palaeosols (buried soils) that offer a number of advantages for high resolution palaeoclimatic studies with particular reference to variations in the palaeomonsoons and fluctuations in the margins of steppe and desert in central and eastern Asia. New data on the micromorphology, magnetic susceptibility and grain size characteristics of four sections along the present-day rainfall gradient across the Loess Plateau of North China have been used to demonstrate progressively higher in stratigraphical resolution (that is, a much more detailed climatic record) westwards towards the semi-arid

margins of loess country. Such analytical data, together with geomagnetic information, the climatically-diagnostic results derived from studies of the micromorphology of soils and loess, and the very closely-spaced particle size analysis of the loess have provided new ideas on changing climatic gradients. The rather sparse molluscan faunas (land snails) in this region have also been used as climatic proxies for the period from the last interglacial through the last glacial to the middle Holocene (about 5,000 years ago). It has been clearly shown that the molluscs provide a more immediate response to even short duration improvements in the climate than either mineral weathering or soil development.

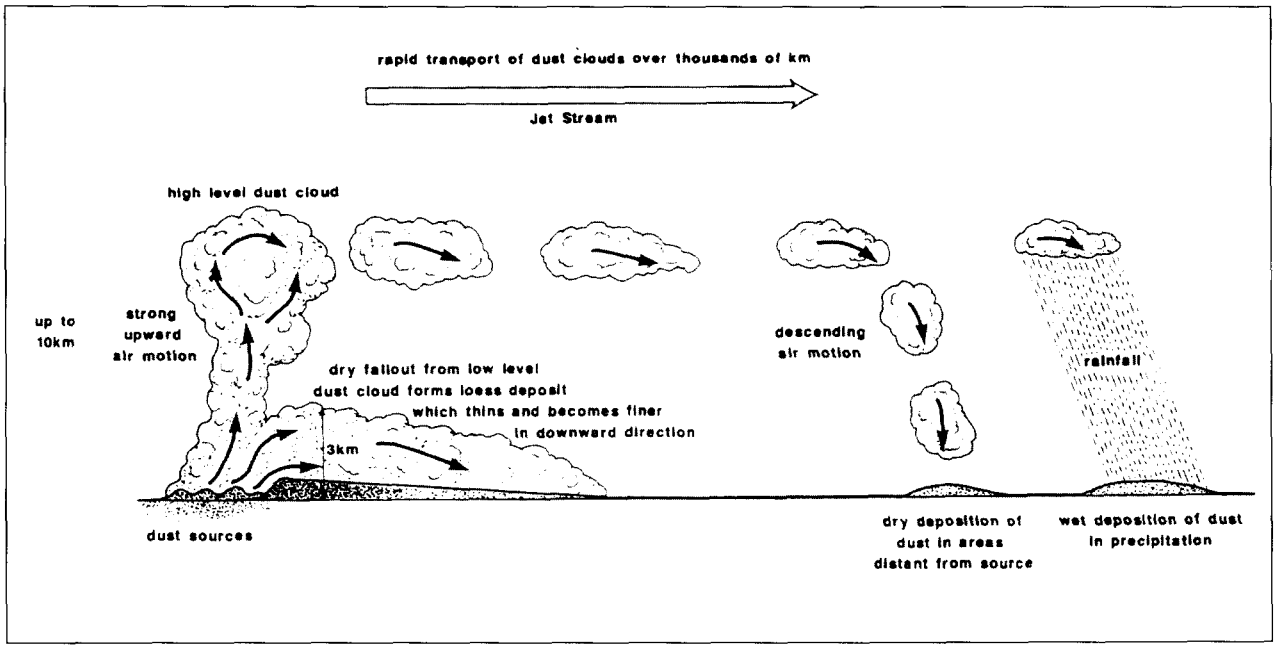


Figure 6: Schematic representation of two contrasting modes of aeolian dust transport and deposition proposed for dust flux from the deserts of Northwest China to the Loess Plateau and North Pacific ocean during the Quaternary (fromS Pye and Zhou, 1989). Rapid vertical accretion of proximal loess is favoured when vertical mixing of dust in the lower levels of the atmosphere is restricted by a low level inversion. Long-range transport of dust is favoured when dust is lifted ahead of cold fronts and becomes incorporated in the upper level westerlies

In the case of the central Asian loess it has been pointed out that the increasingly discredited stratigraphic and palaeogeographical reconstructions based on luminescence dating during the 1970s are now in need of revision. Correlation of the Tadjikistan sections with those of North China and the marine oxygen isotope sequences indicates a clearly increasing trend in loess accumulation rates from the upper Pliocene to the end of the Pleistocene, and explains the incidence of loess and palaeosol units in terms of the relative strength and weakness, respectively, of the Siberian-Mongolian high pressure cell as a control on the north-westerly (winter) monsoon.

There is no doubt that results obtained by a number of IGCP projects have shown beyond any doubt that geology has a vital role to play in providing the temporal framework for change. If the planners are concerned to make provision for a major natural event with a return period of, say, 50 years, then they need a record which goes back 500 years. Similarly, if the planners are concerned with a particular 500-year event, then they need a record extending back 5,000 years. It follows that a fundamental element in any regional planning strategy must be the latest and best available evidence of past environmental changes, for the past is the only reliable key we have to sound future planning.

4. ECOLOGICAL SCIENCES

EAST ASIAN BIOSPHERE RESERVE NETWORK

I. INTRODUCTION

Biosphere Reserves represent a unique category of protected areas established in 1974 within the framework of UNESCO's Man and the Biosphere (MAB) Programme. As of March 1997, there were 337 sites in the international Network of Biosphere Reserves in 85 countries, representing a broad variety of biogeographic and bioclimatic regions of the world, as well as a wide range of economic, demographic, social, cultural and development situations. Biosphere Reserves attempt to reconcile the conservation and protection of biological and genetic diversity, as well as of representative portions of important terrestrial and coastal/marine ecosystems and landscapes, with the rational use of land and of natural resources, the safeguarding of cultural values, the enhancement of traditional practices of resource use, searching for the active participation of local populations in their quest for sustainable and equitative development.

The objectives of Biosphere Reserves are achieved through an innovative and widely adopted zoning system. Each Biosphere Reserve consists of one or several minimally disturbed core areas that protect an important ecosystem sample. Around this core area stretches a buffer zone devoted to basic and applied research, environmental monitoring, traditional land use, recreation and tourism, or environmental education and training. The outer zone of the Biosphere Reserve is a transition area, where research is applied to the needs of the local communities. Some Biosphere reserves represent multiple categories of protected areas.

This article was prepared by Han Quinli, Division of Ecological Sciences, UNESCO, 1 rue Miollis, 75732 Paris Cedex 15, France, fax: + 33 1 45 68 5805. e-mail: han.q@unesco.org or mab@unesco org, from whom further information may be obtained.. The information was mainly taken from the EABRN Reports edited by the UNESCO Jakarta Offices, papers presented at the Network's meetings and notes taken during field trips.

EAST ASIAN BIOSPHERE RESERVE NETWORK

The East Asian Biosphere Reserve Network is a subregional biosphere reserve network of five countries: China, Japan, Mongolia, People's Democratic Republic of Korea and the Republic of Korea. Currently, it involves 20 UNESCO Biosphere Reserves *(Table 1. List of East Asian Biosphere Reserves)*. It is one of the regional networking initiatives of UNESCO's Man and the Biosphere Programme which has emerged in recent years. The five countries adopted the statutes of the Network in 1995, which defined the objectives, membership and activities.

The establishment of the East Asian Biosphere Reserve Network was first proposed in 1993, and shortly afterwards a co-operative scientific study of East Asian Biosphere Reserves was launched in order to create the Network, through which a number of activities have been conducted. To support the network development, the Government of the Republic of Korea has provided important financial input, together with the support from other East Asian Biosphere Reserve Network members and UNESCO. The secretariat for the development of the Network was led by the UNESCO Jakarta Office, in close co-operation with the UNESCO office in Beijing and Headquarters in Paris.

The East Asian Biosphere Reserve Network is intended, primarily, to develop a mechanism for member countries to exchange information and experience in the implementation of the Seville Strategy for Biosphere Reserves and the statutory framework of the World Network of Biosphere Reserves. It promotes cooperative studies on the priority issues identified by the countries and aims to improve the skills and knowledge of people involved in the biosphere reserve development. To this end, it organizes activities such as meetings, workshops and seminars, encourages exchange of specialists and promotes joint research projects

II. MAJOR ACTIVITIES AND RESULTS:

2.1 During the period of 1994-96, a number of network activities have been carried out.

- First meeting of the Cooperative Scientific Study of East Asian Biosphere Reserves and field review mission to the Wolong Biosphere Reserve, Beijing and Wolong, Sichuan, China, 13 - 23 March 1994.

- Second East Asian Biosphere Reserve Network meeting to further the discussions on East Asian Biosphere Reserve Network co-operation and networking of biosphere reserves, Mt. Changbai Biosphere Reserve, China, 15-22 August 1994. This meeting focused on the development of tourism in biosphere reserves and a field evaluation of the Biosphere Reserve was carried out.

- Third East Asian Biosphere Reserve Network meeting, Seouo and Mt. Sorak, Republic of Korea, 29 May - 2 June 1995. This was the first meeting of the East Asian Biosphere

Name of Biospher Reserve	Ecosystems	Area (ha)	Biosphere Reserve since
CHINA			
Changbai Mountain	Temperate forest	217235	1979
Dinghu Mountain	Subtropical forest	1200	1979
Wolong Nature Reserve	Giant Panda habitat	207210	1979
Fanjingshan Mountain	Subtropical forest	41533	1986
Xilin Gol	Temperate grassland	1078600	1987
Fujian Wuyishan	Subtropical forest	56527	1987
Bogdhad Mountain	Mountain forest and Gobi desert	217000	1990
Shennongjia	Subtropical forest	147467	1990
Yancheng	Coast wetlands	280000	1992
Xishuangbanna	Tropical forest	241700	1993
Molan	Karst mountain forest	21330	1996
Tianmushan	Subtropical forest	4284	1996
JAPAN			
Mount Hakusan	Japanese evergreen forest	48000	1980
Mount Odaigahara & Mount Omine	Japanese evergreen forest	36000	1980
Shiga Highland	Oriental deciduous forest	13000	1980
Yakushima Island	Japanese evergreen forest	19000	1980
DPR KOREA			
Mount Paekdu Biosphere Reserve	Temperate forest	132000	1989
R. KOREA			
Mount Sorak	Temperate forest	37430	1982
MONGOLIA			
Great Gobi	Gobi desert	5300000	1990
Boghd Khan Uul	Temperate mountain forest	67300	1996

Table 1. List of Biosphere Reserves in the East Asian Biosphere Reserve Network

Reserve Network following the Seville Conference.[1] It was oranized in conjunction with a regional workshop for the establishment of the biosphere reserve network in Asia and the Pacific. Draft Statutes for the East Asian Biosphere Reserve Network were discussed and approved. A field evaluation was carried out of the Mt. Sorak Biosphere Reserve.

- A small scale study on ecotourism in the Changbaishan Biosphere Reserve (China) was launched in August 1996. The project is a joint activity of research workers from China and the Republic of Korea. Colleagues from Democratic People's Republic of Korea may join the study in 1997.

- Fourth meeting of the East Asian Biosphere Reserve Network, Kagushima and the Yakushima Island Biosphere Reserve, Japan 19-25 October 1996. This meeting was held in conjunction with the International Symposium entitled "Co-existence of the World Evergreen Humid Forest Ecosystems with People" as a special session of UNESCO's Man and the Biosphere Programme. A field trip to the Yakushima Island was made together

[1] The Seville Conference (March 1995) took stock of the 1984 Action Plan for Biosphere Reserves and drew up the "Seville Strategy" identifying actions to be taken in the coming years. Draft statutes for the World Network of Biosphere Reserves were also identified.

with other Symposium participants. An evaluation of Yakushima Island Biosphere Reserve was carried out.

- The detailed results of these activities are published through the East Asian Biosphere Reserve Network Report Series (*photo 1*)

- As decided in Kugoshima, Japan during EABRN-4, the next meeting of the network will be held in Ulaanbatar and Bogdul Mountain Biosphere Reserve, Mongolia, in August 1997. Agenda items will focus on ecotourism in biosphere reserves and transborder conservation development in the region.

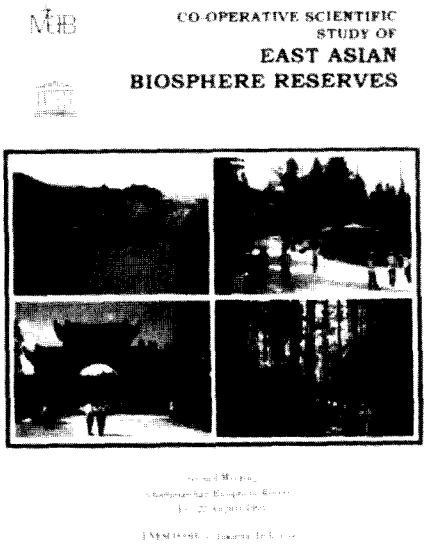


Photo 1: Three issues of EABRN Reports have been compiled and published by the UNESCO Office in Jakarta, with input from the participating countries. The Report No.4 for the meeting at Kugoshima and the Yakushima Island is under preparation. The information in these report will be selected and published on the MABnet on the Internet[2] *Photo: Han Q.*

2.2 The Networks's achievements, preliminary but encouraging:

Considerable information was exchanged and documented. The East Asian Biosphere Reserve Network meetings and reports provide opportunities for the members to present their efforts in harmonizing biodiversity conservation with socio-economic development. This information is useful for countries to explain the roles of MAB and biosphere reserves in contributing to national environment and development efforts. The information exchange concerns:

- National strategies in the implementation of the United Nations Convention on Biological Diversity and Agenda 21 (resulting from the United Nations Conference on Environment and Development, Rio de Janeiro, 1992) and the role of UNESCO and biosphere reserves in the implementation of these strategies.
- Priority issues encountered in pursuing conservation and development in biosphere reserves and pressing needs for assistance.
- Characteristics, advantages and constraints of the present conservation systems and administrative infrastructures for biosphere reserves and other protected areas.
- National classifications of protected areas and relations with present biosphere reserves.
- National mechanisms of planning for biosphere reserves.

The above information is useful for the Network's members to learn and understand each other's position and ways in which their MAB Programmes are contributing to their national systems. Co-operation is thus placed on a clear and solid basis. The information is valuable for the UNESCO secretariat in developing activities in the countries. What should be noted is that

[2] Copies may be obtained from the UNESCO Office Jakarta, JL M.H.Thamrin 14, Tromolpos 1273/JKT, Jakarta 10002 Indonesia. Fax: [62] (21) 31 50 382: E-mail: uhjak@unesco.org

such information was communicated through presentations which, without East Asian Network, the MAB National Committees might not otherwise have the oportunity to exchange.

Direct professional and human contacts are established. The East Asian Biosphere Reserve Network has managed to bring together people from different sectors including scientists, managers, governmental officials, experts from specialized environmental agencies and MAB national committees. Such transsectoral contacts are indispensable for the success of any future co-operation (*Photo 2*).

Subjects of common interest and priority for the co-operation within the Network are identified. One of these subjects is **ecotourism**. The second meeting in 1994 was devoted mainly to this subject and countries presented very interesting papers. The subject was once again underlined by the fourth meeting in Japan, 1996. This is due to the fact that tourism in Asia has greatly developed in recent years and ecotourism is becoming a quite commonly accepted activity in nature reserves and national parks, although most people do not know what it really means and what it may involve in terms of management practices.

Photo 2: Colleagues from China, DPR Korea and R. Korea discuss cooperative research between Mt. Baekdu and Changbaishan Biosphere Reserves, EABRN-2, 1994. Photo Han Q.

It is clear that the technical knowledge on ecotourism is still lacking in biosphere reserve management. What are the differences and connections of ecotourism to the tourism in general and common recreation activities? How big is it as a market for the economy? What are the ecological, economic, social and cultural elements linked to this development? How should ecotourism be organized in the biosphere reserves of this Network (*photo 3*)? Such questions are frequently arising as daily management issues of many biosphere reserves.

As a response, the East Asian Biosphere Reserve Network has lauched a small-scale project on ecotourism in the Changbaishan Biosphere Reserve (China, R. Korea). China organized an ecotourism training workshop in December 1996 at the Dinghushan Biosphere Reserve in co-operation with Australia. The East Asian Biosphere Reserve Network has also decided to develop a number of synthesis papers and draft some guidelines for ecotourism development in these biosphere reserves, to be presented at its fifth meeting in 1997.

- Another important subject is the development of **transfrontier Biosphere Reserves.** Although transfrontier questions (over political borders) are delicate, there is a growing interest in EABRN. The basic idea of many countries is clear: there are a number of reserves or protected areas close to country borders that are either part of same ecosystem or possess habitats that home some rare or endangered fauna and flora species which may move or migrate across boundaries. Often the human communities living in these areas have similar cultural traditions and comparable ways of using natural resources. Co-operation, at least on a level of information exchange, between these sites

is needed and possible. Ways for other cooperative actions should be identified for which biosphere reserves may contribute through the cluster biosphere reserve model or experience in transfrontier conservation. From the many possible sites concerned, the following may develop cooperative actions in the near future. Although some these sites are only potential biosphere reserves, they may be included in the activities of the Network.

- Mt. Changbai (China) and Mt. Paekdu (DPR Korea)
- Mt. Bogdhad (China) and Great Gobi (Mongolia)
- Qomolangma (China) and Makalu-Barun-Mount Everest (Nepal)
- Xilingol-Dalaihu (China)-Eastern Steppe Nomgrog (Mongolia) and (Dausky) Russia
- Uvs Nur Lake Basin (Mongolia and Russia)

Other subjects identified include linking biosphere reserve development with general school education and developing possible field educational centres or programme activities in biosphere reserves; introducing the biosphere reserves concept in planification of urban systems etc.

Scientific input required for biosphere reserves are identified. Emphasis on the above-mentioned issues by the East Asian Biosphere Reserve Network does not undermine the role of science in biosphere reserves development. In contrast, it requires "better science", which is more interdisciplinary-oriented, to help resolve these questions. In Mt. Changbai and Mt. Paekdu, the Network requested the academies of sciences of Democratic Peoples's Repubic of Korea and China to further their scientific investigations, in particular regarding the *biodiversity and its importance and relation with local people.* In Yakushima Island, the East Asian Biosphere Reserve Network highlighted the study *on social and economic aspects of the conservation development* in this biosphere reserve. In Wolong, the Network called for an *integrated study on the conservation of the Giant Panda habitat with particular relation to social economic issues (photo 4) and encouraged the use of GIS and mathematical models for management analysis as well as reserve zoning.* It has a strong interest in cooperating with other biosphere reserve networks such as Biosphere Reserves Intergrated Monitoring Programme for scientific monitoring in biosphere reserves and national networks such as the Chinese Ecological Research Network, which have several research stations situated in biosphere reserves.

III. EAST ASIAN BIOSPHERE RESERVE NETWORK FIELD EVALUATIONS

Review and evaluation are essential to ensure the appropriate development of each biosphere reserve. It was for this reason that periodical reviews are specifically foreseen in the Statutory Framework. In practice, especially at the present stage when there is no prototype experience of such evaluation, it is believed best to focus on practical field issues in order that the countries can review their own experience and identify remaining shortcomings.

So far, four Network field evaluations have been carried out in line with this thinking (Wolong and Mt. Changbai of China in 1994, Mt. Sorak of R. Korea in 1995 and Yakushima Island of Japan in 1996). They were carried out through presentations and reporting by managers and research workers, field trips, visits to local families and schools and a summary discussion. Some points of interest include:

a) The evaluators. Who should be entrusted to carry out such a task? As biosphere reserve practices are so different from site to site and the issues involved are often interdisciplinary in nature, it is difficult for any one person to undertake such an assignment alone. The East Asian Biosphere Reserve Network took the approach of team work, working with

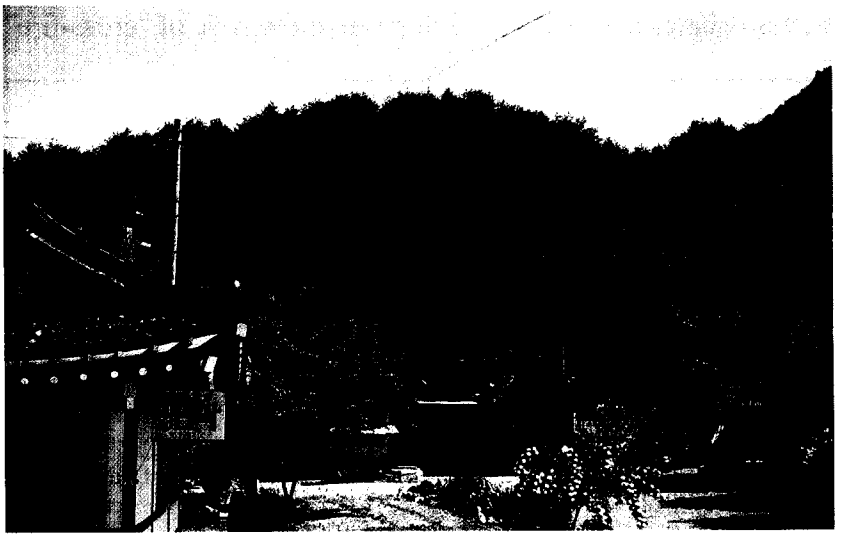


Photo 3: Traditional style of Korea houses in the buffer zone of the Mt. Sorak Biosphere Reserve. Local communities living in the buffer zone are involved in the tourism activities. What will ecotourism mean to them? Photo Han. Q.

Photo 4: A Tibetan couple came down to the valley, after collecting firewood in the forest (Wolong Biosphere Reserve). Research is needed to identify "sensitive areas" crucial for conservation and to determine the "carrying capacity" of the buffer zone for local communities. Photo: Han Q.

managers, scientists, community leaders, nongovernmental organizations, and the UNESCO Secretariat. The evaluation thus becomes a workshop exercise.

b) Evaluation through a dialogue. Dialogue is perhaps a better method at present for biosphere reserve evaluation. Through dialogue, the "one-side-driven" and "top-down" approaches are rejected and an exchange of views and opinions are made on an equal basis, though sometimes debates may become heated and in the style of "cross-fire".

Summary of the International Review of Wolong Biosphere Reserve

An international Panel of Specialists from China, DPR of Korea, Japan, Mongolia, Republic of Korea and UNESCO concluded that Wolong is a functioning Biosphere Reserve. Wolong's status as a special administrative district within Sichuan Province has facilitated the management authorities' ability to design and implement a wide range of activities with regard to the conservation, logistic support and development functions of the Biosphere Reserve. In the future, linkages between development in the buffer zone and programmes for conserving target species, such as the Giant Panda, need to be improved through better coordination and cooperation between Wolong's management and the research community.

Furthermore, the international Panel made the following **recommendations**:

(i) The large volume of data available on the various aspects of the ecology of the Giant Panda should he used to design programmes for rehabilitating degraded bamboo and forest lands, particularly in the buffer zone. These programmes should be directly linked with the Ministry of Forestry's proposal to rehabilitate Giant Panda habitat in about 3,000 sq. Km of Sichuan Province. The relevant Chinese authorities and UNESCO should consider re-organizing the system of Panda Reserves and Linking Corridors in Sichuan as a "cluster Biosphere Reserve" and nominating a selected combination of reserves within the cluster for inclusion in the list of World Heritage Sites.[3]

(ii) The management authority should launch sociological and demographic studies in order to better justify on-going resettlement programmes for local people resident within the core zone. Although these programmes are implemented with the consent of the people, the management authority needs to build a data base that will enable it to analyze and understand alternatives to resettlement.

(iii) The current zoning plan for Wolong needs to be reviewed and revised. At present the Chengdu - Lhasa road that cuts through the core zone of Wolong appears to be hampering the genetic exchange between the two "halves" of the core zone. The feasibility of extending the current boundary of Wolong to incorporate counties within 4 km needs urgent investigation. Studies that provide the basis for the review and revision of the zoning plan should also take into consideration a system for regulating traffic along the Chengdu-Lhasa road, rehabilitation of habitats on either side of the road and re-establishing habitat contiguity between the two "halves" of the core zone.

(iv) The development in Wolong of "ecotourism" should be encouraged. Wolong offers a variety of opportunities for alternative tourist activities ranging from mountain hiking to cultural exposure to Tibetan folk-lore and traditions. The management should design eco-tourism programmes that preserve the architectural styles and traditions of Tibetan people who constitute more than 80% of the local population.

(v) The current environmental education programmes for people living in the Wolong and Genda communes need to be continued. However, the present over-emphasis on nature, wildlife and some species such as Giant Panda, should be tempered with other programmes focusing on health care and waste disposal (particularly plastic sheets and bottles which appear to be used quite extensively in the communes).

(vi) The small hydro-power projects providing energy alternatives to fuel wood seem to be useful. However, the management authority of Wolong should refrain from initiating too many of these projects and initiate programmes for monitoring water quality in downstream areas.

(vii) Wolong's international recognition could be used to promote it as an international research and training centre, not only on the Giant Panda, but also for investigating linkages between conservation and development.

[3] A World heritage Site is a site of outstanding and exceptional value, the conservation of which is ensured by the country concerned. Such a Site can also be a Biosphere Reserve, or part thereof, usually the core area.

c) Evaluation by an international team provides new perceptions which are often not apparant to local management bodies. In Wolong, it was the EABRN group which raised the issue of landscape changes as result of the hydro-power station construction which itself is a conservation effort. As to the human resettlement issue in Wolong, the team suggested to examine the cultivation of alternative crops such as medicine plants for increased income with less consumption of land resources. In Mt. Sorak, the team highlighted the enormous potential of the area for environmental education for school children (*photo 5*)

Photo 5: Among the tourists to Mt. Sorak are thousands of school children, making the site an important location for developing environmental education programmes

d) Learning by doing. The evaluation provides good opportunities for everyone who participate to learn from each other. It helps the team members to learn about new experiences and become familar with the complex issues encountered in different natural, social, economic and cultural contexts. It is important for the team members to bring back new ideas to their own countries, since after all, most of "evaluators" are people who are pursuing biosphere reserve development in their own countries.

IV. WHAT ARE THE UNDERLYING DRIVING FORCES FOR EABRN?

It could be argued that all the above activities are excellent but one could achieve them without a network like EABRN. This is perhaps true for each of the individual activities mentioned above. However, it is certainly not true if one considers these activities taken as a package for the implementation of the Seville Strategy and the Statutory Framework.[4]

[4] The Seville Strategy defined four goals, identified 11 objectives and provide 90 recommendations, some 60 of which are for actions on the part of the national and site management bodies. This is a very challenging work indeed.

While it is relatively easy to understand the objectives and define the required actions to implement the Seville Strategy, it is far more difficult to carry these out in each biosphere reserve. This situation stimulates countries to seek ideas and information. As there is no one person or institute to provide the appropriate answers, networking becomes inevitable: "join your hands with colleagues". In a way, this is the reason why creating networks, either regional or thematic, has become an important development in the MAB Programme.

There are additional reasons for the five countries to work together: geographical neighbours, similar or comparable ecosystems, close economic co-operation in recent years, different development status, about which many lessons can be shared, and common cultural elements. There is much sharing in terms of traditional thinking, rooted in Buddhism, Taoism, the concept of Tian, Di, Rien (interactions between heaven, earth and human beings) and the model of Yin and Yang. Such elements are highly relevant for Asian countries in pursuing conservation and sustainable natural resource management.

An added advantage is that, through the East Asian Biosphere Reserve Network, the countries can better participate in the UNESCO's Man and the Biosphere Programme. This is particularly important for countries that are not elected to the governing body of this programmee and do not therefore particpate in the meetings at UNESCO Headquarters in Paris. One member country of the Network can represent at such meetings all members of the East Asian Biosphere Reserve Network. It has proved useful at such meetings as regards reporting on progress in implementing the Seville Strategy and the Statutory Framework of the World Network of Biosphere Reserves.

V. FUTURE TRENDS

The East Asian Biosphere Reserve Network is about to end its first phase and enter a period of actions. Project activities targeted to ecotourism, transboundary conservation, socio-economic studies in biosphere reserves and use of geographic information systems will be developed. Communication will be further enhanced through meetings, seminars and technical contacts.

The East Asian Biosphere Reserve Network has a special interest in the development of Man and the Biosphere Programme information service on the Internet and agreed to actively participate in this new MAB networking initiative, through developing national MABnet home pages, databases, and participating in the MABnet discussion groups. A recent and encouraging development is that at present, many Network participants have obtained electronic mail and it is expected that communications will be much improved in the near future.

VI. CONCLUSION

The setting up of a real network takes time. It is heartening to witness that through a 3-year joint effort, The East Asian Biosphere Reserve Network has grown to become a functioning regional network. Such a network is highly useful to countries for exchanging information, experience, ideas and skills. It is a practical mechanism to identify regional priorities for the implementation of the Seville Strategy. Field evaluations provide very

important experience. At an intermediary level, The Network helps to contribute to the development of the World Network in general through concrete national actions. It helps to convey the message from the countries on issues of common interest within the UNESCO biosphere programme and provide more visibility for this programme in international co-operation.

In essence, the East Asian Biosphere Reserve Network is the response of UNESCO's bioshere programme to greatly increasing demands for sustainable development on the one hand, and the relatively slow progress on finding ways to realize the identified objectives. Together with other regional ecological networks, the East Asian Biosphere Reserve Network has made an interesting indication for the future of UNESCO programmes: to become more regionally and nationally focused, collectively operated and culturally diversified. It is believed that the implementation of the Seville Strategy and the Statutory Framework will be very much characterized by this type of regional co-operation. This is fully in line with UNESCO's policy of decentralization. For these reasons, the East Asian Biosphere Reserve Network and other similar regional initiatives should be encouraged, consolidated and further supported by the governments and UNESCO

THE INTERNATIONAL CENTRE FOR INTEGRATED MOUNTAIN DEVELOPMENT

INTRODUCTION

The 3,500 kilometre mountain range of the Hindu Kush-Himalaya which stretches from Afghanistan in the west to Myanmar in the east is home to 120 million people. Today, their environment and livelihood are threatened by an increasing imbalance between population and available productive land. In many places, the land's carrying capacity has been exceeded, hence the ever-growing demand for new agricultural and forest land and land-based products. The forested upper slopes of these young mountains are also being cleared for cultivation, grazing fodder, fuel wood and timber. This removal of vegetation together with the heavy monsoon rain has, as a consequence, triggered large-scale erosion and landslides.

The result of all this is soil impoverishment and soil loss, and a deteriorating biophysical environment. The human cost of such degradation is serious. Poverty in the mountain communities is on the rise because the natural resource bases of forest - soil, water, plant and animal life - on which these communities depend for their continued survival are being lost at an alarming rate.

What has contributed to the neglect of mountain habitats? The answer to this must be sought in large measure in the ignorance displayed by policy makers in the past of the natural and human processes affecting these regions. Such little development efforts as were made were often of a sectoral nature, directed more at the symptom than at the cause. Measures to control the damage, therefore, need to be taken quickly before the situation becomes once and for all irreversible.

Further information on the the International Centre for Integrated Mountain Development may be obtained from the Director, UNESCO New Delhi Office, 8 Poorvi Marg Vasant Vishar, 11057 New Delhi, India (Fax: + 91 11 6873351); from the Director, Division of Ecological Sciences, UNESCO, 1 rue Miollis, 75732 Paris Cedex, France (Fax: + 33 1 45 68 5804; e-mail mab@unesco.org) or directly from the Director-General of the Centre, G.P.O. Box 3226, Kathmandu, Nepal (Fax + 997 1 524509; e-mail icimod@mos.com.np)

The International Centre for Integrated Mountain Development was founded on the widespread recognition of this alarming degradation. It is the first and only international institution entirely devoted to integrated mountain development. This autonomous, non-profit and non-political Centre grew out of a regional meeting of UNESCO's Environment Programme in 1975 in Kathmandu. Nepal agreed to host it, while Switzerland and Germany joined UNESCO as founding sponsors. Formally inaugurated in 1983, it became operational a year later. Today, the participating countries of the Hindu Kush-Himalayan region are: Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal and Pakistran.

The Centre receives its core funding from Germany, Switzerland, Austria, the Netherlands, Canada and other participating countries of the region. Project funds are provided by the Asian Development Bank, the Commission of the European Communities, Ford Foundation, the International Development Research Centre, the United Nations Environment Programme, the International Labour Organization, the World Conservation Union, the Overseas Development Administration and UNESCO. As a founding father, UNESCO has all along co-operated closely with the International Centre for Integrated Mountain Development and they have together sponsored innumerable activities.

II. OBJECTIVES AND RESULTS

Objective 1: Documentation and information exchange

- The centre has established a comprehensive documentation centre and library with computerised bibliographic and serial databases and bibliographies on a specific number of subjects.

- Currently, networking, repackaging, accessing and the compiling of databases is being carried out and efforts are being made to upgrade skills and facilities.

- Documents describing the results of original research are published by the Centre (more than 200 so far).

- Workshops, training courses are regularly sponsored.

- Other kinds of information is exchanged through public relations activities using videos.

- A permanent exhibition on major issues affecting mountain development is maintained at the Centre's Headquarters.

Objective 2: Research

- The International Centre for Integrated Mountain Development carries out research on a range of subjects, from state-of-the-art reviews of specific problem areas and policy to action-oriented research which could be of practical benefit to a limited geographical locality.

- The latter includes mountain resource management, rehabilitation of degraded lands. And sloping agricultural land technology in most of its regional member countries.

- The Centre conducts small-scale original research through programmes such as the one on bee-keeping.

- The use of findings are maximised in as many countries as possible.

- The International Centre for Integrated Mountain Development tries to identify successful interventions that can be replicated across the Hindu Kush-Himalayan region.

- Collaboration with research institutions is a major focus of the Centre's activities including provisions for institutional strengthening

Objective 3: Training

- The Centre has been helping to build national capacities in its member countries. This includes both technical skill and policy design for sustainable mountain development.

- Seminars, workshops, study tours and other meetings are organized for senior officials.

- Seminars, workshops, study tours and other meetings are organized for senior and middle-level officials and staff of government, academic and non-governmental organizations.

- Training courses on new and proven technologies and approaches towards sustainable mountain development are organized and sponsored.

Objective 4: Advisory Services

- These are provided on a continuing basis to Governments and non-governmental organizations.

- All services relating to requests for information and advice that can be handled by the Centre's Kathmandu office are provided free of charge.

- The International Centre for Integrated Mountain Development also provides advisory services on both individual and team basis. Individual experts are sometimes used by Governments in specific programmes and sometimes by bilateral and multilateral donors in their programme development and reviews.

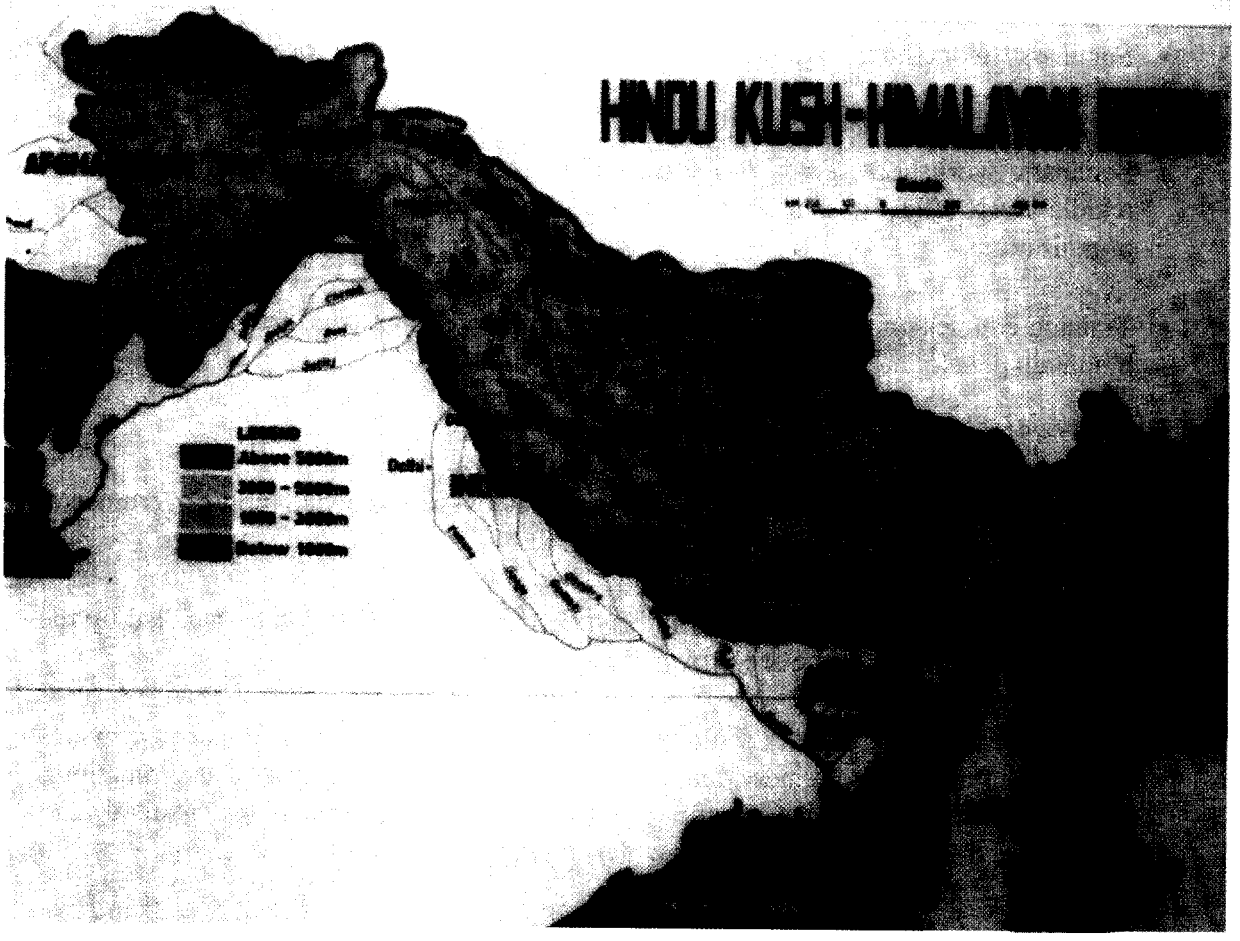
- Consultancies are offered to a programme or project begun by a related organization.

- The International Centre for Integrated Mountain Development helps in the review and assessment of planned, operational, or completed programmes on integrated mountain development or its sub-sectors.

ICIMOD

International Centre for Integrated
Mountain Development

ANNUAL REPORT 1995



III HIGHLIGHTS

(a) As the only international organization with a clearly defined eco-regional focus, The International Centre for Integrated Mountain Development provides linkages between environment and development, research and development, policies and technologies, and between different disciplines in countries of the region.

(b) Its mandate is to "promote the development of an economically and environmentally sound mountain ecosystem and to improve the living standards of mountain populations", to lift mountain communities from poverty, hunger and want while conserving the resources that are so important not only to mountain people but to much larger populations in the adjoining plains.

(c) Its ambitious long-term goal is to contribute to environmental stability and poverty eradication in the Hindu Kush-Himalayas. With this end in view, it has been working towards the diversification of mountain economies and the building up a strong information networks in this field

CONSERVATION, RESEARCH & CAPACITY BUILDING IN THE FOREST OF THE LION KING, SRI LANKA

INTRODUCTION

Biosphere reserves provide geographic "hubs" for the conservation of landscapes containing characteristic ecosystems of a given biogeographical region and for research, monitoring, demonstration, education and training relating to the wise use of these ecosystems and their resources.

Explicit in the concept are the notions of multiple functions and zoning land areas for different uses, including the development of buffer zones and transition areas around protected areas as a way of reducing pressure on threatened sites. In tropical forest regions, the development of buffer zones and transition areas is intended in particular to provide alternatives to forest encroachment and shifting cultivation.

As of mid-1996, the World Network of Biosphere Reserves comprises 337 sites in 85 countries. In the Asian region, a number of biosphere reserves are important sites for research and conservation on tropical forests, including Xishuangbanna in Southern China, Gunung Leuser in Indonesia and Sakaerat in Thailand.

In Sri Lanka, there is a network of nationally recognized biosphere reserves, with two sites recognized internationally by UNESCO as contributing to the world network: Hurulu in the monsoon forest zone in the northern part of the country and Sinharaja in the lowland wet zone in the southeast. This contribution presents an overview of Sinharaja and its conservation importance, and glimpses into the research, training and environmental education activities underway there.

CONSERVATION IMPORTANCE

Sinharaja (in Sinhalese, literally the "lion king") is the largest block of evergreen rain forest remaining in the lowland wet zone of Sri Lanka. Its conservation importance and biogeographic value lie in the high endemism of its flora and fauna with restricted distribution:

This contribution was prepared by UNESCO staff ecologists Malcolm Hadley, Division of Ecological Sciences, UNESCO, 1 rue Miollis, 75732 Paris Cedex, France (Fax: + 33 1 45 68 5804) and Natarajan Ishwaran, UNESCO Jakarta Office, UN Building, 2nd Floor, Jalam Thamrin 14, Tromolpos 1273/JKT, Jakarta 10012, Indonesia. Fax: +(62-21) 315 0382 drawing extensively on articles and reports prepared by Professors Nimal and Savitri Gunatilleke and other scientists working at Sinharaja. Further information on Sinharaja may be obtained from articles and reports referenced at the end of this contribution, or from Professor Nimal Gunatilleke, Department of Botany, Peradeniya University, Peradeniya, Sri Lanka. Fax: (94)(8) 88018. E-mail: nimsav@pdn.sc.ac.lk.

The status of Sinharaja has changed over the years from a wilderness with traditional mysticism to one of exploitation for timber and again to one of conservation. Prior to 1972 it was a protected forest largely due to its inaccessibility. Between 1972 and 1977 the western part of Sinharaja was a production forest, mainly for plywood. During this time 40 ha at Warunkandeniya in the south central part and 1,800 ha in the eastern part were designated as National Biosphere Reserves. In 1978, however, logging at Sinharaja was stopped and the whole area of 8,500 ha, comprising 65% high forest and 34% of fernlands and secondary forest, declared an International Biosphere Reserve by UNESCO. In the 1980s an additional 2,687 ha on the eastern end representing sub-montane forests, was included to the Sinharaja reserve, making a total of 11,187 ha. In 1988, this entire area was declared a National Heritage Wilderness area and subsequently in 1990, UNESCO recognized it as a Natural World Heritage site.

Efforts to promote conservation and sustainable development are rooted in the Conservation Plan prepared in 1986 by the Ministry of Lands and Land Development, the Forest Department, WWF and the World Conservation Union - implemented with financial assistance from NORAD, technical support from the World Conservation Union and participation of a number of universities, NGOs and government agencies. Participatory approaches to buffer zone development involving local people include promotion and propagation of locally useful plants (e.g. cane, palm, wild cardamon), encouragement of local industries to manufacture items such as cane-work, establishment and maintenance of fast-growing timber and firewood species for local consumption, and the setting-up of camping sites and other tourist facilities.

RESEARCH ACTIVITIES

Research at Sinharaja, initiated with tree enumerations to estimate its timber potential, has been systematically expanded over the years into an interdisciplinary research programme subsequent to its elevated protective status in the late 1970s. Research at Sinharaja includes the phytosociology of the tree flora, restoration and regeneration ecology, soil biology and nutrient cycling, reproductive biology and genetic diversity of underutilized species, ecology of birds and small mammals, long-term forest dynamics, rural sociology, and resource economics. Sinharaja was one of the programme sites for the Tropical Soil Biology and Fertility programme of the International Union of Biological Sciences and the Man and the Biosphere (MAB) Programme of UNESCO, and continues to be one of the sites within the Long-term Forest Dynamics Programme launched by the Center for Tropical Forest Science of the Smithsonian Institution. Research information generated so far has not only enhanced the conservation value of the forest but also contributed towards its management for multiple uses, as reflected in the overviews of some research areas provided in the following paragraphs.

Estimation of timber potential

In a study published in 1959, timber potential was estimated using plot sampling in 43.3 ha of undisturbed forest and correlation of air photo distribution patterns to site characteristics. This study identified a total of 118 tree species and eight different primary forest communities, or "forest strata". These communities included two communities in Hora (*Dipterocarpus*) alluvial flats and other alluvial flats, two on medium and high ridges, and the remaining four on the midslopes, with the utility hardwood and Na-Dun type (*Mesua, Doona, Shorea* association) the most extensive, forming a matrix in which the others are distributed. The merchantable stock among these forest types varied between 9-43 stems/ha, 58-74 cm diameter, 9.1-31.6 m height to

the first branch. The highest timber values were reported for utility hardwood and Na-Dun (*Mesua, Doona, Shorea*) type of communities, and the lowest in the midslopes and alluvial flats. Tree species diversity was highest in the utility hardwood forest and reported to be 109 species. In the remaining communities, it varied between 51 and 83.

Floristic studies

Studies were initiated in 1977 to understand the floristic wealth of Sinharaja, specifically of the tree species. Initial quantitative studies focused on trees over 30 cm diameter at breast height in five relatively undisturbed sites, representing different parts of the Sinharaja forest. Aspects examined included variations in tree density (594-769 individuals/ha), basal area (36-41 m^2/ha), species richness (115-144/ha) and dominance in different parts of the forest, as well as the contribution of endemic species to density, basal area and floristic richness (75-93%, 87-93%, 64-75% respectively).

This early work laid the foundation for future floristic studies on the distribution and conservation of threatened woody endemic species of Sri Lanka and underutilized plant resources of Sinharaja. Comparison of phytosociology of neighbouring modified rain forest sites with varying gap sizes (a selectively logged site, an abandoned skid trail and an abandoned shifting cultivated site) was compared with that of the undisturbed forest. This latter study recorded 9-11% of pioneer species in the undisturbed and selectively logged sites compared to 29-32% in the highly degraded sites. The proportion of endemic species was shown to decrease from 62% to 44% with increasing degree of disturbance and larger gap size. It was found that 77% of the species performed better in the primary forest and selectively logged sites.

In 1993, quantitative sampling in a 25 ha plot was initiated to monitor long-term dynamics of forest structure and functions within the primary forest. Information being gathered in the current mega-plot can be used for many purposes, among them, mortality and growth rates of primary forest species, response to climate change, distribution patterns and population sizes of species in the primary forest that are common, rare and of medicinal and other utility value.

Faunistic studies

Systematic studies on the fauna of Sinharaja were initiated in 1981. Of the 262 vertebrate species recorded to date (11 fish, 20 amphibians, 45 reptiles, 147 birds and 39 mammals), 60 are endemic to Sri Lanka (three fish, 10 amphibians, 21 reptiles, 18 birds and 18 mammals). Sinharaja harbours 19% of the fish, 53% of the amphibians, 57% of the reptiles, 90% of the birds and 67% of the mammals endemic to Sri Lanka.

Investigations on the effect of logging and deforestation on small mammals have revealed that the populations of some endemic species like *Srilankamis ohiensis* (Sri Lanka bicoloured rat) declined, while others like *Coelomys mayori pococki* (spiny rat) which prefers bushy habitats increased with disturbance. The pest species (*Rattus* spp. and *Bandicotta* spp.) also increased with logging. Similar compositional changes were also observed for the bird fauna, with the endemics being most affected.

Avian flock feeding patterns were examined at Sinharaja between 1982 and 1987 in the selectively logged northwestern sector of the forest, where pioneer species were common along the logging roads. Different bird species and some mammals - like the giant squirrel, jungle

squirrel, purple faced leaf monkey and mouse deer - were observed to aggregate and move together for feeding efficiency and predator protection. The home ranges of some bird species and visitation of migrants were also studied in the early-mid 1980s. A follow-up study carried out in 1995 indicated that the order of frequency with which species appeared in the flocks changed considerably over the interim period. Among the species whose frequency had declined over 13 years were the Sri Lankan White-eye (*Zoosterops ceylonensis*), Pied Shrike (*Hemiphus pictacus*) and the Yellow Fronted Barbet (*Megalaima flavifrons*). Many birds of the undergrowth seem to have increased in their frequency, especially the Blue Magpie (*Urocissa ornata*), Green-Billed Coucal (*Centropus chlrorophynchus*) and the Hornbill (*Ocyceros gingalensis*).

Only a few studies have been carried out on the invertebrate fauna. An in-depth habitat survey of the mosquito fauna, totalling 34 species in ten genera, reported species associated with tree holes, the pitchers of the plant *Nepenthes distillatoria*, and ground water pools on roadsides, marshes and rocks. The most abundant, diurnal, human-biting species was *Heismania* sp. The Sinharaja mosquito fauna showed low species diversity compared to the 42-117 species in secondary forests elsewhere in Sri Lanka.

Soil studies

The physico-chemical and biological properties of soils in the "undisturbed primary" forest have been compared with those from disturbed or converted sites, including abandoned shifting cultivation sites which have remained as *Dicranopteris* fernlands or replanted with *Pinus* species.

With respect to the soil microflora, endomycorrhizae populations have been compared in the mature forest and in modified forest sites (*Pinus* plantation and *Dicranopteris linearis* fernland). Endomycorrhizal spores at all sites decreased with depth. Spore populations in the upper 20 cm of soil were significantly higher in the *Pinus* plantation compared to those in the fernland and natural forest. Spore populations were lowest in the natural forest. In all sites and at all depths, spore counts increased seasonally from January (< 200 mm rain) through May (450 mm rain). Mycorrhizal infection was observed in 75% of the plant species examined in the natural forest, 42% in the *Pinus* plantation and 50% in the fernland. This suggests that there is adequate mycorrhizal inoculum in the modified sites to support higher plant species growing in them.

Litter decomposition in Sinharaja rain forest and an adjacent fernland has been compared using leaf litter of one of the dominant forest species, *Cullenia ceylanica*, and the dominant fernland species *Dicranopteris linearis*. This study showed higher mass loss through decomposition for both litter types in the natural forest soil (63% and 41.7% respectively) compared to that in the fernland. *C. ceylanica* litter decomposed much faster than that of *D. linearis* in both habitats. Nutrient changes examined in litter over a period of one year showed immobilization of nitrogen in both litter types in both treatments and phosphorous only in *D. linearis*. Concentration and mass of K, Mg and Ca decreased with decomposition in all treatments. There was a relatively slow rate of litter decomposition, an accumulation of organic matter and higher biological nitrogen fixation (by acetylene reduction method) in the fernland, all contributing to the conservation of nutrients in this aggrading ecosystem.

Comparative studies have been undertaken within the aegis of the International Union of Biological Sciences-UNESCO Tropical Soil Biology and Fertility programme on the structure and functioning of natural and managed ecosystem (primary forest vs. *Pinus* and *Hevea* plantations),

with a comprehensive site characterization study using standardized and calibrated methods selected and/or developed by the tropical soil biology and fertility programme.

Ecology and reproductive biology of timber and non-timber forest species

Studies on the population and breeding biology of several plants important in the local economy have been designed to understand the potential for their domestication, with a view to products traditionally gathered from the undisturbed forest becoming available from agroforestry systems in the buffer and transition zones. Species studied include rattans, *Coscinium fenestratum* (a medicinal vine), *Caryota urens* (a palm which provides a sugar sap) and wild cardamon (used for both its spice and medicinal properties) and several dipterocarp tree species. The initial work, supported through a US-aid initiative, was mainly undertaken by Sri Lankan post-graduate students working in the Department of Botany of the University of Peradeniya. American scientists associated with the project included principal investigator Peter Ashton (Harvard University) and co-principal investigators Kamaljit Bawa (University of Massachusetts), Mark Ashton (Yale University) and Richard Primack (Boston University).

The various non-timber forest species all performed better in the selectively logged forests as compared to the undisturbed forest, where they were either absent or showed poor growth. Some of the canopy trees (*Shorea megistophylla, Shorea distica, Shorea cordifolia* and *Vateria copallifera*) provide a source of carbohydrate from their cotyledons, which also have medicinal properties. Some of these species also yield resin. Work on the reproductive biology of these and several other species (*Shorea congestiflora, Shorea trapezifolia, Shorea affinis*) has aimed at understanding their pollination ecology, breeding biology, seed germination and seedling ecology, with results being presented in several international scientific periodicals and proceedings volumes.

Phenological studies over a 10-year period showed that *Shorea* spp. at Sinharaja flower annually and sequentially, with non-overlapping peak periods. Based on their flowering patterns, two major groups have been identified among these species. In one group, the *thiniyas*, good flowering occurs annually. In the second, the *beraliyas*, good flowering years alternate with many years of poor flowering. Studies have also been carried out on the amount and distribution of genetic variation in natural populations of Dipterocarpaceae, the tree family that dominates the tropical lowland wet rain forests of South and Southeast Asia. Information on genetic variation is important not only for the understanding of the mode of speciation in tropical forests but also for the conservation of rapidly declining forest genetic resources.

One species that has been particularly studied is *Shorea trapezifolia*, a species of hardwood dipterocarp found only in Sri Lanka, which has some special and potentially important characteristics. Researchers have found that, unlike other rain forest dipterocarps, it flowers every year, sometimes even more than once. Added to this, the species, remarkably for a dipterocarp, grows very fast. The reason for this rapid growth appears to be that, unlike others examined, this species puts on new flushes of leaves at the same time that it flowers, and thereby remains perpetually in full leaf. With the fruit wings photosynthesizing in addition, the tree may well carry more photosynthetic surface than any of its cousins.

The species is found in pure stands on sloping land at medium altitude in Sri Lanka on various soils. The importance of the discovery of the unique characteristics of this species, which is an excellent species for making quality plywood, is that it will apparently grow faster and stronger than other species and that it flowers each year, so that it should provide plenty of seeds. It is therefore an exceptional candidate for reforestation efforts.

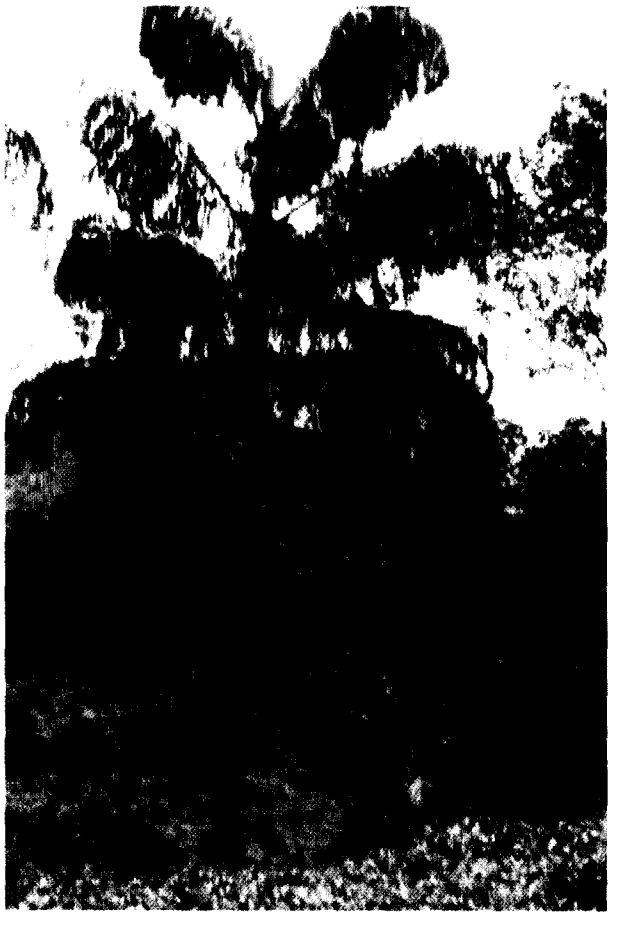


Photo 1: A fishtale palm of kitul (Caryota urens) whose inflorescences are tapped by villages. Its sugary exudate may be concentrated and set to make a candy called "joggery" or fermented to give an alcoholic brew called "toddy". Photo by N. Gunatilleke

Silviculture

Initiated in 1985, seedling studies on nine *Shorea* spp. (section *Doona*), two *Dipterocarpus* spp. and two *Mesua* spp., all canopy species, have aimed at understanding their specific growth requirements for establishment. Seedling performance has been compared in controlled environments within shelters simulating different microsite conditions of light and moisture encountered in the natural forest. Each of the study species appears to have specific requirements enabling it to grow best in certain microhabitats that are different from its congeneric associates. The ecophysiological and morphological differences exhibited by each species under different microsites and different species under the same microsite, have also been described.

Performance of seedlings grown in soils collected across a topographic gradient (ridge to valley, 100 m distance apart) in the natural forest and in soil taken from the midslope of a *Pinus* plantation have been examined. In this study, all species showed higher growth in the valley soil of the natural forest and the soil from the *Pinus* plantation, as compared to soils from the ridge and midslope of the natural forest. Midslope soil showed the least growth for all species. Differences in growth among the species within each soil type were also observed.

Seedling establishment and growth of the test species in different microsites of canopy gaps have been examined. The study included microsites within each gap and those different gaps positioned along the topographic gradient (valley, midslope, ridge) in a natural forest. In each gap, seedling performance has been compared at the gap centre, edges and the forest understorey adjacent to the gap.

Photos 2 and 3: Field Research station at Sinharaja, where experimental work has included trials with tree seedlings under different fertilizer treatments and light conditions. Photos by N. Gunatilleke

Study of competition among seedlings of congeneric species in natural forest gaps is also in progress. Here too, the performance at the gap centre, edges and the forest understorey adjacent to the gap have been compared. Results also demonstrate specialization of species on different sites.

Response of seedlings to altitudinal variation (125 m, 580 m, 1060 m) has been examined by growing potted seedlings in artificial shelters at each elevation to understand why some of them are not found at low and high elevations. In this transplant experiment, all seedlings at all sites were potted (to exclude competition among them) in soil taken from the upper layers of a *Pinus* plantation at mid elevation (to exclude soil variation in the experiment).

Seedlings of dipterocarps and several other commercial species have been planted under different canopy-opening treatments in *Pinus caribaea* plantations in the buffer zone of the reserve. This field experiment has examined the growth and survival of three groups of species: primary forest timber species, non-timber forest species and agricultural export species (domesticated cardamon, pepper, cinnamon and coffee). The results are being used to develop enrichment planting guidelines for these species in *Pinus* plantations of the hill regions in southwest Sri Lanka.

Other studies are investigating methods of initiating rain forest succession on fernlands. Removal of the fern rhizome and root mass, and raking the soil, have led to the initiation and establishment of pioneer vegetation by seed of buried and aerial origin.

Socio-economic studies

Socio-anthropological surveys at Sinharaja provide insights into the interaction between people living around the reserve and the forest, including the importance of forest products for households, both for subsistence and commercial use. In Sinharaja and surrounding forests, some 179 forest species, of which 33% are endemic, provide forest products gathered by villagers. Folk knowledge on the indigenous use of forest products, gathered by surveys in two villages bordering Sinharaja, reveal significant relationships with age, gender, distance to forest, and social participation.

The Yale University School of Forestry and Environmental Studies is among those foreign institutions which have developed close research and training links with Sinharaja, with several students undertaking work for masters theses. One study has used the time allocation method to determine the direct use of non-timber forest products by women from the village of Pitikele (in Sinhalese, "outside the forest") in the pine buffer zone of Sinharaja. The study forms part of a broader project on the impacts of economic development on the extraction of non-timber forest products. The working hypothesis that women would allocate a significant proportion of their time to collecting forest products from Sinharaja proved incorrect. Women spent most of their summer months cultivating home-gardens. One conclusion is that the time allocation method is probably a weak valuation technique for non-timber forest products use in the particular study situation due to the gender division of labour and changes in the subsistence strategy of villagers living in Pitikele. This particular village behaviour may not be replicated in other peripheral villages at Sinharaja.

Other studies on resource economics have focused on the value of Sinharaja as a conservation commodity, including the use of the travel cost method, where visitors coming from

nine districts have been sampled to assess Sinharaja's scenic beauty, recreational, educational and scientific value. Contingent valuation has also been used to compare the willingness of rural and urban communities to pay for its conservation.

TRAINING AND ENVIRONMENTAL EDUCATION

In Sri Lanka, Sinharaja is an important site for training and environmental education. Since 1988, visitors to Sinharaja have increased almost exponentially (Tables 1 and 2) due to the large publicity given to it through the mass media and tour guidebooks on Sri Lanka, and its inclusion in ecology curricula of pre-university and university courses in the island. Of particular note is the large number of schoolchildren and students among the visitors (of 16,357 visitors to the northwestern side of Sinharaja in 1994, 7150 were shoolchildren and students).

Visitors and village guides

All visitors to Sinharaja are accompanied by guides, selected from among the young people in villages surrounding the forest. These guides, resident in the area, have a first hand knowledge of animals and plants in the forest. In addition, they are given a formal training through workshops organized by the Forest Department and the Universities. English classes too have been arranged for them, so that they can communicate with overseas visitors. One noteworthy initiative is that local guides are guaranteed a basic income equivalent to 15 days work per month, by the management agency responsible for Sinharaja (i.e. the Forest Department), whether or not they have visitors to accompany for that number of days.

There is also an education centre, equipped with posters and exhibits, for visitor use at Sinharaja. Over-night visitors are also shown films and a slide presentation, and on request the officers also give presentations on Sinharaja. Through the organization of 1-2 day medical camps, villagers around the forest are given an opportunity to see a medical specialist. This not only enhances the village-Forest Department relationships, but the medical officers themselves get to know the forest. In the case of one group of medical officers, their enthusiasm on Sinharaja culminated in including one whole session of their annual meeting to biodiversity. In 1990, 1994 and 1995, health camps were conducted at Sinharaja.

Trainers and managers

Training workshops of several days duration are often conducted at Sinharaja for selected groups, such as school teachers, officers of the various environment-related departments, rural leaders, journalists, university students and members of non-governmental organizations. Thus in 1994, six such workshops were conducted, drawing on resource personnel from the Forest Department, non-governmental organizations and university departments of biology and socio-economics.

As an example, mention might be made of a three-day seminar organized at Sinharaja in December 1993 on the topic of 'Some interdisciplinary research insights towards sustainable management of lowland rain forests of Sri Lanka'. The main objective of the workshop was to communicate research findings emerging from Sinharaja in different disciplines (e.g. forest biology, forest ecology, nutrient dynamics and soil fertility, silviculture, rural sociology and resource economics) through a series of lectures, poster and publication displays and field visits.

The significance of interdisciplinary research approaches in moving towards the sustainable management of rain forests was emphasized in each section. In addition to six resource persons (from Peradeniya and Sri Jayawardenapura Universities and the Yale University School of Forestry), taking part were twenty-eight forest managers, researchers, environmentalists and policy planners. They were drawn mainly from the Forest Department, Forestry Planning Unit of the Ministry of Forestry, Irrigation and Mahaweli Development, Environmental Officers of the Ministry of Environment and representatives of a non-governmental organization, a Sri Lankan weekly science paper and several donor agencies.

Introductory lectures addressed the use of Sinharaja as a centre of excellence for interdisciplinary research and education in forest sciences, and the role of environmental economics in sustainable forest management. Other topics addressed in the workshop included: Natural forest dynamics; Growth and ecophysiological responses of selected canopy species under different light and moisture regimes under controlled conditions; Enrichment of broadleaf species under *Pinus caribaea* plantations subjected to different thinning regimes; Sociological aspects of peripheral villages in relation to buffer zone management; Economic incentives for sustainable forest management; Biology of timber and non-timber forest species in relation to their management.

Research and education for undergraduates and postgraduates

Training is one component of almost all research programmes conducted at Sinharaja. Post-graduates reading for higher degrees through full-time research, acquire an in-depth knowledge of specialized fields in ecology, silviculture, and socio-economics. In addition, those following taught courses for graduate and post-graduate degrees related to biology, forestry and environmental studies are most often taken to Sinharaja as part of their field classes. In addition, special field training courses are organized at Sinharaja for graduate and post-graduate groups. One recent example was a four-day field work programme held in March 1996 for post-graduates in forestry of the University of Sri Jayawardanapura and in botany and zoology of the University of Peradeniya.

CONCLUDING REMARKS

Sinharaja Biosphere Reserve and World Heritage site in the lowland wet zone of Sri Lanka, is a site where a real effort is being made to develop and integrate the multiple functions of the biosphere reserve concept and to involve multiple stakeholders and partnerships.

In seeking to reconcile the often conflicting interests of conservation and development, there is an involvement and presence of government, particularly through the Department of Forests which operates the main field base and is responsible for the elaboration and implementation of the management plan for Sinharaja. Approaches to improved rural development and local livelihoods include enrichment planting using primary forest timber and non-timber species in *Pinus* stands in the buffer zone of the reserve, exploring the potential of locally esteemed non-timber species for domestication, and encouraging young people from adjacent villages to guide visitors around Sinharaja.

Sinharaja fulfils an important training and education function, reflected in the inclusion of Sinharaja in ecology curricula of pre-university and university courses in the country (e.g. questions specifically on Sinharaja are set periodically in terminal examinations of secondary school and university students). In this vein, nearly half of the total number of the 16,000 visitors to the northwestern side of Sinharaja in 1994, were schoolchildren and students. There is an education centre, equipped with posters and exhibits, and all visitors to Sinharaja are accompanied by guides selected from among the youth in villages surrounding the forest. Training workshops of several days duration are organized for selected groups, including school teachers, officers of various environmental related departments, journalists, rural leaders, university students.

Research provides essential underpinning for the activities of conservation, integrated rural development, training and education. Crucial here is the long-term commitment of a core group of dedicated university-based researchers to working at Sinharaja. Research combines long-term process work and more focused problem-oriented projects incorporating biological and socio-economic studies, and long-term co-operation has been developed with researchers based in prestigious tertiary institutions abroad. Among other spin-off benefits, these links facilitate the training of post-graduate students from Sri Lanka in specialized institutions having access to techniques not yet available in the country.

A range of other institutional links have been developed with national governmental departments, research and training institutions and non-governmental bodies (e.g. March for Conservation, World Conservation Union-Sri Lanka), as well as with outside technical bodies and financial sources, including the Global Environment Facility (via the World Cnservation Union) and the MacArthur Foundation. Although the flow of financial and other support remains a continuing concern and challenge, the diversity and very nature of linkages such as these are important for the long-term viability of Sinharaja as a multifunctional site for conservation, community development, research, education and training.

Table 1. Number of annual local and overseas visitors to northwestern Sinharaja (Data from Forest Department).

ANNUAL VARIATION OF VISITORS TO SINHRAJA

Year	1988	1989	1990	1991	1992	1993	1994
Local	633	369	1,673	4,171	10,365	12,617	14,562
Overseas	148	114	196	357	808	921	1,795
Total	781	483	1,869	4,528	11,174	13,538	16,357

Table 2. Number of visitors to the northwestern side of Sinharaja for the months of 1994 (Data from Forest Department).

1994	**VISITOR CATEGORY**			
	Locals		Overseas	ALL
	Students	Others		
January 307	466	10	874	
February	851	1,102	198	2,151
March	2,146	1,260	187	3,593
April	954	900	73	1,927
May	307	568	41	916
June	538	444	22	1,004
July	816	614	104	1,534
August	272	504	162	938
September	162	108	717	990
October	219	272	65	556
November	101	256	61	418
December	474	918	64	1,456
ALL MONTHS	7,150	7,412	1,795	16,357

SELECTED BIBLIOGRAPHY

The following selected references provide glimpses into the conservation and research activities at Sinharaja, and entries into the broader scientific literature relating to the Forest of the Lion King.

Abeygunawardena, P. 1993. Total economic value of forests: The case of Sinharaja Forest in Sri Lanka. Paper presented at the World Bank sponsored regional seminar on forest conservation, Kandy, 3 Oct. 1993 (Forthcoming World Bank paper).

Anon. 1988. Project Proposal - Sinharaja Conservation Project, Sri Lanka. Forest Department, Ministry of Lands and Land Development, and WWF/IUCN. Colombo.

Anon. 1993. Management Plan for the Conservation of the Sinharaja Forest. Phase 11. Forest Department, Ministry of Lands and Land Development, and WWF/IUCN, Colombo, Sri Lanka.

Ashton, P.M.S. 1994. Seedling growth of co-occurring *Shorea* species in the simulated light environments of a rain forest. *Forest Ecology and Management* 72: 1-12.

Ashton, P.M.S.; Gunatilleke, I.A.U.N.; Gunatilleke, C.V.S. 1995. Seedling survival and growth of four *Shorea* species in a Sri Lankan rain forest. *Journal of Tropical Ecology* 11: 263-279.

Banyard, S.G.; Fernando, D. 1988. Sinharaja Forest: monitoring changes by using aerial photographs of two different dates. *Sri Lanka Forester*, 18: 101-108.

Cohen, A.L.; Sinhakumara, B.M.P.; Ashton, P.M.S. 1995. Releasing rain forest succession: A case study in the *Dicranopteris linearis* fernlands of Sri Lanka. *Restoration Ecology*, 3(4): 261-270.

Dayanandan, S.; Attygalle, D.N.C.; Abeygunasekera, A.W.W.L.; Gunatilleke, I.A.U.N.; Gunatilleke, C.V.S. 1990. Phenology and floral morphology in relation to pollination of some Sri Lankan Dipterocarps. In: K.S. Bawa & M. Hadley (Eds.), *Reproductive Ecology of Tropical Forest Plants*, pp. 105-135. Man and the Biosphere Series 7. UNESCO, Paris & Parthenon Publishing, Carnforth.

De Zoysa, N. 1994. 10 years of interdisciplinary research at Sinharaja. *Inside CTFS* (Newsletter of the Center for Tropical Forest Science of the Smithsonian Tropical Research Institute), Fall 1994: 6.

De Zoysa, N.D.; Gunatilleke, C.V.S.; Gunatilleke, I.A.U.N. 1990. Comparative phytosociology of natural and modified rain forest sites in Sinharaja MAB reserve in Sri Lanka. In: A. Gómez-Pompa, T.C. Whitmore & M. Hadley (Eds.), *Rain Forest Regeneration and Management*, pp. 215-233. Man and the Biosphere Series Volume 6. UNESCO, Paris & Parthenon Publishing, Carnforth.

Ekanayake, E.M.A.; Abeygunawardena, P. 1994. Valuation of conservation commodity of the Sinharaja forest: towards total economic value. *Sri Lankan Journal of Agricultural Economics*, 2(1): 7-22.

Gunatilleke, C.V.S.; Gunatilleke, I.A.U.N. 1981. The floristic composition of Sinharaja - A rain forest in Sri Lanka with special reference to endemics and Dipterocarps. *The Malaysian Forester*, 44: 386-396.

Gunatilleke, C.V.S.; Gunatilleke, I.A.U.N. 1985. Phytosiology of Sinharaja - A contribution to rain forest conservation in Sri Lanka. *Biological Conservation*, 31: 21-40.

Gunatilleke, C.V.S.; Gunatilleke, I.A.U.N.; Ashton, P.M.S. 1995. Rain forest research and conservation: The Sinharaja experience in Sri Lanka. Paper presented at the Interaction Conference on Biosphere Reserves. Seville (Spain), 20-25 March 1995.

Gunatilleke, C.V.S.; Perera, G.A.D.; Ashton, P.M.S.; Ashton, P.S.; Gunatilleke, I.A.U.N. 1996. Seedling growth of *Shorea* section *Doona* (Dipterocarpaceae) in soils from topographically different sites of Sinharaja rain forest in Sri Lanka. In: M.D. Swaine (Ed.), *The Ecology of Tropical Forest Tree Seedlings*, pp. 245-265. Man and the Biosphere Series, Volume 17. UNESCO, Paris & Parthenon Publishing, Carnforth.

Gunatilleke, I.A.U.N.; Gunatilleke, C.V.S. 1993. Underutilized food plant resources of Sinharaja rain forest, Sri Lanka. C.M. Hladik, A. Hladik, O.F. Linares, H. Pagezy, A. Semple & M. Hadley (Eds.), pp. 183-198. Man and the Biosphere Series, Volume 13. UNESCO, Paris & Parthenon Publishing, Carnforth.

Gunatilleke, I.A.U.N.; Gunatilleke, C.V.S. 1996. *Sinharaja: World Heritage Site, Sri Lanka.* Natural Resources, Energy and Science Authority (NARESA), Colombo.

Gunatilleke, I.A.U.N.; Gunatilleke, C.V.S.; Abeygunawardena, P. 1993. Interdisciplinary research towards management of non-timber forest resources in lowland rain forests of Sri Lanka. *Economic Botany*, 47(3): 282-290.

Gunatilleke, I.A.U.N.; Gunatilleke, C.V.S. 1994. An Interdisciplinary research initiative towards sustainable management of forest resources in lowland rain forests of Sri Lanka. *Journal of Sustainable Forestry.*

Hafeel, K.M.; Gunatilleke, I.A.U.N. 1989. Distribution of endomomycorrhizal spores in disturbed sites of a lowland rain forest in Sri Lanka. In: A. Mahadevan, N. Raman & K. Nadarajan (Eds.), *Mycorrhizae for Green Asia*, pp. 37-45. University of Madras, Madras.

Ishwaran, N.; Erdelen, W. 1990. Conserving Sinharaja - an experiment in sustainable development in Sri Lanka. *Ambio*, 19(5): 237-244.

Jasatuliyena, A. 1994. Sinharaja 25-hectare plant established with help of villagers and students. *Inside CTFS* (Newsletter of Center for Tropical Forest Science of the Smithsonian Tropical Research Institute), Fall 1994: 4-5.

Kariyawasam, D. 1994. Balancing conservation and villagers' needs in Sinharaja. *Inside CTFS* (Newsletter of the Center for Tropical Forest Science of the Smithsonian Tropical Institute), Fall 1994: 7.

Kotagama, S.W.; Karunaratne, P.B.; Ratrayake, A., de Zoysa, N.D. 1986. Faunal studies in the Sinharaja rain forest. ii. Study of mixed - species foraging bird flocks. Proceedings of the 42nd Annual Sessions of the Sri Lanka Association for the Advancement of Science, pp. 134.

Maheswaran, J.; Gunatilleke, I.A.U.N. 1988. Litter decomposition in a lowland rain forest and a deforested area in Sri Lanka. *Biotropica*, 20(2): 90-99.

Maheswaran, J.; Gunatilleke, I.A.U.N. 1987. Soil physico-chemical properties of Sinharaja forest, Sri Lanka and the effect of deforestation. In: A.J.G.H. Kostermans (Ed.), *Proceedings of the Third Round Table Conference on Dipterocarps*, pp. 121-134. UNESCO Regional Office for Science and Technology for South-east Asia, Jakarta.

Maheswaran, J.; Gunatilleke, I.A.U.N. 1990. Nitrogenase activity in soil and litter of a tropical lowland rain forest and an adjacent fernland in Sri Lanka. *Journal of Tropical Ecology*, 6(3): 281-290.

UNESCO. 1990. Sinharaja (Sri Lanka): an experiment in local community development in the forest of the lion king. In: *Ecology Chronicle. Twenty-four windows on the Man and the Biosphere Programme 1989-1990*, pp. 36-37. UNESCO, Paris.

HONG KONG : BURGEONING, POLYVALENT, PLURALISTIC AND UBIQUITOUS

I. DIVERSITY AND UBIQUITY

It is difficult to imagine a citizen or a place in this world that, at some point of their existence, have not come in touch with a product "made in Hong Kong", all the way from the most functional, technically perfected and sought after, to what the fastidious consumer would consider to be the most fatuous and kitsch. Thus, high tech electronics, electronic gadgets, electric appliances, clothing, exotic food and drink, household items, plastics, tools, machines, ships, watches, cameras, shoes, decorative objects, toys, musical recordings, martial arts schooling, action movies, large-scale banking, stock market and exchange services, tourism and leisure activities, traditional medicine, genuine imitation antiques, and colorful folklore are just part of an incredibly wide array of products "made in Hong Kong" that find their way in the most remote corners of the world. This extraordinary productivity and ability to find appropriate niches in different marketplaces and economies in all continents of our world suscitates admiration, awe, apprehension and of course, stimulates consumerism on the basis of maintaining very competitive prices, even in places with low purchasing power and weak currencies. We thus witness a burgeoning phenomenon which is associated to the transition of Hong Kong from a trade community in the beginning of our century, to a globally recognized industrial and commercial power as we steadily approach the Third Millennium.

As we shall see later, the environmental dimension of Hong Kong not only has helped to exemplify how human beings and their activities can affect the total environment, but also how the environment impacted and changed by human beings and their activities can affect the human population itself. In fact, during the second half of this century, Hong Kong has become a unique laboratory for human, urban and regional ecological studies (Boyden, 1976, 1976a, 1976b, 1977, 1979, 1980, 1984), thus helping to develop the basis for an ecological paradigm for cities (Boyden *et al,* 1981; Boyden and Celecia, 1981; Celecia 1987, 1992, 1996).

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II. A FEW FACTS AND FIGURES ON HONG KONG

We witness one of the most density populated urban/industrial areas in the world, with close to 6 million inhabitants packed in 1,067.43 km_2 (2,903.5 km_2 with its interior waters). This implies a density of some 60,000 inhabitants per 1,000 hectares. Nevertheless, the population growth rate keeps at about 0.86 %, which is equivalent to that of Cuba, New Zealand and the Republic of Korea, and only slightly more than Canada, the Russian Federation, the United States of America and Uruguay (United Nations Centre for Human Settlements, 1991).

Hong Kong is now a Special Autonomy Zone of the Peoples' Republic of China, following the transfer of its sovereignty from the British Government on 1 July 1997. It is located in South Eastern China, on the South China Sea and at about 130 km from the city of Canton (Guangzhou). It includes Kong Kong Island (78.94 km_2), Kowloon Peninsula et Stonecutters Island (1 1.31 km_2) and a section of Chinese mainland (973.77 km_2 and 35.4 km of frontier). The capital is Victoria in Hong Kong Island with over 500,000 inhabitants. Hong Kong, which in Cantonese (heung gong) means "perfumed harbor", enjoys a sub-tropical climate with a monsoon season from March to May. The highest elevation is Tai Mo Shan at 957 m. asl. Since part of its territory includes about 1,836.1 km_2 of interior waters, about 60,000 people live in junks and sampans (Chinese vessels). The bulk of its population, about 98%, is Chinese; but it also includes British, Vietnamese, Japanese, Indians, Philippines, Americans, Malaysians, Pakistanis, Australians and French. The major languages are English and Chinese. All major religions are represented: Buddhist, Taoist, Christian, Moslem, Jewish, Hinduist and Sikh. (World Almanac and Book of Facts., 1990; Dictionnaire Encyclopédique de la Langue Francaise, 1990; Frémy, 1996)

There is an intensive horticultural, piscicultural and poultry production, although close to 45% of the food is imported from China, as well as raw materials, mostly for building, and drinking water. Hong Kong's impressive financial and commercial activity, which places it just after New York and London, is confirmed by the presence of some 150 banks and over 340 business concerns. However, its predominant sector is industry, both light and heavy, as reflected by the diversity of products mentioned above, with a strong proportion of textiles. Its port rivals with the major ports of the world, such as Rotterdam, Yokohama, New Orleans and Marseille. The spectacular growth of East Asian and Southeast Asian economies in recent years has largely contributed to Hong Kong's privileged position in the global market.

III. A TOUCH OF HISTORY

An unwelcome choice for an uncertain future

In the beginning of its history in the mid-19th Century, Hong Kong was far from being a welcoming, propitious, healthy and resource-rich site to establish a harbor settlement. Nobody could have predicted then that in the second half of the 20th Century, Hong Kong would become one of the major commercial and industrial hubs of the world. In fact, this small bit of land located in the farthest Southern portion of China and had been appropriated from the Qing Dynasty by the British to establish a focal point for exchanges and transit between China and Europe. The site was described by a Colonial official in those days as "a small, desolate, unhealthy, valueless island". In fact, the choice of this island was the responsibility of Captain Charles Elliot who, a century and a half ago, had been charged officially with identifying a

strategically located island with a harbor close to mainland China. The choice was strongly criticized, on the basis of its mountainous terrain and desolate appearance and its poor commercial future (Agee, 1989). Even more, in those days the island supported a scattered community of a few hundred traditional fishermen and farmers. Thus, fishing, farming and piracy were about the only activities in the island (Boyden *et al*, 1981; Dict. Enc. Lan. Fr., 1990).

Some highlights of the last 150 years

Aside from the more anecdotal accounts given in the previous section, it would seem convenient to outline chronologically some major episodes between the mid-nineteenth century and the present, to place the evolution of Hong Kong in a historical context (Boyden *et al*, 1981; Dict. Enc. Lan. Fr., 1990; QUID, 1994).

Following the First Opium War in 1841, the island of Hong Kong was ceded perpetually to the British crown in 1842 through the Nanking Treaty. It becomes a British Crown Colony and free port in 1843 following ratification of the Nanking treaty by the British Parliament, and starting in the 1850's is a major point of departure of migrants towards North America, Malaysia, Singapore and Australia. The year 1856 marks the Second Opium War and in 1860 China cedes Kowloon in the southernmost tip of the island, and Stonecutters Island to the British through the Pekin Convention. In 1898 China leases the New Territories to Great Britain for 99 years, that is, until July 1st, 1997. The New Territories consists of 945 km_2 of the peninsula North of Kowloon. In the period proceeding World War 11, a wave of refugees lands in Hong Kong in 1938 upon the occupation of Canton by the Japanese. From 1937 to 1941, during the Sino-Japanese War, the influx of immigrants increases the population of Hong Kong by 750,000. On Christmas 1941 Hong Kong itself is occupied by the Japanese, until August 1945, at which time it comes again under British rule. Starting in 1949, a further wave of immigrants arrives in Hong Kong from the newly declared People's Republic of China, in particular from Kwangtung Province and Canton, others from Shanghai and other points in mainland China.

Queen Elisabeth II visits the colony in 1975. From 1979 to 1982, two subway lines are built between Hong Kong/Kowloon and the New Territories, indicative of the unprecedented economic and demographic growth of the colony.

In 1982, Deng Xiaoping indicates that the People's Republic of China intends to recover its sovereignty over Hong Kong in 1997. This is followed through 1983-84 by a exodus of capital and a fall of the HK dollar in the international exchange, plus a series of riots resulting in the loss of lives and property. In December 1984 China and Great Britain conclude an agreement to return the sovereignty of China over Hong Kong starting on July 1st, 1997. Nevertheless, Hong Kong continues to be for China an important commercial and financial opening towards the rest of the world. In 1986 Queen Elisabeth II visits Hong Kong for the second time. Another fall of the stock market takes place in 1989. In the same year the government of Hong Kong takes strong measures to deal with Vietnamese refugees, who continue to migrate massively from Vietnam to different countries in Asia and to other regions.

The overall trend in the century and a half which has occurred since the foundation of the British Crown Colony of Hong Kong has been one of continuing and often massive migration

(Boyden, 1981). Of course, there have been periods in which the trend has been slowed down, halted and even reversed, such as in 1896 when the plague descended on Hong Kong.

IV. FASCINATION, CONTRASTS, TRADITION AND MODERNITY

Crowds, Boats, Food, Noise and Fumes

A visitor arriving for the first time in Hong Kong will be assailed by a multitude of tumultuous impressions, experiencing at the same time contradictory reactions in which are mingled surprise, fascination, confusion, elation and fatigue. The first impression, of course, is that of teeming humanity. People everywhere. Crowds of them. We recall that the built-up zones represent the most densely populated area of its size in the world, and that for half the population, only about two square meters of floor space are available for each inhabitant in their homes (Boyden, 1981).

In films, travel agency brochures. beautifully illustrated coffee-table books, travel guides and airline magazines the imagery repeats itself, thus perpetuating the impressions and even reinforcing the interjections of both visitors and inhabitants. The contrasts are so obvious that they become dominant upon a first visit. The immensely rich, who may live in Victoria Peak with a right to silence and a superb view of the cityscape, traveling in British, German or American sumptuous cars, dressed in pin-stripped suits, attended by a battalion of servitors and attendants, and probably working in sumptuous offices in Central District, where the banking centers may make their Texan counterparts pale. In a *moto perpetuo* the masses of, among others, factory workers, employees, delivery men, food hawkers, street sellers, shopkeepers, tailors, sailors, schoolchildren, child-caring elderly, shanty town dwellers, unemployed youth and adults, tramps, refugees and tourists, move about as if under a compulsion to move, as if to maintain collectively the overall dynamic stance of a city that cannot stop.

The harbor, lying between Hong Kong Island and the Peninsula, offers the kaleidoscopic view of dozens of large trans-oceanic cargo ships sharing space with ferries, hover-crafts, hydrofoils, yachts and excursion boats moving about, plus hundreds of smaller junks and sampans with their characteristic sails, the latter equipped for fishing, and which serve as living quarters for thousands of families.

There are no limits in food choice and availability. From endless lines of street stalls to thousands of restaurants offering an immense variety of tastes. The cosmopolitan pluralism of Hong Kong is reflected in the unlimited diversity of its cuisine, ranging from sophisticated European specialties, to the most standard fast food chains. However, the Chinese cuisine, which constitutes a varied and dominant gastronomy, is the one that offers the most of surprises and exoticism, and where tradition still reigns in a patchwork of spices, seasoning and raw materials which fascinate the Western visitor, such as shark fins, swallows' nests, deer tails, duck's feet, snake ribs, sea turtle, abalones, all of it in an atmosphere saturated with the perfume of sauces, spices and condiments. The Cantonese traditional cuisine is the most reputed one, itself strong in contrasts: sweet and sour, ginger and onions. After all, Hong Kong is purportedly a Cantonese city.

Noise and fumes constitute an inescapable experience in this restless beehive. Luxury cars, buses, tramways, taxicabs, scooters, contribute to a cacophony of engine and mechanical noises, the tooting of horns, the chiming of bells and the effluvia of exhaust gases. To the

traffic noise one should add the decibels contributed by radio and television sets operating full blast. In fact, there would seem to be an extraordinary adaptability to noise on the part of the population, tolerating levels that would be considered intolerable in other societies. This tolerance is extended to crowding, which seems to be inherent to the Hong Kong population. To the casual observer, crowding is a way of life in Hong Kong, and people seem to thrive in it. However, the perceived adaptability does not prevent the population from suffering from the impacts of all the combined factors and processes which characterize the exacerbated expression of urbanization and industrialization. This forms part of the findings of the human ecology studies described in a later section. More recent reviews (Fouchier, 1995) corroborate the findings of studies undertaken in the second half of the 1970's and the first half of the 1980's.

Concerning traffic, measures are being taken by the authorities to favor the development and use of public transport and to discourage the use of individual transport through measures such as taxation and expensive parking (Fouchier, 1995).

The Immediate Hinterland: Nature, Leisure and Food

There are spaces which escape from the crowding, the hubbub, the noxious fumes, the skyscrapers, the endless urban strife. Travelers and residents will evoke the attractiveness of the coastline of Southeast China (Canton Bay), with its spattering of small islands, its towering steep hills, its inlets suggesting peace and protection harboring a fascinating biological diversity. Over 40 beaches of varying size are listed in which the temperature of the water may reach over 30°C, attracting hosts of bathers. The fine golden sand, the blue turquoise water and the scarcity of buildings add to the beauty of the still pristine landscapes, which offer a welcome contrast to the densely urbanized areas (Fouchier, 1995).

Even if the terrain is mountainous and rugged, some 124 km_2 can be considered fit for agricultural use. Agriculture is practiced in small labor-intensive exploitation, which nevertheless occupy less than 2% of the labor force. Horticultural products are in high demand and represent one third of the daily consumption of the Hong Kong population. Rice fields have been gradually replaced by colorful vegetable plots. Farmers breed ducks in ponds and ditches, and practice a traditional pisciculture, raising close to 6,000 Tons per year of different varieties of carp (Agee, 1989). Fish is an essential staple food, and the ocean provides an important proportion of Hong Kong's animal protein supply. Fisheries are both traditional and industrial. In fact, Hong Kong is a major fishing port and fishing vessels must travel hundreds of kilometers to the South to maintain an adequate supply of fish and other marine products to meet the needs of the growing population of Hong Kong (Newcombe, 1977; 1979).

So Cosmopolitan and so Chinese

Modernization and Westernization in commerce, advertising, business practices, eating habits, timetables, communications, hotels of international caliber, architecture, industry, bilingual press and signs, and many other presence and influences create a misleading impression on outsiders. In fact, Westernization is mostly apparent. The Chinese society keeps staunchly Chinese, tradition being strongly imprinted in the population. Tradition and adaptability go hand in hand. Tradition ensures the cohesion and identity of the Chinese society. Adaptability ensures an internationally competitive industry and commerce. This is also exemplified in the double calendar. In fact, it is the events of the Chinese calendar and the

booming international market of thousands of products at unbeatable prices which attract tourists by the millions. Both the rhythms of the sun and the moon are respected and made profitable through their respective calendars. Christmas is profitable and the Chinese New Year is fabulous, and both are holidays.

The Chinese New Year is the most spectacular and colorful celebration in Hong Kong, dominated by the red color which serves as the background for messages of happiness, health, longevity and prosperity. Tradition in food, dress and customs is paramount. Other festivities include the Mid-Autumn Holiday *(Chung Chiu),* on the fifteenth day of the eighth moon, marked by processions with colored lanterns and the eating of "moon cakes", filled with sesame and lotus seed. In April the Chinese celebrate the *Ching Ming,* visiting the cemeteries to honor their ancestors with food offerings and prayers, and later share the food together in family gatherings. The *Ta Chiu* holiday is a Taoist festivity of peace and renewal, which is celebrated at different intervals, ranging from three to sixty years, depending on divinatory directives. Its importance is such, that numerous migrants return to Hong Kong just for the celebrations.

The spirituality and beliefs of the Hong Kong population permeate the whole of the human environment. Countless small brilliantly colored shrines share space in homes and shops. On the other end of the scale, over 350 temples are visited by legions of believers who pray, make offerings and burn impressive quantities of incense. Among the monumental religious sites are the Po Lin Monastery in the Island of Lantao, which contains the largest (35 meters high) statue of Buddha in Asia. The Monastery of the 10,000 Buddhas (in reality there are 12,800) in Shatin contains the mummified remains of its founder and a 9-story high rose pagoda.

Business, industry, tradition and beliefs coexist and even complement each other. The skyscrapers which dominate the Hong Kong skyline and which belong to powerful banking, business and media concerns have surely benefited from the *feng shui,* a form of geomancy which results in unwritten guidance or advice as to the most propitious and auspicious moments and manners to build a giant business building, a huge hotel, a large engineering work or a tomb (Agee, 1989; Fouchier, 1995).

V. HUMAN AND URBAN ECOLOGY : THE CASE OF HONG KONG

The Synergism of international Collaboration

In the 1970's Hong Kong became the subject of a study undertaken by the Human Ecology Group of the Center for Resources and Environment Studies of the Australian National University (ANU) of Canberra, in collaboration with academic and government institutions in Hong Kong. This project soon became one of the major pioneering activities within Project Area N° 11 on urban systems of UNESCO's Intergovernmental Man and the Biosphere (MAB) Programme. In fact, MAB is the first international venture to consider cities and other human settlements as ecological systems. Towards the late seventies, the Hong Kong MAB Project became part of a UNESCO-MAB/UNEP* joint venture entitled "Integrated Ecological Studies of Human Settlements as a Basis for Planning and Decision-

* United Nations Environment Programme

Making". The UNESCO-MAB/UNEP joint venture assembled concrete case studies in different regions of the world, in a great diversity of bio-geographic , bio-climatic, economic, social, cultural, political and development situations (Celecia, 1987 , 1990, 1992, 1994, 1995, 1996)

MAB research in urban, peri-urban and industrial systems has advocated since those pioneering days, ecologically-oriented interdisciplinary, inter-sectorial, integrative approaches, examining the complex interactions that take place within them and between them and their hinterlands, rather than studying specific problems in isolation. The MAB approach to research in human settlements is to look at them as ecosystems (Boyden and Celecia, 1981; Celecia, 1987, 1990, 1994, 1996). The Hong Kong integrated ecologically oriented studies were designed to increase knowledge and understanding of these extremely complex human systems, as a departure from sectorial, specialized studies which narrowly look at components of the urban systems individually, with little reference to complex reality (Boyden, 1980).

The Hong Kong studies undertaken in the 1970's into the 1980's and more particularly the hypotheses and approaches formulated therein, stimulated the initiation of projects undertaken in other parts of the world which, with varying levels of success, had direct repercussions on planning, management, decision-making, energy-use policies, food production, training of scientists and planners, information for managers and decision makers, environmental education and, most importantly, awareness-building and active participation of local populations (Celecia, 1987, 1996). Such is the case of Lae in Papua New Guinea; Bangkok, Thailand; Ciudad Guayana, Venezuela; Bali, Indonesia; Mexico City, Mexico; among others. Parallel to the Hong Kong studies, other important projects were carried out within the framework of UNESCO's MAB Programme, in Frankfurt, Germany; Rome, Italy; Gotland, Sweden; Tokyo, Japan; Barcelona, Spain, which tested different integrative approaches which responded to local environmental, socio-economic and cultural situations, and which also provided examples to other sites in the world. In developing countries a new generation of projects were carried out in the 1980's in very diverse conditions, namely in Porto Alegre and Sao Paulo in Brazil, Buenos Aires, Argentina; Kuala Lumpur, Malaysia; Chipata, Zambia, among others. The Hong Kong and related studies became widely known in the enlarged MAB 11 Project Area interregional network, particularly through the numerous writings which had resulted from the Hong Kong research, including the book "The Ecology of a City and Its People" (Boyden *et al.*, 1981), the special issue on MAB of The UNESCO Courier (Boyden and Celecia, 1981); the MAB 36-poster exhibit "Ecology in Action", translated in over 20 languages (UNESCO/MAB, 1981), the special issue on "The City" of A/mbiente Magazine (A/mbiente, 1983) and the MAB Human and Urban Ecology Digest (Spooner, 1986), among others. More recently, synthesis reports retrace the evolution of the MAB project area on urban ecosystems in over twenty years, in which the pioneering role of projects such as Hong Kong is fully recognized (Celecia 1994, 1995, 1996).

VI. AN IMMODERATE HUNGER FOR ENERGY

Because every action requires energy, a useful way to study natural or urban systems is by tracing their energy flows. Moreover, in the study of regional systems, it is possible to ascertain the heavy demands of cities for energy. The Hong Kong study permitted to establish increasing massive energy consumption, mostly from fossil fuels, through increasing urbanization and industrialization. It introduced the comparison of *somatic energy*, that is, the energy that flows through the body of human beings and domestic animals and which is derived

from food; and *extrasomatic energy*, energy outside the human body. The study of the transition of Hong Kong from a trade settlement in 1900 to a burgeoning industrialized, densely populated urban system in the mid-1970's demonstrates how its extrasomatic energy consumption and dependency increased dramatically (Boyden, 1979, 1981, 1984).

The graphic in figure 1 shows extrasomatic and somatic energy use compared to population size in Hong Kong for the years 1900, 1950, 1971 and 1974. While population less than doubled from 1959 to 1974, energy use increased more than fourfold. This shows that such drastic energy consumption increase was not due primarily to population growth, but to increasing *per capita* consumption, as production patterns and life styles changed. The chart in figure 2 shows extrasomatic energy flow in Hong Kong, then a city of 4 million inhabitants, in 1971. About 99% of the total energy inputs was petroleum, with less than 1 % of renewable energy sources such as firewood and charcoal. The end uses included domestic, commercial, industrial, transport, and ship and airplane bunker fuels. However, in spite of its massive consumption of energy, the *per capita* energy use in 1971 was about half of the world average, three times that of developing countries, but only 17% that of industrialized countries. The Hong Kong study also showed that patterns of energy use are a key to understanding and predicting changes in human society.

VII. A GARGANTUAN APPETITE FOR MATERIALS

We have seen that urban systems can be studied by analyzing flows of energy, materials and information between components. The illustration in figure 3 shows the metric tons per day of materials entering and leaving the city of Hong Kong in 1971. The city imported fuel, biological and mineral resources and exported manufactured products and waste. The Hong Kong study benefited from the fact that the British Colony of Hong Kong can be considered, in effect, as a city state (Newcombe, 1977). Government records of trade, local production, and other information provided excellent basic data for determining materials inputs, throughputs and outputs in the system and between the system and other systems. The study of energy and related materials flows in Hong Kong thus represents a study of such flows in a contemporary urban/industrial system.

VIII. THE HUMAN DIMENSION: A CASE FOR THE INTANGIBLES

Like any other teeming and burgeoning urban/industrial systems of the world, Hong Kong suffers from the impacts stemming from its enormous production, consumption and demographic patterns (Aston 1977 ; Boyden 1977, 1977a, 1977b ; Millar, 1979; Boyden *et al.*, 1981; Keating, 1981; EPA Hong Kong, 1985; Fouchier, 1995). The Hong Kong studies demonstrated that the city is an ecosystem with quantifiable flows of energy, materials and information, as well as interrelationships and flows between the city and its hinterlands. But the urban ecosystem is unique in that its overwhelming dominant component is its human population, with its array of social, cultural, economic and political characteristics. The well-being of the urban population depends of course, on the availability of adequate amounts of materials resources. However, increasing *per capita* consumption of energy in no way will guarantee improvement in the quality of the human experience. Unfortunately, in urban studies, planning, management and decision-making, the intangible, unquantifiable aspects of the human experience remain neglected and overlooked.

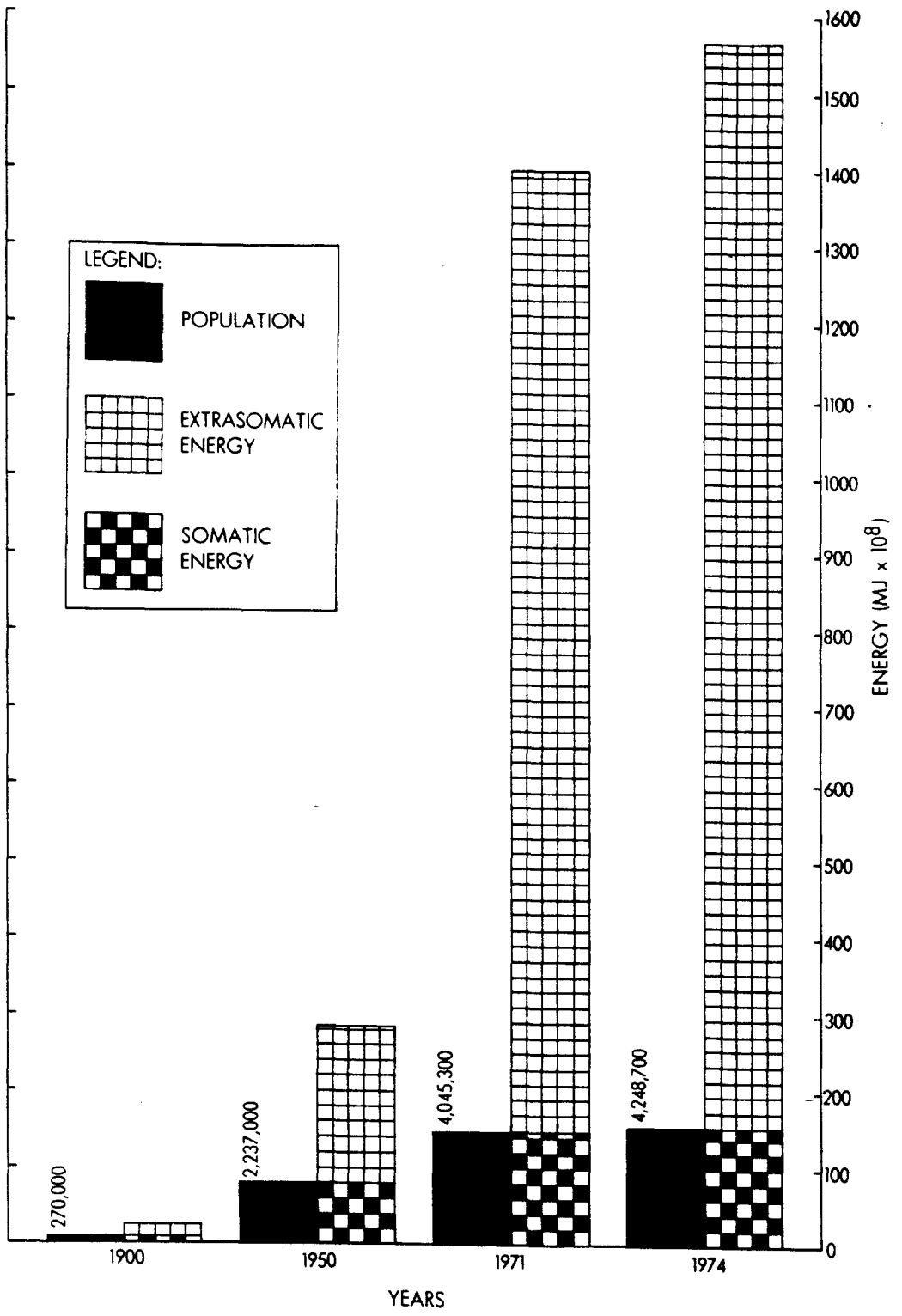


Figure 1: Extrasomatic and somatic energy use compared to population size in Hong Kong, 1900, 1950, 1971 and 1974

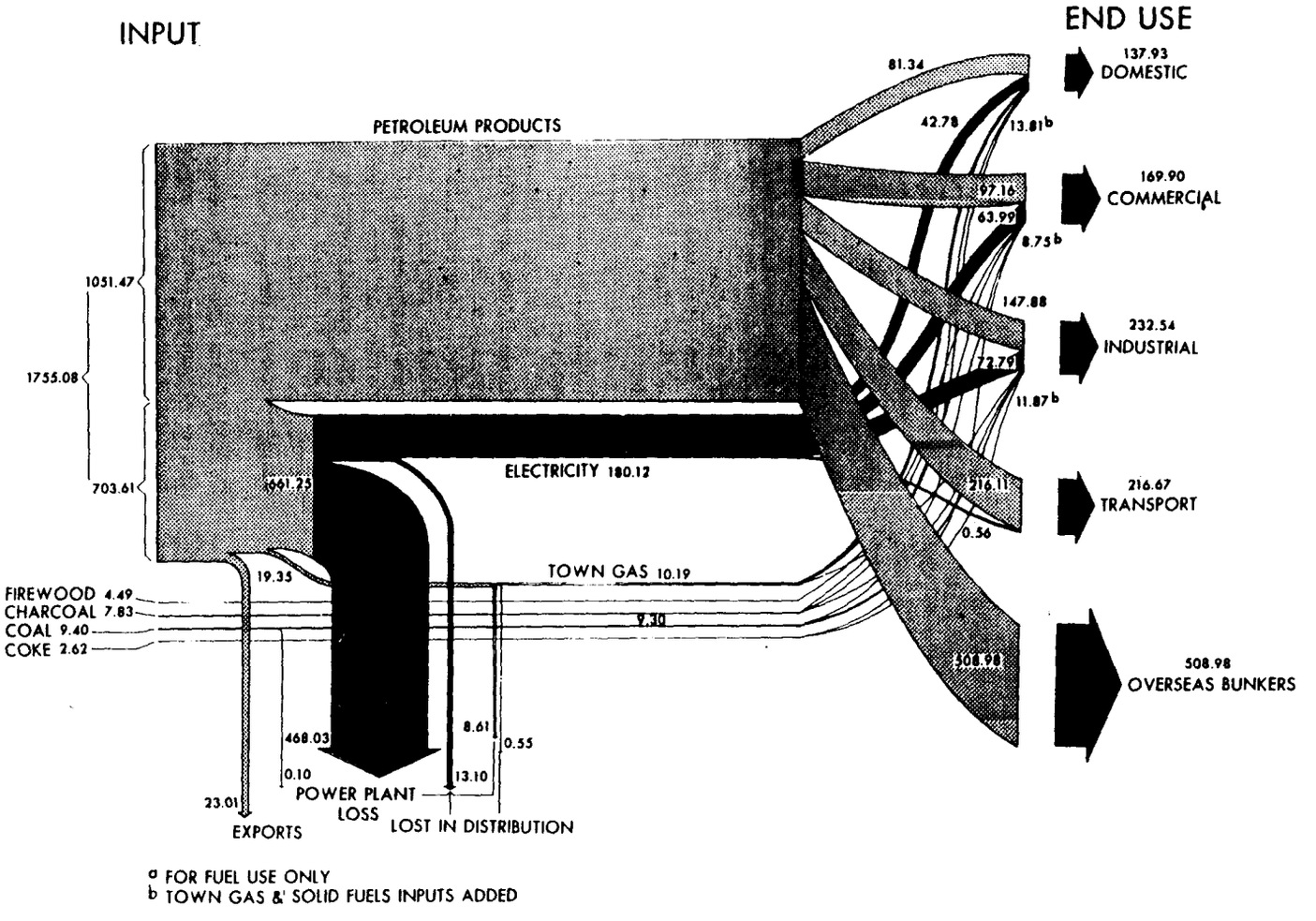


Figure 2; Extrasomatic energy flow chart: Hong Kong, 1971 (MJ x 10^8)

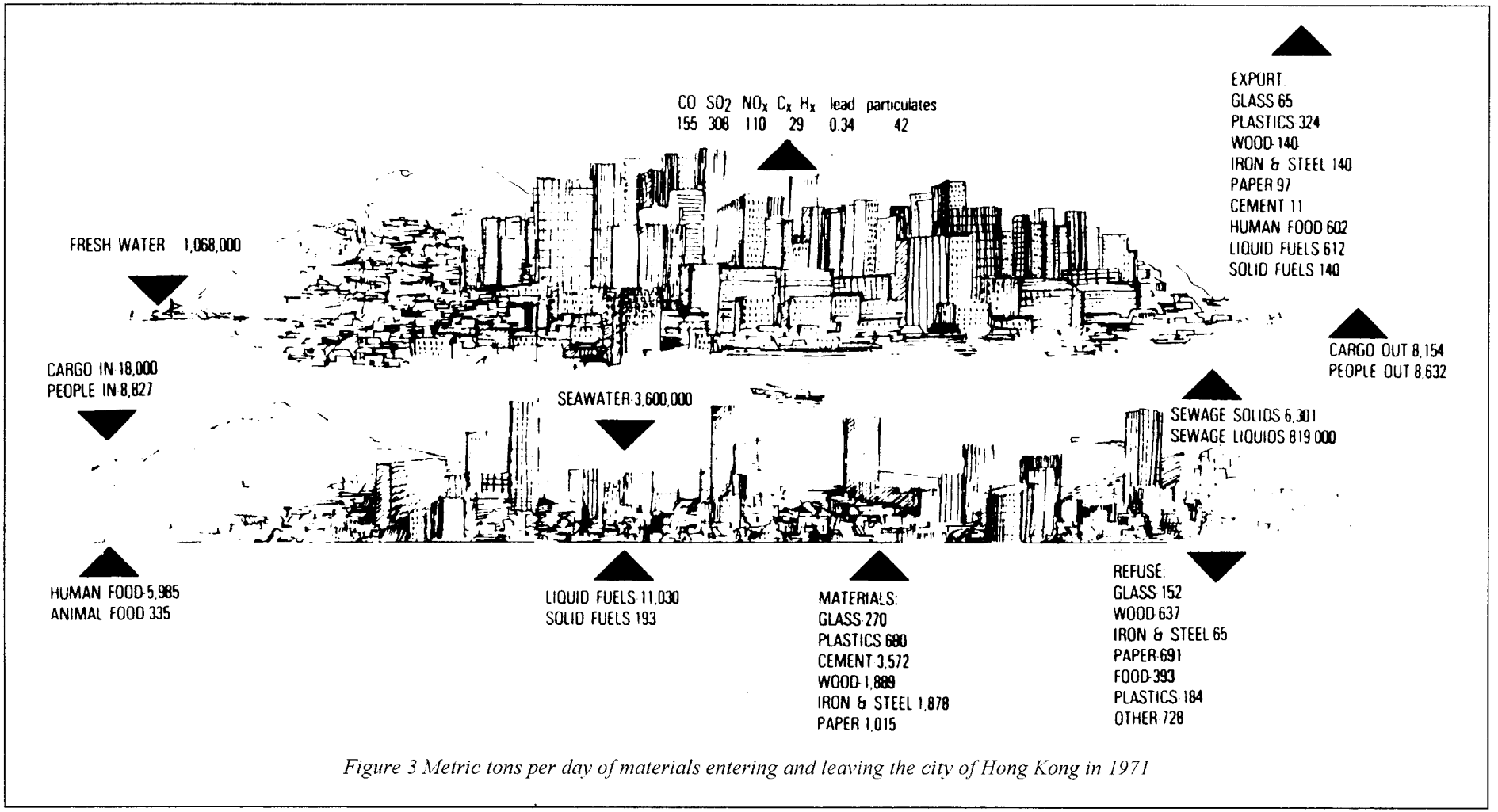


Figure 3 Metric tons per day of materials entering and leaving the city of Hong Kong in 1971

These intangibles include social values, cultural patterns, perceptions of prevailing life conditions from different actors in the urban scene. The Bio-social Survey undertaken by the research team in Hong Kong (Millar, 1979), aimed at improving understanding of the relationship between the ecological characteristics of the urban ecosystem as a whole and the state of health and well being of the population and at improving knowledge and understanding of the cultural processes of adaptation to detrimental environmental influences. The Biosocial Survey in Hong Kong permitted to take the intangibles into consideration, as well as the health and nutritional status of the human population, using variables such as: Perception of density (Solitude, Overcrowdedness); Attitudes towards the family (Interaction/Solidarity/Support Loneliness/ Isolation/ Alienation); Passive or Active Leisure (Presence or Lack of Opportunity); Job Satisfaction (Creativeness, Fulfillment, Meaninglessness/Monotony); Perceived Harmony in Social Relationships (Very Inharmonious-Very Harmonious); Perception of Safety and Security (Fear of Crime-Sense of Security). The research team observed that the hypotheses which were formulated on the basis of the Western experience in relation to overcrowding, did not necessarily have to apply in Hong Kong. Although it is one of the most densely populated cities in the world, it was observed that Chinese traditional values and strong family cohesion in Hong Kong contributed to reduce tensions which are usually associated with overcrowding, and which can cause serious social problems in other socio-cultural settings. For example, in the 1980's the crime rate, even if increasing, still kept at about one-tenth as high as in many Western cities. Moreover, when members of the research team carried out a mental health survey, using an internationally accepted scale, they found that the people in Hong Kong had about the same level of mental illness as the people of the city of Canberra, capital of Australia, which enjoys far more space and tranquillity than Hong Kong and of course, a low population density.

XI. ELEMENTS OF A PARADIGM FOR URBAN ECOLOGY

The pioneering work of the interdisciplinary Hong Kong research team, as well as all other research projects undertaken within the framework of UNESCO-MAB and the joint UNESCO-MAB/UNEP project, plus previous forward-looking work (Stearns and Montag, 1974), have permitted to elaborate the elements of a paradigm, which are outlined below (Celecia, 1987, 1992, 1994). This section thus represents a synthesis of the search for an ecological paradigm for cities:

X. CITIES AS ECOSYSTEMS

The ecological approach considers that the city, like other ecosystems, has its own characteristic structure and functioning, with living and non-living elements and a conversion and cycling of energy and materials. There is also a distinct spatial organization and changes over time that affect behavior patterns, species distribution and population and community dynamics. There are, however, certain characteristics which, taken as a whole, confer a uniqueness on the urban ecosystem which can be summed up as follows:

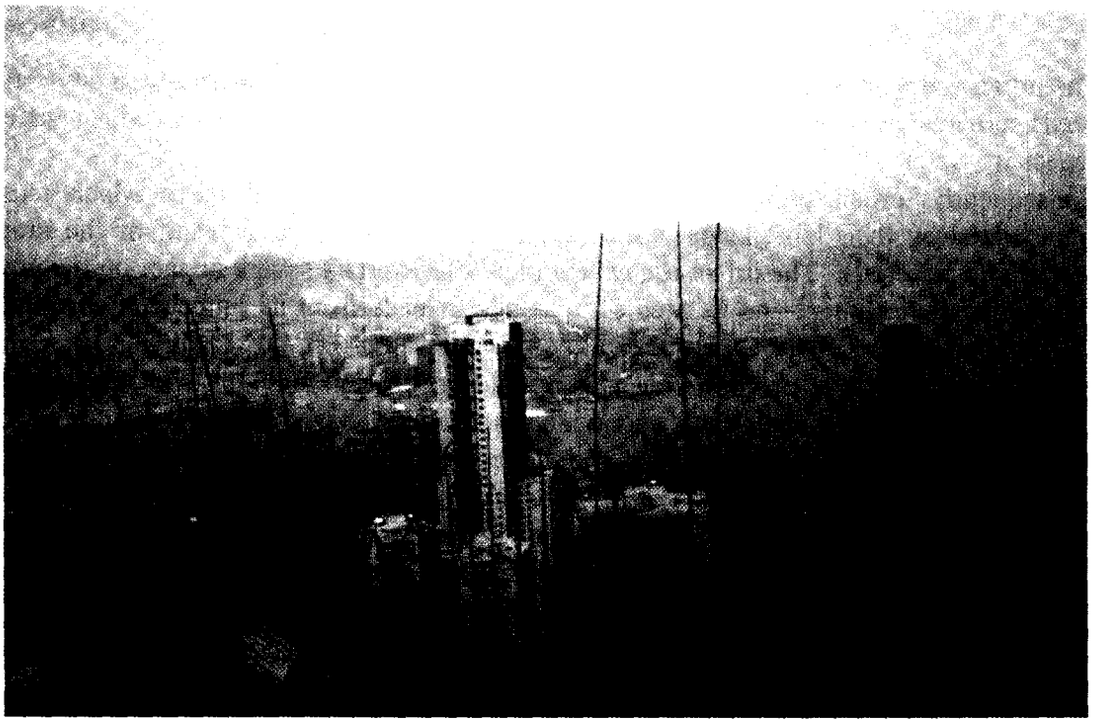
- It is a particularly open system, as can be seen from a study of flows, interactions and exchanges, especially in relation to other ecosystems on which it depends.
- From the point of view of the society and the population, the urban ecosystem produces a great amount of information, knowledge, creativity, culture, technology and industry, amongst others, which it exports to other systems.
- From the biological point of view, the urban ecosystem exhibits a low biological productivity, and therefore depends to a great extent on the surrounding area.

- The urban ecosystem consumes enormous amounts of energy. Furthermore, a city's energy needs snowball as people are replaced by machines, with corresponding need for materials, especially water.
- Consequently, urban systems produce an enormous amount of waste which must be metabolized by their hinterlands, which are already suffering as a result of the drain on energy and materials. The urban ecosystem therefore exerts a severe impact on the physical and human environment and its area of influence extends from its immediate surroundings to other parts of the planet thousands of kilometers away.
- Urban growth involves profound changes in land occupation and soil use. These changes are highly conflictive and have economic implications based on speculation which is oblivious to environmental and socio-economic impacts, particularly in rural systems and protected areas.
- This dependence and this pattern of supply and demand makes urban systems, and especially large cities, unstable, fragile and highly vulnerable, from both the environmental and the socio-economic point of view.
- The most singular feature of the urban ecosystem is its human dimension, which includes all aspects of the human population, whether cultural, social, psychological, economic, socio-political, etc. In particular this human dimension consists of intangible variables which are difficult to define and even more difficult to quantify, such as creativity, a sense of security, work satisfaction, goals, aesthetic considerations, etc. If we overlook these aspects of reality, which have as much bearing on the quality of the environment as on the quality of human experience, we could arrive at erroneous interpretations or conclusions and misdirected planning and management.

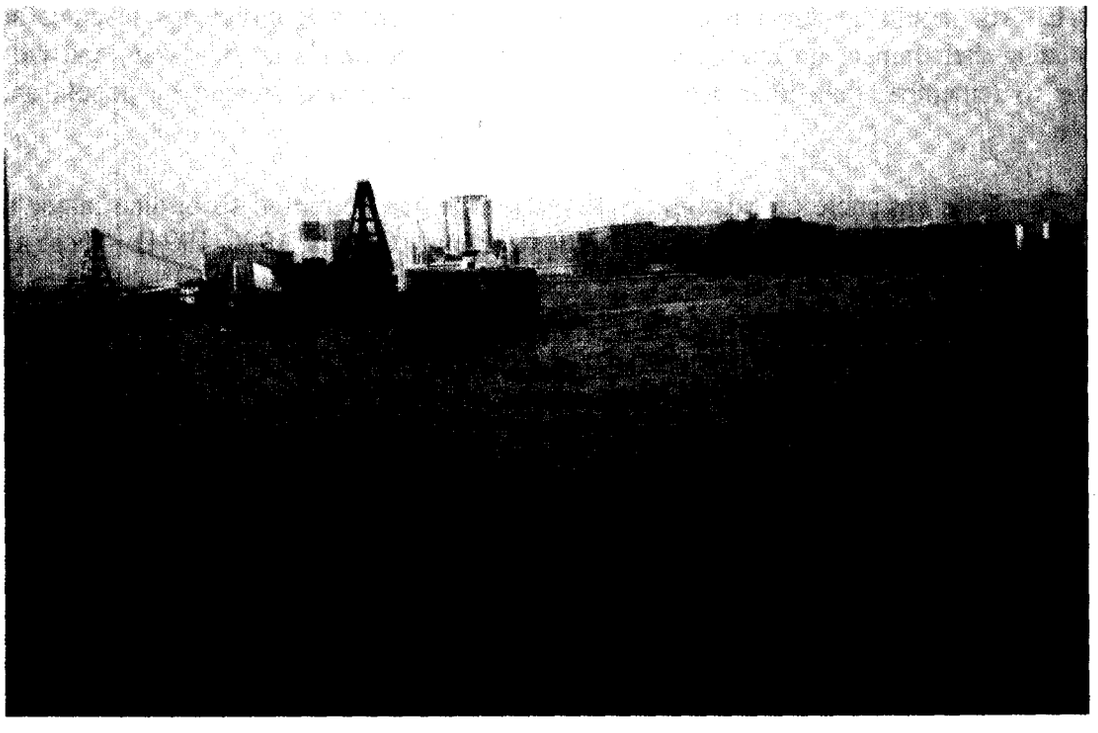
Efforts should be directed at increasing efficiency and self-sufficiency in cities and at minimizing their impact on the surroundings, both close at hand and far away, and we need always to remember that cities are the most human ecosystems, created by people and for people.

The same ensemble of experiences through time has permitted to outline major issues which require reinforce attention form all parties involved (Celecia, 1990, 1994). These are:

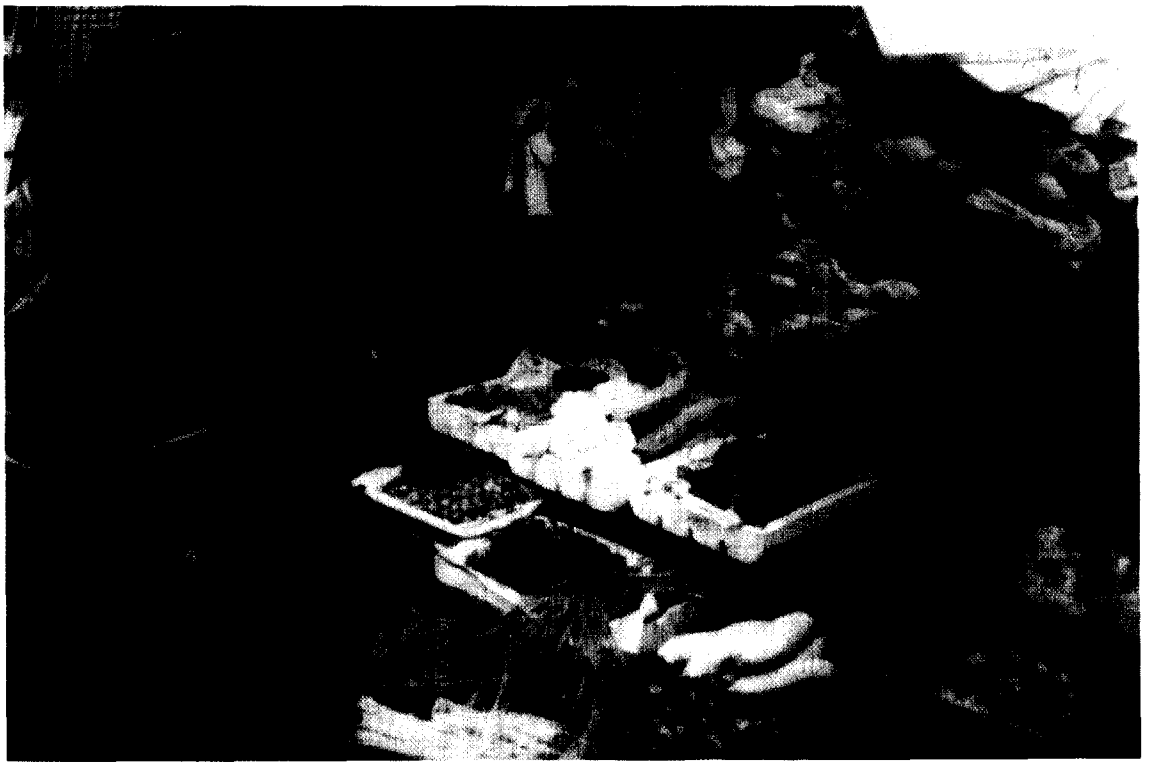
- Water and sanitation, availability of a fresh-water supply of sufficient volume and quality and the provision of drainage systems for the removal of human and animal sewage.
- Conditions of physical and mental health, quality and accessibility of services.
- Appropriation of urban space, speculation in the real estate market and urban policies. Unplanned and uncontrolled land occupation in high-risk areas.
- Urban disasters and vulnerability to natural phenomena (e.g. earthquakes), "less natural" phenomena (e.g. floods and landslides) and non-natural phenomena (e.g. chemical accidents).
- Habitat, housing, alternative forms of accommodation. Overcrowding at the city level and in homes.
- Transport: availability, access, type, quality and impact and alternatives.
- Energy: sources, use, access, impact and alternatives.
- Air pollution (emissions of gas from industry and traffic).
- Contamination of rivers and underground water supplies.



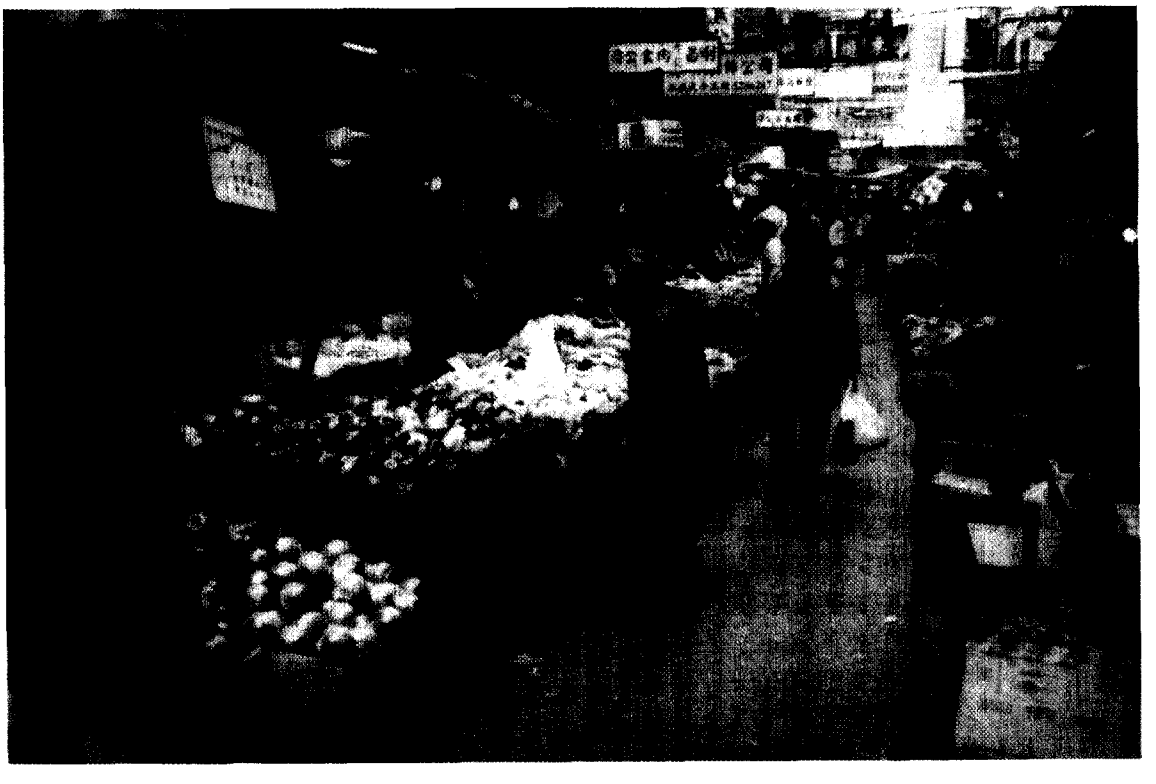
Hong Kong view from scaffolding (bamboo). Photo: Pamela Coghlan



Hong Kong, Harbour and Ferry. Photo: Pamela Coghlan



Hong Kong: Vegetables vendor. Photo: Pamela Coghlan



Hong Kong: Street market. Photo: Pamela Coghlan

- Noise pollution.
- Availability of and access to educational facilities and infrastructures. Formal and informal education at all levels (especially in literacy).
- Job creation schemes to counter high unemployment which particularly affects the less favored sectors.
- Planning, management, use and treatment of green spaces in cities and natural or rural areas around cities.

XII. A PLIGHT FOR THE CITY WITH A HUMAN FACE

In spite of its unicity and specificity, Hong Kong still exemplifies the plight, problems, uncertainties and difficulties that face mankind towards the 21st Century, in particular in terms of urbanization and industrialization (Boyden 1981). Its ever-increasing dependency on energy and materials, with the corresponding pollution problems, reflects its dependence on ever-increasing industrial growth implying bigger and increasingly complex machines and on international commerce, with all the implications pertaining to stressed life conditions and the quality of the human experience. Hong Kong also exemplifies the paradoxes, conflicts, contradictions, dilemmas and dichotomies which have already acquired a global dimension (Boyden *et al,* 1981): traditionalism vs. modernism; capitalism vs. communism; centralism vs. de-centralism; capital-intensive vs. labor-intensive industry; modern technology vs. traditional practices; youth vs. the aged; human indifference vs. human concern and solidarity; laissez faire vs. state control; cosmopolitanism vs. provincialism; propriety vs. permissiveness; West vs. East.

Hong Kong is entering a global society more concerned with the gross national product and the efficiency of machines, institutions, networks and systems, than with the improvement of life conditions, the quality of human experience, solidarity and concern for the community and for personal relationships. Yet, beyond an increasingly frenetic pace of life, the indifference to the problems and hardships of other people, the stench of traffic fumes, the suffocating crowding, the dominance of stock markets, there is still left the respect for family bonds, the place of the elderly and children in the social framework, people earnestly engaged in their occupations, whether work, leisure, food sharing, or rest in market places, along the streets, in little stores, in family-based small factories. Within these intense social interactions, as the keenly observing visitor admires the grace of an old lady practicing tai chi chuan in a mini park; the concentration of children doing their homework on the street sidewalk; the inspiration of a man playing softly his string instrument at his doorstep; and while his neighbour reads one of the 68 newspapers of the island in a little tea room, his bird sings in a cage hanging from a special railing along the tea-room window. Lots of people still take their birds out for a walk.

BIBLIOGRAPHY

AGEE, A. 1989. *Hong Kong.* The Guidebook Company Ltd., Hong Kong. 80 pp. (in French).

A/mbiente. 1983. *La ciudad* (Roma, Bolonia, Venecia, Francfort, Hong Kong, México, Cono Sur). Número Aniversario dedicado al Programa MAB "El Hombre y la Biosfera". A/mbiente, N° 38 Fundación CEPA. La Plata, Argentina. (in Spanish).

ANON. 1991. Report of *UNESCO Regional Symposium on the Comparative Study of Metropolis Ecosystems in Asia.* Seoul, Republic of Korea, 5-8 December 1990. Korean National Commission for UNESCO. Seoul. 371 pp.

ASTON, A. 1977. *Water resources and consumption in Hong Kong.* Urban Ecology, 2:327-353.

BOYDEN, S. 1976. *A conceptual basis for the study of the ecology of human settlements. Nature and Resources,* Vol. 12 N° 3, pp. 6-12. UNESCO. Paris.

BOYDEN, S. 1976a. *Hong Kong human ecology programme.* Australian national report to Habitat. Habitat Australia, pp. 231-238. Australian Government Press, Canberra.

BOYDEN, S. 1976b. *The ecological study of human settlements. Lessons from the Hong Kong human ecology programme.* In: Human ecology and the development of settlement. J. Owen Jones and Paul Roper (Eds), pp. 93-99. Plenum, New York and London.

BOYDEN, S. 1977. *Integrated ecological studies of human settlements.* Impact of Science on Society, 27, pp. 159-169. UNESCO, Paris.

BOYDEN, S. 1979. *An Integrated Ecological Approach to the Study* of *Human Settlements.* MAB Technical Notes 12, UNESCO, Paris.

BOYDEN, S. 1980. *Ecological study of human settlements.* Nature and Resources, Vol. 16, No. 3, pp. 2-9. UNESCO, Paris.

BOYDEN, S. 1984. *Integrated studies of cities considered as ecological systems.* In: Ecology in Practice. Part II: the Social Response, F. di Castri, V.W.G. Baker and M. Hadley (Eds), pp. 7-29. Tycooly, Dublin and Unesco, Paris.

BOYDEN, S.; MILLAR, S. 1978. *Human ecology and the quality of life.* Urban Ecology, 3 : 263-287.

BOYDEN, S.; CELECIA, J. 1981. *The Ecology of Megalopolis.* The UNESCO Courier. April 1981, pp.24-27. UNESCO, Paris. In 21 languages.

BOYDEN, S.; MILLAR, S.; NEWCOMBE, K.; O'NEILL, B. 1981. *The Ecology of a City and its People : The Case of Hong Kong.* Australian National University Press, Canberra.327 pp.

CELECIA, J. 1987. *La planification urbaine face aux situations de crise.* Santé mentale, 94/95: 16-21.

CELECIA, J. 1990. *Half of the World and Increasing: Cities, Ecology and UNESCO's Action.* The Statistician. 39 : 131-141.

CELECIA, J. 1992. *Un Ejemplo de Enfoque Interdisciplinar: El Modelo MAB sobre Sistemas Urbanos.* Universidad Nacional de Educación a Distancia. Master en Educación Ambiental. Programa de Postgrado 1992-1994. Fundación Universidad-Empresa. Madrid. 65 pp. In Spanish.

CELECIA, J. 1994. *Villes.* TOUS. Cahier N° 6. Cahiers d'Education Environnementale. Centre UNESCO de Catalunya. Barcelona. (also in Catalan, English and Spanish). 8 pp.

CELECIA, J. 1995. *Towards the Resourceful City. MAB Research in Urban, Peri-urban and Industrial Systems.* In: Qualification of Human Resources, Teaching and Research for the Planning and Management of the Urban Environment. Final Report of the Technical Meeting. June 6-9, 1994. Open University for the Environment MAB/UNESCO. Curitiba, Brazil. pp 1-11.

CELECIA, J. 1996. *Reconciling the City with the Natural and Rural Environment : In Search of a Dialogue Between Two Open Systems (A view from the City).* II Symposium on Natural Spaces in Conurbations and on City Outskirts. Museu de la Ciència. Barcelona. 25-27 October, 1995. (In Press).

CELECIA, J. 1996. *Towards an Urban Ecology.* In: The City: So Human an Ecosystem. Nature and Resources 32 (2). UNESCO, Paris. (In Press).

CHAN, K.W.; XU, X. 1985. *Urban population growth and urbanisation in China since 1949: Reconstructing a baseline.* Project Ecoville Working Paper No. 25. Project Ecoville, Institute for Environmental Studies, University of Toronto, Ontario, Canada.

Dictionnaire Encyclopedique de la Langue Française 1990. *Hong Kong* p. 629. Editions Hachette, Paris.

FOUCHIER, V. 1995. *Hong Kong: L'extrême densité.* Urbanisme. n° 284. 12-20. Septembre-Octobre 1995.

FREMY, D. & M. 1996. Encyclopédie Quid. *Hong Kong.* pp. 1188-1189. Editions Robert Laffont, Paris.

Environmental Protection Agency of Hong Kong. 1985. *Environment Hong Kong* 1985. Hong Kong, 165 pp.

HILL, M.J., MACLENNAN, R., NEWCOMBE, K. 1978. *Diet and large bowel cancer in Hong Kong: The relationship between diet and large bowel cancer mortality in three socio-economic groups in Hong Kong.* The Lancet.

KEATING, R. 1981. *Taming the Cities* In: MAB After 10 Years. Ecology in Practice. Insights from the Programme on Man and the Biosphere (MAB). A special UNESCO Features production. UNESCO, Paris. 114 pp.

MILLAR, S. 1979. *The Bio-social Survey of Hong Kong.* Hong Kong Human Ecology Programme. Centre for Resource and Environment Studies. Australian National University, Canberra. 517 pp.

NEWCOMBE, K. 1977. *Nutrient Flow in a Major Urban Settlement.* Human Ecology, 5 (3): 179-207.

NEWCOMBE, K. 1979. *An Integrated Ecological Approach to Agricultural Policy-making with Reference to the Urban Fringe: The Case of Hong Kong.* Agricultural Systems, 4:1-27.

NEWCOMBE, K. 1983. *Energy conservation and diversification of energy sources in and around the city of Lae, Papua New Guinea.* In: F. di Castri, F.W. G. Baker and M. Hadley (Eds.), Ecology in Practice: establishing a scientific basis for land management. Tycooly, Dublin: 88-11 1.

SPOONER, B. 1986. *MAB Urban and Human Ecology Digest.* UNESCO, Paris. 137 pp. (Spanish version with additional entries prepared by the UNESCO Regional Office for Science and Technology for Latin America and the Caribbean. Montevideo. 1988).

STEARNS, F.; MONTAG, T. 1974. *The Urban Ecosystem : A Holistic Approach.* Report of the Urban Ecosystems Project. Dowden, Hutchison and Ross, Inc. Distributed by Halsted Press. Stroudsburg, Pa, USA.

UNCHS (Habitat). 1991. *Graphic Presentation of Basic Human Settlement Statistics.* United Nations Centre for Human Settlements. Nairobi, Kenya. 39 pp.

World Almanac and Book of Facts. 1990. *Hong Kong* pop. density. p. 774. Pharos Books. Scripps Howard Co., New York. 960 pp.

YANITSKI, O. (Ed.) 1987. *The City and Ecology.* Two volumes. Nauka, Moscow. (in Russian. English version published in 1988).

5. WATER SCIENCES

THE ECO-HYDROLOGY REHABILITATION OF DEGRADED LANDS IN WESTERN GHATS

I. INTRODUCTION

Within the humid tropics, it is widely reported in the popular media that a consequence of deforestation is an increase in the frequency of floods and conversely a reduction in dry season discharge (vital to rural and urban water supply) within organized drainage networks. Paradoxically, the results from the limited number of controlled experimental catchment studies in east Africa, northern Australia and Malaysia provide contrary evidence (Bruijnzeel, 1990). Such experiments involve the hydrological calibration of paired experimental catchments of similar area, topography and geology. Subsequently, the forest on one of the catchments is converted to another land-use, and the differences in *total water flow* (e.g. annual stream discharge), *stormflow* (often termed *quickflow*) and *dry-weather flow* (often termed *delayed flow*) are analysed using simple statistical methods (Hewlett *et al*, 1969; Hewlett & Fortson, 1983). The results from these catchment experiments show that total water yield increase is mostly connected with *dry-weather flow*, and *not stormflow*, in agreement with findings from humid temperate forests (Bruijnzeel, 1990). The replacement of deep-rooted trees by more shallow rooted crops, such as a herbaceous cover, reduces the transpiration demand and the ensuing "savings of water use" are credited to dry-weather flow.

Nonetheless there has been a recent scientific appraisal of the above controversy, and the recognition that the existing catalogue of experimental catchment studies may not be sufficiently representative of the more widespread, human-impacted landscapes which have been in various states of "degradation" for several decades into centuries. In other words, the controlled experiments only monitored the initial few years following forest conversion to a replacement crop, and this period was insufficient for the soils (and their associated hydrological properties) to adjust to the new land-use type. Furthermore, socio-economic pressure on such disturbed areas in these experimental catchments was considered minimal and unrepresentative compared with the wider human-impacted landscapes found elsewhere in the humid tropics. Consequently, the alternative hypothesis is that in severely degraded landscapes the surface soil infiltration rates are drastically reduced which leads to a reduction in groundwater recharge via vertical percolation through the soil/rock profile. Conversely

Further information on the activities described in this "story" may be obtained from the Michael Bonell, Division of Water Sciences, UNESCO, 1 rue Miollis, 75732 Paris Cedex 15, France. Fax: + 33 1 45 68 5811. e-mail: m.bonell@unesco.org

from the reduced infiltration, an increase in overland flow downslope occurs during storms which feeds into streams and augments storm runoff. In these circumstances there is less groundwater storage available to seep into organized drainage, which thus reduces dry season flow. Paradoxically, replanting of degraded land with trees in the short term may only aggravate the existing problems of 'dry-weather' flow by reducing it even further because of increasing demands on soil water for transpiration (Bruijnzeel, 1989).

Presently, there are no long term experimental catchments within the humid tropics to test the above hypothesis. Even more surprising there has been minimal field testing of basic soil hydrologic (hydraulic) properties, using soil physics *in situ* methodologies (to minimize soil disturbance), which, in turn, are linked with rainfall records to provide a preliminary assessment of the above hypothesis (Bonell with Balek, 1993). Moreover, the time span for the ecohydrological recovery of degraded lands which have been reforested using different strategies in terms of species composition and cultivation is presently unknown (e.g. bulldozer ripping of compacted surface and use of furrows *vis-à-vis* minimal disturbance in planting). For example, one of the key questions is the length of time it takes for a selected reforestation strategy to cause a recovery in infiltration rates and change the hydrological dynamics of the landscape, as well as reduce erosion. Allied to the same question is the recovery in the hydrochemistry and biogeochemical cycling linked with the changing nutrient status and soil biology.

Aside from the hydrological question of degraded lands, there are also related ecological and social issues. At a time when the global attention remains focused on the continued escalation in the rate of removal of closed, tropical humid forests; the global extent of land degradation, through depletion of soil and nutrients through erosion, continues to escalate. Moreover, people need their indigenous trees for a variety of products, and not just simply for fuel. The substitution of indigenous trees by exotic species such as Australian acacias or eucalyptus are not the sole solution.

Nonetheless the technology for restoration of native hardwoods on severely degraded landscapes in the tropics is comparatively a new area of research, and significant challenges still remain. India is taking the lead in global reforestation in the humid tropics using native hardwood species, and such pioneering work should progressively become more important as the rate of global deforestation extends to less accessible areas.

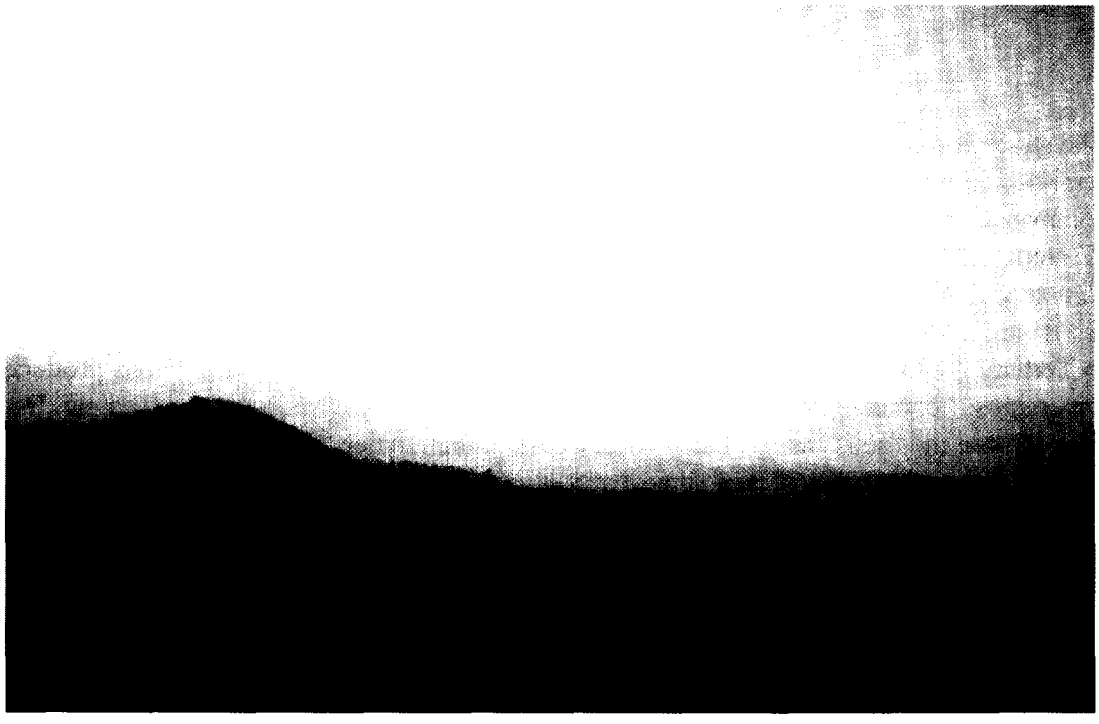
II. WESTERN GHATS, INDIA

The climatic environment

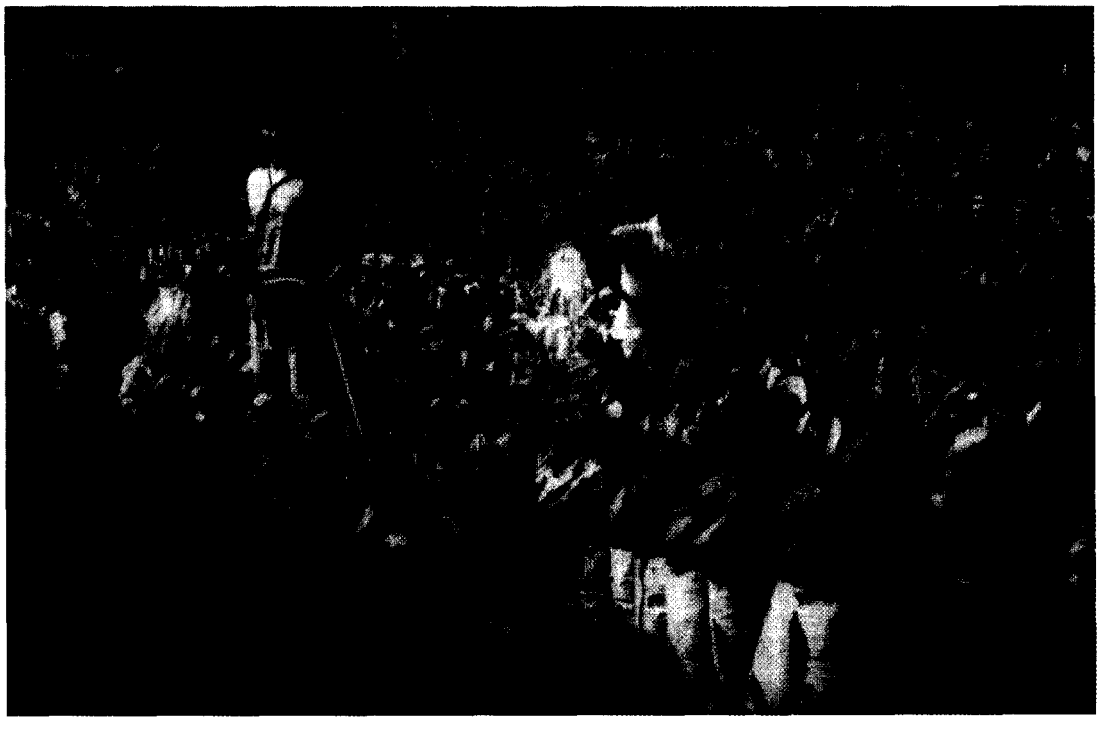
In common with other areas of the coastal strip of south-west India, the Karnataka forestry district of the Western Ghats encompasses a broad range of forest types (e.g. deciduous, semi-deciduous, wet evergreen), (Photo 1) which reflect the marked rainfall gradient, typical of this monsoon-climatic environment. Annual rainfalls can be as low as 600 mm to over 4,000 mm in the more exposed locations adjacent to the Arabian Sea. More significant, the bulk of the rainfall occurs in the very short monsoon season, June to September, which requires trees to be able to withstand up to 6 months of drought.

Reforestation management

The Karnataka Forest Department works closely with the local communities to encourage community forest management. Nurseries throughout the district are managed by the local people.



1. The Western Ghats escarpment looking south covered by wet evergreen forest. Photo: M. Bonell



2. An example of a community-based nursery near the semi-evergreen forest. Photo: M. Bonell

The strategies adopted in rehabilitation depend on the state of land degradation. For example in the semi-deciduous forests, hardwood seedlings are successfully interplanted between existing trees at the commencement of the monsoon. (Photo 2) By contrast, large areas of the coastal foothills of the Western Ghats (beneath the escarpment) are severely degraded with laterite induced by natural climate variability, and not anthropogenic causes. Estimates for the age of formation of such lateritic "soils" are in the broad band of 500,000 to 30 million years ago which extends across the Pleistocene to Tertiary geological periods (Rajaguru, pers. comm. 1996). These lateritic soils produce an almost impervious, concrete-like pavement which militates against natural seedling regeneration. Furthermore the "soils" are so hard that the local communities 'chisel' blocks out of them for use in house construction. There are some patches of natural forest in between the lateritic pavement. Dynamite is used by the Karnataka Forest Department to break up the lateritic surface and *Acacia auriculiformis* are planted in the created holes. (Photo 3)

This tree species acts as a pioneer crop which encourages the return of soil micro-organisms and soil moisture through the incorporation of fresh leaf litter. In addition, the trees provide shade to stabilize surface temperatures and prevent cementing agents such as iron from allowing the surfaces to return to a hard, lateritic surface. In the longer term, underplantings with selected native hardwood species will be trialled whilst still being *Acacia auriculiformis* as a "cover" crop to furnish the necessary microclimate conditions associated with shade as well as increased soil moisture retention by the organic litter.

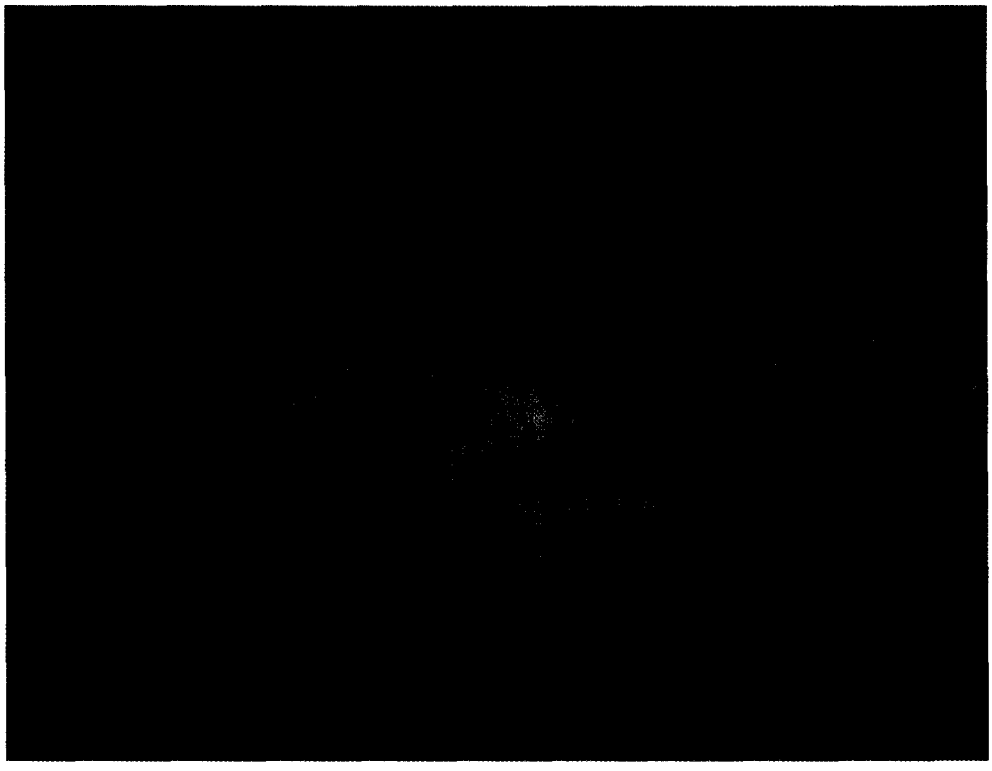
III. ORGANIZATIONS INVOLVED

The work is being jointly undertaken on behalf of the IHP by the Karnataka Forest Department (Dharwad) and the National Institute of Hydrology, Belgaum. Prior to commencement of the project, the International Hydrological Programme sponsored the training of a young scientist from the National Institute of Hydrology (Belgaum) by the Commonwealth Scientific and Industrial Research Organization, Division of Environmental Mechanics, Canberra, Australia so that he would become familiar with the most recently developed field, soil hydrologic techniques (which are described below). The International Hydrological Programme also sponsored the purchase of equipment to implement the project and field work commenced in September 1995. The Karnataka Forest Department and National Institute of Hydrology are financing both the field and laboratory logistical support, as well as the required follow-up computer analyses.

IV. EXPERIMENTAL STRATEGY

The experimental strategy followed is divided into three principal components:

1. analysis of rainfall characteristics
2. field *in situ* measurements of selected soil hydrologic (hydraulic) properties for both the surface and subsurface horizons
3. soil laboratory analysis for soil description (texture, moisture retention and nutrient status). *This aspect will not be discussed here.*



3: Acacia forest in the background; lateritic surface in the foreground. Right of the photograph in the foreground are young plants in dynamite holes (Kumta Site). Photo M. Bonell

(1) Rainfall

The rate at which rainfall is applied (expressed in mm per hour equivalent) linked with the infiltration properties of the surface soil controls whether rainwater moves over the surface as overland flow or enters the soil by *infiltration* (the infiltration rate expressed in mm per hour), and continues down the soil profile by *percolation.* Consequently, a good understanding of the rainfall characteristics is required.

A survey of existing rainfall records across the region is being undertaken for rainfall intensity-frequency-duration analyses. This is being supplemented by the establishment of an automatic weather station which will have the capability of continuously measuring rainfall amounts over very short time intervals, say 1-6 minutes, for specific storm events. Such sophisticated information helps to determine at which parts of a storm the infiltration capacity of the soil is exceeded or not.

(2) Field *in situ* measurements of soil hydrologic properties

Two different techniques are being used for the surface and subsurface.

The surface soil is being tested by the Commonwealth Scientific and Industrial Research Organization (Australia) disk permeameter (Perroux & White, 1988) (Photo 4) and enables the rapid measurement of *hydraulic conductivity (otherwise known as permeability* which is the ability of the soils to transmit water in units of mm s^{-1}) and *sorptivity* (the ability of the soil to absorb water in units of mm $s^{-½}$). Both these variables control the rate of entry of water into the soil

4. The field utilization of the disk permeameter on the Jenmury Site at the east of the Western Ghats escarpment near Dharwad in an environment previously covered by deciduous forest. Photo: M. Bonell

profile via infiltration. It is important to note that hydraulic conductivity becomes a variable when soil moisture content falls below saturation. Consequently, there are two types of hydraulic conductivity, *viz, field, saturated hydraulic conductivity* (where most of the soil pores are occupied by water) and *unsaturated hydraulic conductivity* (where soil pores are increasingly occupied by air as moisture content declines). The unsaturated hydraulic conductivity therefore reduces with decreasing soil moisture content. Most of the discussion will centre on the field saturated hydraulic conductivity, but the unsaturated parameter is linked mathematically with the calculation of sorptivity and the two remaining parameters outlined below.

The disk permeameter also provides measurements on two additional variables, one of which is related to hydraulic conductivity and sorptivity and is technically known as *macroscopic capillary length*, in units of mm. The second, the characteristic *soil pore size radius* (with minimal disturbance, expressed in units of mm) is a measure of the soil structure and offers a hydraulic approach to studying the impact of environmental and land-use changes(White & Sully, 1987; White. *et al*, 1992).

One would expect that with reforestation of the more degraded lands, the roots would "open-up" the soil and lead to an improved soil structure with a larger characteristic soil pore size radius. Thus the contribution of preferential flow paths through biopores for stormwater infiltration and subsequent percolation can be assessed quantitatively with the permeameter.

There are two versions of the disk permeameter, the first makes measurements at saturation (positive water pressure potentials, or positive water pressure), that is, under ponded conditions of infiltration. The second, allows measurements to be taken when the soil surface is unsaturated (i.e. some of the soil pores contain air) with the instrument set at a specified negative water potential (or negative water pressure). From the use of both versions, the four hydraulic properties listed above can be calculated (Perroux & White, 1988; White *et al*, 1992).

During the first phase of the project (September-October 1995/May-June 1996), field experiments were conducted at 13 sites across an array of climatic-soil-forest types coupled with different reforestation strategies in terms of forest species (mono- or mixed species) and type of cultivation. The project is continuing, and the sample sizes of field testing need to be enlarged before any preliminary conclusions can be made. Nonetheless, the surface field saturated hydraulic conductivity is commonly less than 15 mm hr^{-1} on the degraded sites which suggests that during major monsoon events, infiltration-excess overland flow can be easily generated, and cause significant erosion.

The subsoil hydraulic conductivity and sorptivity is measured by the Guelph (named after the Canadian university) Constant Head Well Permeameter (Reynolds *et al*, 1983; 1985). This

instrument maintains a constant head of water in a freshly augured hole at pre-specified range of depths depending on the horizons in the soil profile. The measurements of water transfer to the auger hole can be equated with the absorption (sorptivity) and transmission (hydraulic conductivity) of water into the surrounding soil using mathematical formulae.

The constant head well permeameter was originally designed by Commonwealth Scientific and Industrial Research Organization, Australia (Talsma & Hallam, 1980), but without the facility to measure sorptivity. The value of the constant head well permeameter in the context of this project is to provide changes in field, saturated hydraulic conductivity with depth for different soil horizons. Such details indicate whether vertical transmission of percolating rainwater can continue or there are certain soil layers whose permeability is so low that they act as 'impeding' horizons. The latter facilitate the development of temporary water tables (technically known as *perched water tables*) which encourage *lateral, saturated flow* or *subsurface stormflow*. If such impeding horizons are close to the surface, which is common in forests below the organic layer, then continued rainfall encourages perched water tables to emerge at the surface and produce saturation overland (saturation-excess) flow. Hence, if short-term rainfalls are compared with measured saturated hydraulic conductivity from the surface downwards, then the potential for the occurrence of saturation overland flow and subsurface stormflow can be assessed.

In common with all *in situ* soil physics techniques, the above methodologies have limitations which require considerable skill and prudence in the interpretation of collected data. Some of these limitations arise because of simplification in the assumptions so as to obtain the required soil hydraulic properties. For example, such assumptions include the soil as being "uniform", otherwise known as having the "ideal" soil properties in terms of structure, texture, moisture content as well as being non-swelling (a problem with selected clays). Non-uniformity can for instance give negative values of field saturated hydraulic conductivity when using the disk parameter, which of course are physically meaningless (White *et al*, 1992). When using this technique, there are also problems with steep slopes and freshly cultivated soils (for tree planting) (both factors of which are being addressed in this project). The constant head well permeameter method also introduces the long recognized additional problem of 'smearing' of the freshly-augured hole which reduces the estimate of field, saturated hydraulic conductivity (Talsma, 1987). Whilst there are empirical correction factors available to revise the estimated field, saturated hydraulic conductivities; recent research has established the greater importance of vertical preferential flow during storms within spatially-variable, inter-connected soil macropore networks. The constant head well permeameter technique is more biased towards the measurement of horizontal saturated hydraulic conductivity and the hydraulic properties of the surrounding soil matrix because of smearing (Talsma, 1987). The principal limitation is the small volumes of soil tested, which at this scale are strongly affected by the well known problem of spatial (and temporal) variability of soil hydraulic (and related physical) properties because of a diverse range of pore sizes occurring in natural soils. This is partly a result of the science of soil physics having its roots at the "laboratory" scale and the practical consideration that the current techniques are more manageable in terms of the portability of instruments and the volumes of water required for the experiment.

The scale of interest in field measurement is at the hillslope or small catchment (~ 1 km^2). Consequently, the results from this preliminary study can only be regarded as 'indicators', as a step towards the establishment of viable hypotheses to underpin the second stage of the project.

V. THE NEXT STEPS

By 1998 an extensive data base of the five parameters will have been collecte d. Following careful quality control on the data, both statistical analyses and infiltration modelling will be undertaken to quantitatively establish the differences between sites to infer the impacts of various reforestation strategies on the hydrology of these landscapes. The results will also indicate whether the stated hypotheses at the commencement of this article are valid or not. They are also likely to raise further points of enquiry, not currently recognized.

VI. THE FUTURE

Forest hydrology has been firmly entrenched in the classical paired experimental approach once described as 'calibrate, cut and publish' to evaluate the impacts of forest conversion. What is now required is a reversal of this approach, whereby at least two degraded catchments are calibrated and then the hydrological impact of selected reforestation strategies are monitored. Options of site selection, in preparation for adopting this strategy, are currently being considered. The final decision, however, will rest with the results from the present preliminary survey. The above experimental catchment strategy will also address the above-mentioned problems of measurement scale. Moreover, it will act as a framework for more cross-disciplinary activities including soil science (soil fertility and trace biology), biogeochemical cycling-hydrochemistry and socio-cultural aspects through community forestry.

REFERENCES

Bonell, M. with Balek, J. (1993) Recent scientific developments and research needs in hydrological processes of the humid tropics. In: *Hydrology and Water Management in the Humid Tropics*, Bonell, M., Hufschmidt, M.M. & Gladwell, J.S., eds., Cambridge University Press-UNESCO International Hydrology Series, pp. 167-260.

Bruijnzeel, L.A. (1989) Review Paper. (De)forestation and dry season flow in the tropics: A closer look. *J. Trop. Forest Sci. I*, pp. 229-243.

Bruijnzeel, L.A. (1990) *Hydrology of Moist Tropical Forests and Effects of Conversion: A State of Knowledge Review*, UNESCO IHP, Humid Tropics Programme, Paris.

Hewlett, J.D. & Fortson, J.C. (1983) The paired catchment experiment. In: Hewlett, J.D. (ed.) *Forest Water Quality*, School of Forest Resources, Univ. of Georgia, Athens, GA, pp. 11-14.

Hewlett, J.D., Lull, H.W. & Reinhart, K.G. (1969) In defense of experimental watersheds. *Wat. Resour. Res. 5*, pp. 306-316.

Perrous, K.M. & White, I. (1988) Designs for disc permeameters. *Soil Sci. Soc. Am. J. 52*, pp. 1205-1215.

Reynolds, W.D., Elrick, D.E. & Clothier, B.E. (1985) The constant head well permeameter: Effect of unsaturated flow. *Soil Sci. 139*, pp. 172-180.

Reynolds, W.D., Elrick, D.E. & Topp, G.C. (1983) A re-examination of the constant head well permeameter method for measuring saturated hydraulic conductivity above the water table. *Soil Sci. 136*, pp. 250-268.

Talsma, T. (1987) Re-evaluation of the well permeameter as a field method for measuring hydraulic Talsma, T. & Hallam, P.M. (1980) Hydraulic conductivity measurement of forest catchments. *Aus. J. Soil Res. 18*, pp. 139-148.

White, I. & Sully, M.J. (1987) Macroscopic and microscopic capillary length and time scales from field infiltration. *Wat. Resour. Res. 23*, pp. 1514-1522.

White, I., Sully, M.J. & Perroux, K.M. (1992) Measurement of surface-soil hydraulic properties: Disk permeameters, tension infiltrometers and other techniques. (In) Advances in Measurement of Soil Physical Properties: Bringing Theory into Practice. *SSSA Special Publication No. 30*, SSSA, Madison, Wisc,, pp. 69-103.

BIODIVERSITY CONSERVATION AND ECOSYSTEM REHABILITATION EMPHASIZING TRADITIONAL KNOWLEDGE SYSTEMS IN INDIA

UNESCO New Delhi recently won a grant of US$ 210,000 from the McArthur Foundation, USA to implement this research project over the next three years in collaboration with the School of Environmental Sciences at the Jawaharlai Nehru University in New Delhi. This research programme vAR adopt a comparative approach to investigate and describe the specific links between biodiversity status, traditional resource use ('practical knowledge') and ecosystem rehabilitation performance and potentials in three localities from the two biodiversity 'hotspots' of India - the Himalayas and the Western Ghats.(see page... "The Eco-Hydrology Rehabilitation on Degraded lands in Western Ghats).

The programme owes its design to the premise that ecosystem rehabilitation is an essential first step towards sustainable rural development, particularly in areas near, and in buffer zones of protected areas. One of the three study areas, located in and around the Nanda Devi National Park, is recognized as an Indian biosphere reserve and included in UNESCO's World Heritage List. The other two study areas are in the Western Ghats - one of them is located in and around the Chinnar Wildlife Sanctuary of Kerala and the other includes all the natural and planted forests managed by the Kamataka Forest Department. The local institutions responsible for conducting the research at the study sites are the G.B. Pant Institute for Himalayan Environment and Development, Almora (Nanda Devi National Park), the Kerala Forest Research Institute, Peechi (Chinnar Wildlife Sanctuary) and the Kamataka Forest Department, Bangalore (natural and planted forests in Kamataka). Analysis of location-specific data, and comparisons of trends and patterns among the three study areas are expected to lead to the design and elaboration of sustainable rural development models where biodiversity conservation, traditional knowledge and resource use, and ecosystem rehabilitation mutually reinforce one another. Ecosystem rehabilitation has been selected as a focus not only to promote protection and recovery of biodiversity, but also as an entry point to re-establish environmental amenities and services provided by ecosystems as the basis for planning sustainable socio-economic development of people and cultures. Training vAU be provided to each of the study teams by the School of Environmental Sciences, Jawaharlal Nehru University, New Delhi in order to ensure that the techniques and methodologies employed at the different study sites are comparable, and allow comparisons between the study sites at later stages of the project.

Further information on the this project may be obtained from the Director, UNESCO New Delhi Office, 8 Poorvi Marg Vasant Vishar, 11057 New Delhi, India (Fax: + 91 11 6873351; e:mail: UHNDL@unesco.org)

THE REGIONAL HUMID TROPICS HYDROLOGY AND WATER RESOURCES CENTER FOR SOUTH-EAST ASIA AND THE PACIFIC

The fourth phase of the International Hydrological Programme (IHP) (1990-95) established a project devoted to the hydrology and water management of the humid tropics in response to the recommendations from the International Colloquium on the Development of Hydrologic and Water Management Strategies in the Humid Tropics, which was held at the James Cook University of North Queensland, Townsville, in July 1989. One of the initiatives of IHP-IV was the establishment of a Regional Centre in Panama for the Latin America and Caribbean region in November 1992 (named CATHALAC - Centro Regional de Recursos Hidricos en las Zonas Tropicales Humedas de America Latina y el Caribe). A description of that Centre was given in the report on Science and Technology in Latin America and the Caribbean (1996). Following the 26th Session of the UNESCO General Conference in 1991, it was decided that a second regional centre on humid tropics hydrology and water resources for Southeast Asia and the Pacific would be established in Malaysia under the auspices of UNESCO. Subsequently in April 1996 the Government of Malaysia gave its approval for the Department of Irrigation and Drainage (DID) Malaysia to establish the Regional Humid Tropics Hydrology and Water Resources Centre for Southeast Asia and the Pacific. It is expected to become operational in 1997 and shall have the following functions:

1. *co-ordinating the implementation of co-operative hydrological and water resources research projects and activities in the region;*
2. *networking with IHP National Committees and other similar centres for exchange of scientific and technical information on research results;*
3. *organizing training courses, seminars, workshops and meetings for knowledge and technology transfer;*
4. *production of related hydrological and water resources publications and media for distribution.*

Further information on these Centres may be obtained from the Division of Water Sciences, UNESCO, 1 rue Miollis, 75732 Paris Cedex 15, France. Fax: + 33 1 45 68 5811. E-mail: m.bonell@unesco.org

INTERNATIONAL RESEARCH AND TRAINING CENTER ON EROSION AND SEDIMENTATION

The International Research and Training Center on Erosion and Sedimentation (IRTCES) was established by the Chinese Government under the auspices of UNESCO in 1984. The objectives of IRTCES are to organize international training courses, symposia and workshops, international study tours and lecturing activities, and to serve as the permanent secretariat for the organization of the International Symposium on River Sedimentation (ISRS); to create a mechanism for the exchange of scientific and technical information on the results of research among specialists in various countries; to co-ordinate co-operative research activities and to provide facilities for laboratory and field work for specialists from various countries; to publish the "International Journal of Sediment Research". IRTCES aims at the promotion of international exchange of knowledge and co-operation in the study on erosion and sedimentation problems. Since then, many symposia, workshops, seminars, training course and professional study tours have been organized.

NATIONAL INSTITUTE OF HYDROLOGY, INDIA

I. INTRODUCTION

In a tropical country like India, it is difficult to make accurate predictions about the availability of water resources, and this places certain restrictions on their optimal use. Even with an efficient use of water, the country's ultimate irrigation potential can be set at only 150 million hectares. However, if water availability and variability are to be assessed quantitatively, modern methods of estimation, analysis and design are necessary. This would be particularly helpful in evaluating and mitigating disasters such as floods and droughts and in streamlining the operation of water resources systems in order to meet water needs.

Several government agencies and academic institutions have been involved in studying those aspects of the hydrological cycle which deal with operational and organizational commitments. The National Institute of Hydrology, however, was created in an effort to build a comprehensive approach to scientific studies in both applied and theoretical hydrology. It was intended to pave the way for developing methodologies that could be then applied to the planning, design and operation of water resources.

A proposal for assistance to set up the Institute was submitted by the Government as a project in 1974 through UNDP. With UNESCO as Executing Agency and the Department of Irrigation as the Government Co-operating Agency, the National Institute of Hydrology was finally established in 1978.

Further information on the this project may be obtained from the Director, UNESCO New Delhi Office, 8 Poorvi Marg Vasant Vishar, 11057 New Delhi, India (Fax: + 91 11 6873351; e-mail uhndl@unesco.org)

II. Objectives and Results

Objective I: **Promote and co-ordinate systematic scientific studies in theoretical and applied hydrology in order to improve water resources management.**

- The Project helped the Government to ensure that applied hydrology functions as a basic tool for the optimal utilization of surface and ground water resources. This approach allows the preparation of detailed, quantitative basin plans. The plans indicate how much water can be collected and used from the ground, from melted snow and/or precipitation.

- In addition, the Project provided for infrastructure facilities such as buildings; it covered recruitment and training of manpower and equipment to facilitate computer oriented studies and research in the different phases and components of the hydrological cycle.

- The phases and components were assessed quantitatively in relation to planning and evaluation of how water resources can best be used.

- The Government of India's contribution focused mainly on the infrastructure, counterpart and administrative staff and related facilities.

- Training programmes were linked to the Institute's scientific activities.

Objective II: **Regional Centres**

In order to study hydrological problems of various agro-climatic regions of the country, the Institute has established regional centres in the following places:

- Deccan Hard Rock Regional Centre, Belgaum
- Western Himalayan regional Centre, Jammu
- Northeastern Regional Centre Guwaliati
- Ganga Plains Regional Centre (1), Patna
- Ganga Plains Regional Centre (2), Sagar
- Eastern Coastal and Deltaic Regional Centre, Kakinada

The establishment of two other regional centres has been proposed:

- Arid and Semi Arid Regonal Centre, Udaipur
- West Coast Regional Centre, Goa.

Objective III **Research Activities and Technology Transfer**

To cover scientific and technical activities in the various aspects of hydrology, the Institute has a team of 60 well-qualified and trained scientists besides scientific, technical and administrative staff.

Research activities cover all the component processes of the hydrologic cycle and their interaction as well as the influence of human activity on the quantity and quality of water resources.

The assessment and utilization of surface and groundwater levels include planning, design, construction and operation phases of water resources projects.

The National Institute of Hydrology has been actively involved in technology transfer. It co-operates with Central and State Governments in carrying out studies of specific field-related problems and circulates its technical reports free of cost to government institutions.

Objective IV: Documentation and Publications

Results:

A modern library has been set up containing books, reports, publications and journals in the field of water resources, hydrology and allied disciplines.

A computer-based library information system is being developed for disseminating information.

Results of studies conducted at the Institute are being brought out in the form of technical reports. More than 400 reports in different categories have been prepared since the Institute's inception.

At present, UNESCO is assisting the National Institute of Hydrology in strengthening its research capabilities through another UNDP-funded project entitled "Developing Capabilities for Hydrological Studies" through TSS-2 programme facility. The expertise gained from this project will be used in the proper estimation of hydrological parameters

The National Institute of Hydrology has established itself as a premier research institution not only in India but in the entire region.

ATOLL GROUNDWATER RECHARGE IN KIRIBATI

The UNESCO-South Pacific Applied Geoscience Commission study is part of UNESCO's International Hydrological Programme, and a contribution to UNESCO's new project on Environment and Development in Coastal Regions and in Small Islands. The study aims to quantify the recharge of fresh groundwater lenses which float above seawater in islands, atolls, and some coastal areas. The sustainability of water extraction from these shallow freshwater lenses is crucial to many Pacific nations where groundwater is the major water reservoir. Overpumping can lead to salt moving into the groundwater from underlying seawater. In addition, these shallow groundwater systems, in highly permeable coral sands, are easily contaminated by surface wastes and are therefore extremely fragile.

The study aims to supply relevant information on the amount of fresh groundwater used by coconut trees and the effect of pumping on the groundwater lens. The study also aims to record oral traditions, particularly on climatic fluctuations and groundwater pumping, and their impact on crops and drinking water.

A weather station has been established on the island of Bonriki in Tarawa atoll, Republic of Kiribati to monitor relevant climatic variables. Watertable monitors and tree sap flow meters have also been installed. As well, the salt in the groundwater is being monitored using specially designed salinity wells. The project also includes a strong training component and includes participants from the Cook Islands, Federated States of Micronesia and Tuvalu.

Installation of a sap flow meter to study transpiration of groundwater by coconut trees
Photo: Trevor Sankey

Groundwater beneath a water reserve on this island provides drinking water for the majority of people on Tarawa. Local villagers, who owned the land and live adjacent to the water reserve were interviewed. They believe that the coconut trees and taro, which grow in pits excavated to the watertable, are not as productive in the water reserve since pumping began. The interviews also revealed a politically, economically and socially complex situation.

Preliminary results from the first field measurements indicate that the lowering of the watertable due to pumping in the specially designed horizontal pumping galleries was less than 20 mm. Since the watertable fluctuates diurnally by about 120m, due to tidal influence, this drawdown is negligible. Perceived changes in vegetation do not therefore seem due to the pumping.

It was shown that direct evaporation from the lens can be no greater than 4mm/day. Potential evaporation rates are close to 4.6 mm/day. Coconut trees appear to use between 100 to 150 litres of water per day in the dry season, about three times the water allocated per head to people in Kiribati.

Further information on this project may be obtained from the Science Adviser, UNESCO Apia Office, P.O. Box 5766, Matautu uta P.O., Apia, Western Samoa, Fax no. + 685 22253

ECOLOGICAL AND WATER RELATED RESEARCH IN THE ARAL SEA BASIN

I. BACKGROUND

Words have not been spared in depicting the predicament of the Aral Sea and its wider region: water management disaster, ecological catastrophe, tragic example of poorly planned and implemented development projects, etc. The case is described in innumerable documents, papers and reports, from scientific analyses to political pamphlets. A simple listing of these would require tens of pages.

The fact is that the Aral Sea region, shared by five independent Central Asian republics of the former Soviet Union, is hit by serious social, economic and environmental difficulties and the desiccation of the Aral Sea is the most visible mark of that crisis, both a source and a consequence of the overall degradation of the environment in its basin. It is this phenomenon which attracts most of the external attention and which distinguishes the Aral region from many other parts of the contemporary world in economic and environmental distress.

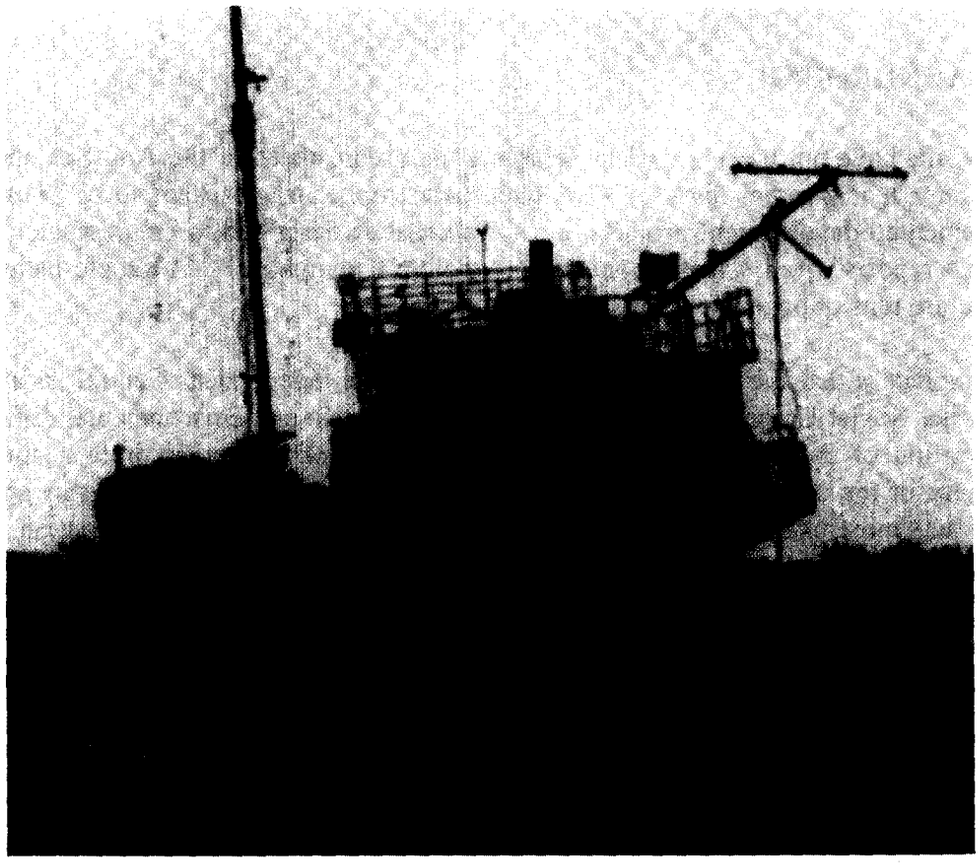
The dividing line between cause and effect of the Aral Sea crisis is fuzzy: the most frequently quoted causes of the crisis are water management strategies, such as excessive development of irrigation in the basin, uncontrolled water pollution, and so on; the main consequences of the desiccation are the drying of the lake bed, the deterioration of water quality, the salinization of the adjacent land, the deterioration of the economy and the resulting impoverishment of the affected population, etc.

The shrinking of the Aral Sea was rather the result of deliberate planning than of oversight or miscalculation: in the first half of this century and even before, the reclamation of the lake area was considered as an objective, in the believe that the former lake bottom could be transformed into fertile land with flourishing agriculture, like the rest of the basin, where the water resources would be "harnessed" and put in the "service of progress". At that time, such a planning philosophy did not provoke criticism: environmental awareness and conscience was a far cry from what it is today. The consequences of this philosophy are now evident.

Further information on these activities which were carried out under a Funds-in-Trust project by UNESCO and BMBF, Germany, may be obtained from Vefa Moustafaev, Division for Policy Analysis and Operations, Asia and Pacific Section, Natural Sciences Sector, UNESCO, 1 rue Miollis, 75732 Paris, France. Fax: + 33 1 45 68 5824; e-mail: v.moustafaev@unesco.org

II. ADDRESSING THE ARAL SEA CRISIS

The approach to a multi-objective and highly complex problem like the Aral Sea crisis must be cautious, gradual and flexible. No simple solutions can be envisaged, nor can the crisis be reduced to its water management or environmental aspects only: it has its social, economical and political dimensions. The needs of a rapidly increasing population with a huge potential work force, are such that very little of the water conserved through improved water management (irrigation, etc.) will be restored to the Sea simple to maintain its level: the stabilization of the lake at a certain level must be imposed by the planners as a constraint rather than as a planning objective of the envisaged development strategies.



A boat left high and dry on the shrinking Aral Sea

No wonder that such an disaster has attracted the attention of many international, national and non-governmental bodies, promoting a variety of proposals on how to approach and address this crisis. As it is impossible to give account of all such initiatives, only those which are relevant for the current UNESCO/Federal Ministry of Research Education and Technology of Germany (BMBF) Project, its follow-up and possible extensions will be reflected here. These are the actions of the World Bank, UNDP, UNEP and the European Community, all of which call for a synergy of the current efforts in the region and offer a wide opening for further initiatives. Their chronology is listed below:

CHRONOLOGY OF ACTIONS IN THE ARAL SEA BASIN

1992 July	UNEP	Diagnostic Study for the Development of an Action Plan for the Aral Sea
1992 November	*BMFT (now BMBF) F.R. Germany*	*Project Document "Ecological Research and Monitoring in the Syr-Darya and Amu-Darya Deltas at the Aral Sea as Basis for Restoration"*
1992 August Geneva	UNEP, World Bank, UNDP, UNESCO, etc.	Meeting on the Diagnostic Study
1993 March 2	*World Bank*	*The Aral Sea Crisis: Proposed Framework of Activities*
1993 March 24-28, Paris	UNESCO, BMBF, (Germany)	Discussion on Project Document 509/RAS/40
1993 April 26 Washington	*World Bank, UNDP, UNEP, UNESCO, etc.*	*International Seminar on the Aral Sea Crisis*
1993 June	World Bank	Evaluation mission to the Aral Sea basin
1994 January 11 Nukus	*Heads of States*	*Approval of the "Nukus Programme"; creation of ICAS, EC and IFAS*
1994 Feb/Mar	World Bank Mission to the Aral Sea Basin	Aral Sea Programme Phase 1
1994 May 10-13 Tashkent	*UNESCO, BMBF*	*Aral Sea Project Seminar*
1994 June 23-24 Paris	World Bank, UNDP	Donors' Meeting
1994 August	*European Economic Community -Technical Assistance to the Commonwealth of Independent States (EEC-TACIS)*	*Invitation to Tender for Water Management and Agricultural Production in the Central Asian Republics*
1996 December	World Bank, EEC-TACIS, UNDP	Aral Sea Project, Phase 2

A significant evolution took place early in 1994, with the adoption of the so-called "Nukus Programme" of the Heads of States of the five republics in the basin. The five republics made a commitment on action to be undertaken and two bodies were created to coordinate that action at regional levels:

- The Interstate Council for the Aral Sea with its Executive Committee;
- The Interstate Fund for the Aral Sea.

COMPONENTS OF THE ARAL SEA CRISIS

ARID CLIMATE, FERTILE SOIL, IRRIGATED AGRICULTURE & MONOCULTURE (Cotton)	LOW GNP, HIGH POPULATION GROWTH	TRANSITION FROM COMMAND TO MARKET ECONOMY	TRANSBOUNDARY WATER RESOURCES PROBLEMS
ENSUING ENVIRONMENTAL DISASTER			

III. UNESCO INVOLVEMENT

UNESCO has been concerned with the Aral Sea Crisis since the Diagnostic Study Meeting convened by UNEP in Geneva, in August 1992. In parallel, German scientists in close contact with local researchers, worked out a project programmeme on ecological monitoring of the Delta areas. By a funds-in-trust agreement between the Federal Ministry of Research, Education and Technology of Germany and UNESCO, this programmeme then became Project 509/RAS/40 (March 1993).

IV. OUTLINE OF THE UNESCO/BMBF PROJECT 509/RAS/40

Project title

Ecological Research and Monitoring of the Syr-Dar'ya and Amu-Dar'ya Deltas of the Aral Sea as a Basis for Restoration.

Funding

Federal Ministry of Research, Education and Technology (BMBF) of Germany

Executing Agency

UNESCO

Budget (in US $)

Total	1993	1994	1995
839,610	525,004	186,362	128,244

Project area

The most ecologically affected region of the basin, which include the Amu-Dar'ya and Sir-Dar'ya deltas and adjacent areas of the Aral Sea.

General Objectives

The general objective of the project is the assessment and modeling of the terrestrial and aquatic ecosystems of the study area as a basis for rehabilitation and sustainable development. Research methods and know-how in the project area will be improved by a supply of instruments, and the transfer of knowledge through fellowships, seminars, etc. The results of past research and studies will be assessed and presented in a comprehensive and accessible form. The project is also expected to help preserve and upgrade the local scientific and technological human resources potential, by involving them actively in the efforts to arrive at ecologically sustainable development policies.

Contribution to Aral Sea Action Plan

The UNESCO/BMBF Project is closely linked to the Aral Sea Programme, approved by the Heads of States in Nukus, January 1994, and directly contributes to the environmental studies of the Programme.

Subprojects

The research and studies, implemented through 22 sub-projects, deal with the following subjects:

- changes in plant and soil cover in the deltas
- assessment of desertification processes
- protection of the Tugai ecosystem in the degraded areas
- plant succession in the newly-formed water bodies
- effective irrigation and drainage parameters
- monitoring and simulation of the small Aral and Syr-Dar'ya lacustrine systems water and salt regime
- effects of pesticides on aquatic biocenoses and animals
- improved standards of water quality
- adaptation and changes of biocenoses from historic times up to the present
- water regime model for the Amu-Dar'ya, including pollution transport
- use of saline soils by cultivation of salt-tolerant plants
- use of biological treatment of waste water
- limnology of flat water bodies in the Aral Sea region
- pollution by chemicals of abandoned agricultural airports
- research of fish species and fisheries
- research of animal species
- groundwater regime in the Aral Sea depression
- research for ecological modeling criteria
- establishment of a geo-information system for the project area

Implementation

More than 140 researchers in the region have received support in order to continue their research; two water quality monitoring stations have been established and equipped on the main rivers (Muinak at the Amu-Darya and Karateren at the Syr-Darya); the research capacity has been upgraded by supplying instruments, computers, etc.; research methods and know-how are improved. Progress reports were presented at a Seminar in Tashkent, 10-13 May 1994 and the results will be evaluated through international workshops and seminars in the region. The Project has been supported by the highest authorities in the respective countries.

Follow-up

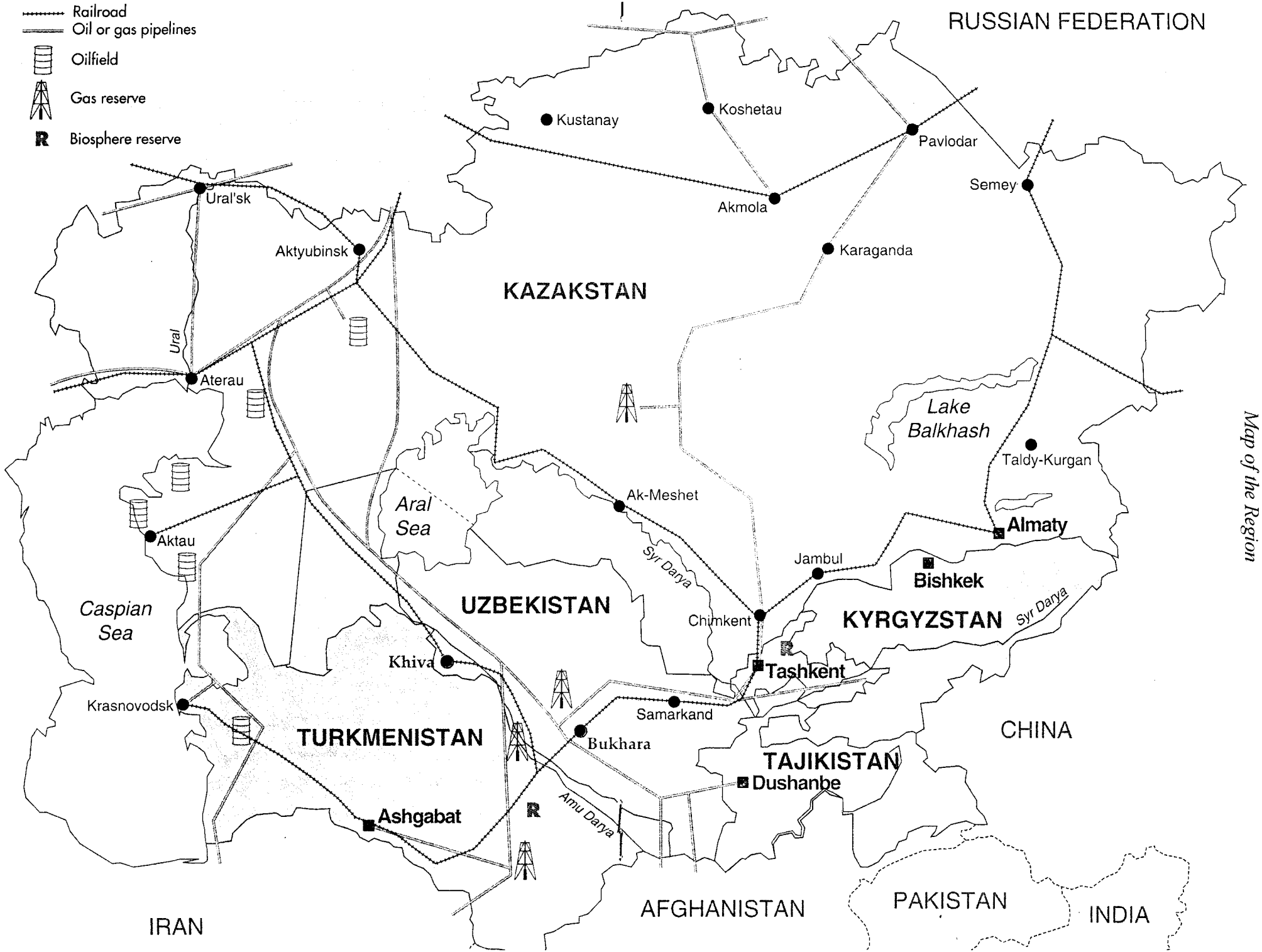
The second phase of the project entitled: *Research on ameliorating the environmental situation in the ecological crisis on the Aral Sea* began in 1996 with a total budget of more than US$398,000 for a period of four years. Intensive work will be carried out within the Programme, funded by the World Bank, European Economic Community-Technical Assistance to Commonwealth of Independent States (EEC-TACIS), United Nations Development Programe and other international and bilateral agencies and donors. It is thus essential to achieve a synergy of all efforts, in order to obtain the maximum benefit from each of these bodies.

The follow-up of the current project will be geared towards applicable proposals to the governments in the region and streamlined with other national and international efforts in the region. It will aim at:

- Setting-up a **water information system for the region**
- **New research subjects**, such as remote sensing for monitoring ecology and water resources; revitalization of river bank and fluvial vegetation; rehabilitation of saline lakes; control of sand

- and dust blowing off the dry sea floor; determination of infection patterns in animal and human diseases; improving irrigation practices by advancement of water saving methods, including cultivation of paddy rice, drop irrigation techniques, etc; optimization of engineering biological processes for drinking water treatment; assessment and protection of groundwater resources, etc.
- **Capacity building in water and environmental management** through training of specialists in water resources management, environmental sciences, earth sciences; upgrading scientific and educational equipment of key institutions; setting-up a central chemical laboratory for the field stations; improving communications facilities and skills, etc.

LANDSAT images (1985 and 1992) indicate clearly the degradation that has occurred in seven years


Railroad
Oil or gas pipelines
Oilfield
Gas reserve
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RUSSIAN FEDERATION
Kustanay
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Pavlodar
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Ural'sk
Aktyubinsk
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TURKMENISTAN
Bukhara
TAJIKISTAN
Dushanbe
Ashgabat
Amu Darya
IRAN
AFGHANISTAN
PAKISTAN
INDIA

6. OCEANOGRAPHY & COASTAL MARINE SCIENCES

DEVELOPMENT OF THE UNESCO CORAL REEF PROGRAMME OVER THE LAST DECADE

Part I:

CORAL REEF ASSESSMENT AND STATUS EVALUATION IN SOUTH-EAST ASIA

WHY MONITORING ?

At the 5th International Coral Reef Congress (1985) in Tahiti at the opening session, on the basis of work done by the UNESCO Coastal Marine Programme in Jakarta Bay, Indonesia, UNESCO made a call for more systematic data sets describing natural reef responses to commonly occurring physical gradients so that man induced pressures can be readily recognized and quantified. Since that time, a considerable amount of data has been collected showing degradation and simplification of reef structures throughout the world.

Along with the effects of pollutants and exploitation patterns, it may be anticipated that global warming, due to the greenhouse effect, will also result in structural adjustments to coral reef communities. Provided that the effects of the various factors can be distinguished one from another, coral reefs may thus serve as sensitive indicators of heat-stress induced by global warming, the "canary" in the coal-mine. Although the calcium carbonate skeletons that form coral reefs provide modest carbon storage (sinks) overall they are none-the-less true sinks unlike trees which, although they are the primary sources of fixed carbon, are merely temporary storage structures unless the vegetative material becomes buried or otherwise immobilized. Additionally, because coral reefs provide dynamic protective structures to islands, it is important that their health and responses toconditions governing their well-being be monitored. Coral reefs also provide the basis for direct and indirect support of human communities in the form of fish and invertebrate protein, as well as building materials and decorative products derived from a number of organisms. Lastly, coral reefs are an important source of revenue in the growing field of eco-tourism.

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M0NITORING PRINCIPALS

As far as coral reefs are concerned, the problem in environmental analysis involves the elaboration of monitoring strategies capable of:

(1) detecting and identifying long term trends such as those that may be supposed to act in the form of global warming induced by increased atmospheric CO_2 concentrations since the 1800's;

(2) distinguishing and quantifying thè more immediately persisting or fluctuating changes induced by other direct human influences such as those arising from discharges of pollutants and other kinds of disturbances, (this may be accomplished through the identification of consistent environmental trends and then determining apparent causal deviations from the generally expected pattern);

(3) generating responsive data to map real and potential changes across a broad variety of population densities and community structures;

(4) actively sampling across environmental gradients.

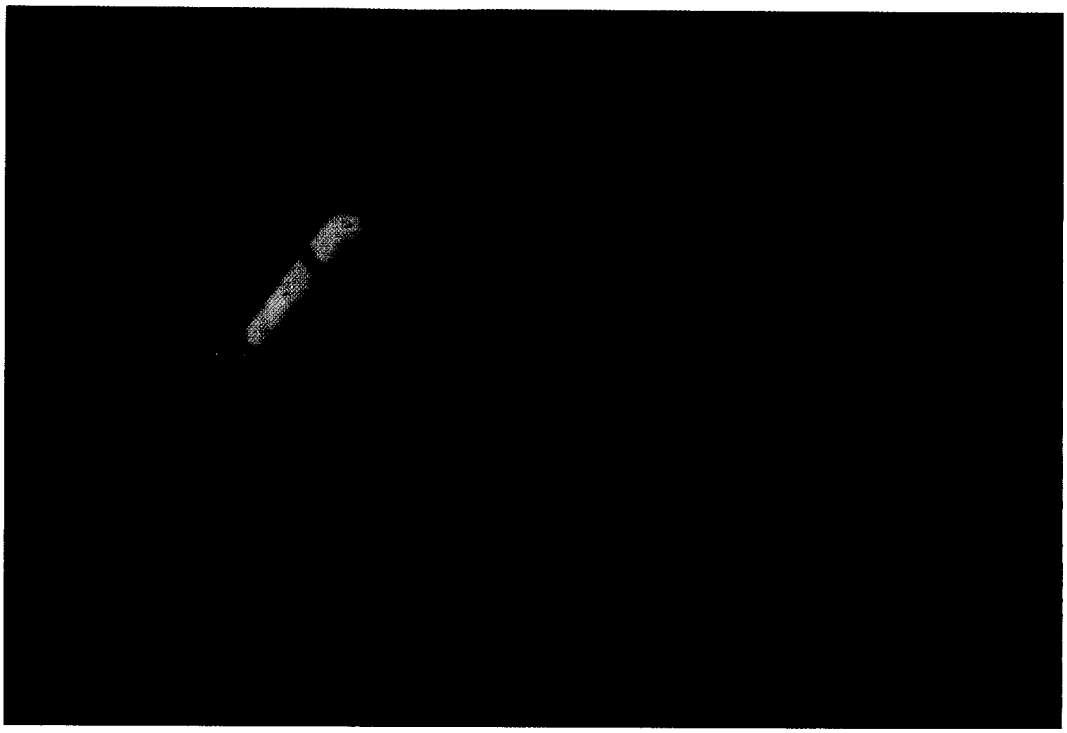
One of the main purposes of an assessment programme is to provide a knowledge-base that can be used to carry out deductive reasoning with respect to the environment by monitoring the major active factors. A competent monitoring programme is an essential adjunct to any attempt to manage a coral reef system in an ecologically sound and sustainable manner. This is particularly true of biological factors. In general one must look first at economically important species (commercial and recreational), nationally protected or internationally endangered species, and finally at the structure of the food web supporting such "important" species. Any species or group of species through which a major energy flux takes place (coral reefs, mangrove ecosystems, seagrass beds etc.) should likely also be considered.

Sampling Coral Reefs

Natural coral reef communities are sampled and examined for a of reasons the most common being to satisfy the requirement of quantitative description so that one situation may be compared with another. The requirement for such comparisons may arise in response to a variety of circumstances some of which are listed:

1. To determine the influence of various ecological factors acting on the distribution of coral communities (research);
2. To assess the effects of development projects on coral ecosystems (impact);
3. To obtain a base-line description of the distribution and abundance in order to detect secular changes such as those involved with a response to global warming, the progressive influence of pollutants etc.;
4. To develop management strategies based on existing distributions etc.
5. To define the basic information required as input to programme aiming at environmentally sound and sustainable development.

In the case of a monitoring programme, the first priority is the detection of change in existing patterns or trends. However, once this has been accomplished attempts should be made to determine the causes of such changes through experimental analysis and associated manipulation, where this is possible.



Research scientist measuring coral growth. Photo: R. Harger

ASSERTION 1: THERE ARE NO LOCATIONS FREE FROM ANTHROPOGENIC EFFECTS !

IMMEDIATE ANTHROPOGENIC EFFECTS

High population density situation, Jakarta Bay, Indonesia

The negative impact of industrial development both on the land and in the marine environment has long been understood by various coastal communities. The deliberate introduction of pollutants in many regions of the world's coastal waters, such as heavy metals, hydrocarbons, and pesticides, by factories has increased the burden of pollutants in these waters to such an extent that many communities have been warned to take special care in using the waters and their biological resources. This is particularly true for areas where large-scale industrial projects have been and are being developed, where broad expanses of agricultural land drain into the sea, and near large cities.

A survey of the reef structure associated with islands in the Pulau Seribu (Thousand Islands) chain (Indonesia) extending northwest into the Java sea from Jakarta Bay on the north coast of Java was made in 1985 by a UNESCO training course looking at the effects of man-made influences. Data on coral reef structure was obtained at two depths (roughly 1 meter and 3 meters, below the mean tidal level) from the north face of approximately 28 islands. Additional measurements of physical environmental factors were also made. The city of Jakarta through its extensive discharge of pollutants was found to be responsible for the dominant pattern of degraded reefs in Jakarta Bay with progressive improvement out to a distance of 45 km. Perhaps not surprisingly, it was also found that reefs associated with resort developments were usually healthier (higher coral cover, more species) than nearby islands without resorts. Thus eco-tourism may be said to offer some degree of protection to coral reefs. A further assessment over the same islands was made 10 years later in 1995 and the results indicated that the outer islands had suffered yet further reductions in diversity.

Specific results from the latter survey are discussed further in Part II of this article.

Explaining variance in coral reef population structure

The dominant influences on the coral reefs in the Pulau Seribu region can be split into two categories:

1. the action of combined effects of proximity to land and the influence of pollutants discharged by the city of Jakarta and its immediate environs;
2. the possible secular effects of global warming.

The fact that great changes have been induced in the reefs within recent times is clearly demonstrated by comparing the present day structure of inshore reefs within Jakarta Bay with the situation as described by the J.H.F. Umbgrove in the 1920's. The obvious conclusion to be drawn from this comparison is that the inshore Jakarta Bay reefs have been largely destroyed in recent times since very few if any scleractinian (hard coral) species can now be found on the islands affected to the greatest extent (within 10-20 km of Jakarta) as opposed to the situation described by Umbgrove where previously extensive reefs are noted. In fact, it is now necessary to move 40-50 km beyond the islands Umbgrove described in order to find reef structures which match his original accounts.

The next point that may be made is that many of the islands further from the mainland show considerable coral reef development at the present time so that a trend exists between degraded reefs close to Jakarta and those further from the mainland along the island chain. Although the dominant influence on the reef systems appears to arise as the result of pollution discharges from the city of Jakarta, the nature of the trend is not straightforward. One reason for this is that islands further out tend to be more disturbed by various activities such as "blast fishing" than those closer to Java.

The most degraded reefs in the Jakarta Bay area have completely lost the large "massive" boulder-like Porites colonies which were mapped by Umbgrove in 1929 and in addition now support virtually no coral. Pulau Nyamuk Besar, 6.6 m from Jakarta and a former resort in Dutch colonial times is now almost devoid of hard corals (2.3%-4.0% cover) and has been abandoned as a recreation spot.

The above considerations suggest that the first indication of degradation in reef systems might be associated with the loss of the "interstitial short-lived" elements (including secondary species such as butterfly fish which generally eat coral polyps in a species-specific manner). When this progresses to the long-lived structural species, the reef has been "lost" to all intents and purposes as far as current monitoring is concerned although some forms of "secondary invasion" by otherwise resistant long-lived forms can take place.

Since the initial survey of 1985 (and even before that time), a minimum of one and often two assessment exercises per year have been carried out by senior high school students from the Jakarta International School as part of the field studies required by the International Baccalaureate programme. These exercises were first initiated in 1983 using transects placed at right angles to the reef face but were changed after 1985 to favour the use of transects placed parallel to the reef face in order to obtain better statistical control of variance associated with depth. Data have been gathered from three of the islands surveyed during the 1985 UNESCO training course (Pulau Tikus/Pulau Pari, Pulau Kotok Besar, Pulau Hantu/Pulau Pantara). In order to connect the information-base to the community at large, an "international" group of media correspondents responsible for "environment reporting" has also been trained in the interpretation of scientific findings and exposed to the activity as participants.

The array of hard-coral forms that can be easily scored by a high school class in this form of investigation may be conveniently summarized as: 1) encrusting (lichen-like), 2) branched (staghorn-like), 3) massive (rock-like), 4) sub-massive (pillar-like), 5) tabulate (table-like), 6) foliose (scroll-like), 7) solitary. Other organisms include 1) algae, 2) soft corals, 3) sponges, 5) other forms. Physical conditions include 1) coral sand, 2) dead coral/rubble. What matters is the detection of systematic change in existing patterns or trends and not necessarily the particular elements chosen for inclusion in the survey.

Implementation of the simplified assessment procedure described above, across the range of degraded reefs that can be identified as the result of Umbgrove's 1929 report, would have been more than sufficient to map the changes that have occurred in the interim. The aggregate of class data gathered has at all times been sufficient to enable students to clearly detect significant and consistent differences in reef structure with respect to depth (1 and 3 meters) and in relation to the exposure. A critical element in this exercise is the high degree of replication since a class of 30-40 students works in groups of 4-6. Each group is responsible for 3 x 60 meter line-intercept transects at each of two depths and two locations (exposed and sheltered). Normally, such a procedure generates data from 30-60 separate transects (if not more) and "observation errors" are swamped by the "environmental effects".

A low-profile, widely distributed programme of the nature described above would clearly be able to track coral reef changes and could also cover broad areas of reef structures and so be liable, both by accident and design to encounter anomalous situations.

The reef systems of Jakarta Bay are extensively damaged by the immediate and obvious discharges from the city of Jakarta. These include heavy nutrient loads, heavy metals, toxic organic chemicals as well as sediments. In spite of strenuous efforts which have been made recently, the possibility of locating reef structures removed from the negative effects of human activity is now quite low or even negligible.

Low population density situation, Dravuni Island, Fiji

A three week Science and Resource Management Workshop from November 27th to December 12, 1989, was held by UNESCO for high school teachers at the University of the South Pacific Field Station on Dravuni Island, inside the Great Astrolabe Reef, Fiji. Among other things, the participants carried out assessments of the reefs and of beach-litter.

Beach Litter Survey

Beach litter was divided into 4 categories (1) polythene bags (2) polystyrene blocks (3) footware (4) other. Participants picked up all materials between the water edge and a distance of 10 meters or so above the upper strand-line. Material was then sorted, counted and weighed. There was 200 Kg. in 1.7km of beach on the windward side of Dravuni Island and 1.7 kg. on 1.6 km of beach on the sheltered side. The volume of beach debris in the mid-Pacific on Dravuni was found to be unexpectedly high. By comparison, data gathered by the UNESCO workshop in Indonesia indicated that the level of contamination corresponds to the same amount of debris found on islands about 20 to 25 km from Jakarta, one of the largest cities in Southeast Asia (estimated population 8.8 million).

The population of Fiji is 727,000 people of which only 120 reside on Dravuni Island, this fact, associated with the level of beach-drift industrial debris collected, poses a significant question: from whence did where did all this debris come? Although Fiji is marginally

industrialized, most of the debris apparently originated from industrialized countries on the Pacific Rim. Many items carried brand names from surrounding countries (Japan, Australia, New Zealand, U.S.A.). Significant items included PVC bottles, aluminum beer and soft drink cans, pieces of drift and gill nets, net floats, styrene and urathane foam blocks, footwear, inhalers and a syringe. Among the breakdown products arising from such plastics include PCB's (poly-chlorinated bi-phenyls), unreacted curative or hardening agents from resin systems such as 4,4' methylene bis di-chloro aniline (Curene or MBOCA) and many other as yet unknown chemicals which have the potential for invasion of the food chain. This may pose a problem for situations where such chemicals might accumulated over long periods of time. Plastic debris stranded on the beaches of the Persian Gulf, for instance, lasts only a matter of 1-2 months before it is reduced to fine powder under the influence of extended periods of direct sunshine and abrasion.

Participants were unable to agree upon an appropriate disposal method for the materials.

Silt and associated run-off

Further findings arising from the field study concerned the practice of goat grazing on small islands such as Yanuyanuiloma Island about 2 km southwest of Dravuni Island. The factors of assessment were the distribution of butterflyfish and hard-coral cover. Two areas were investigated in detail by using standard observation and counting methods involving two observers per transect line. The Dravuni area appeared to be a relatively healthy inshore fringing reef whereas the Goat Island area was exposed to silt-run-off from the small adjacent overgrazed island. Overgrazing was judged in comparison to the situation on Dravuni island. The difference being that no green ground-level vegetation was apparent on Goat Island, the bare ground having been exposed by the goat population whereas Dravuni Island supported an almost continuous cover of ground-level vegetation.

Fourteen butterfly fish species were recorded on Dravuni Island reefs with 40%-60% coral cover and only four species of butterfly fish with 5%-10% coral cover at Yanuyanuiloma Island. Overgrazing has resulted in excessive soil erosion which has left the island almost barren and has silted up the coastline and the fringing reef. This island, an emergent rock-outcrop, was badly overgrazed to the extent that all surface ground-level vegetation appeared to have been removed leaving only bare soil with evidence of extensive silt run-off onto the adjacent reef. Adjacent islands were covered in green vegetation in contrast, but Yanuyanuiloma-(Goat Island) was, on the contrary, red-brown due to the appearance of the bare soil which supported only a few upright green trees, heavily grazed around the trunks.

This brief comparison between reef conditions in the Thousand Islands region in the Java Sea, Indonesia, a relatively densely populated area and of Dravuni Island, Fiji, in the south Pacific is instructive. This is because a deliberate attempt was made to seek a coral reef structure in a comparatively undisturbed location (Dravuni Island) after it was realized that heavily fished reefs in southeast Asia could not be used as teaching areas when assessment procedures for larger fish species were to form part of the field teaching exercises associated with reef evaluation.

The reef systems of Jakarta Bay are extensively damaged by the immediate and obvious discharges from the city of Jakarta. These include heavy nutrient loads, heavy metals, toxic organic chemicals as well as sediments. The Dravuni system is also damaged by sediment run-off and is presumably also exposed to chemicals derived from plastic drift accumulations.

ASSERTION 2: LONG-TERM ANTHROPOGENIC EFFECTS ARE ALREADY DETECTABLE !

LONG-TERM ANTHROPOGENIC EFFECTS

The degree of inter-species competition is greatest in high diversity systems such as tropical rain forests and coral reefs and as a consequence of this complex organization, high diversity systems may also be expected to collapse towards species-poor associations when faced with the effects of rapid global climatic change, as has been documented in paleontological records for the deep past (at least for coal-mire systems) as well as in modern communities exposed to the stress of man-made pollutants. Fossil records have also shown that carbon sequestering systems of the past (e.g. coal-forming mires) which remained in virtual unchanged stasis for tens of millions of years, were susceptible to climate change and that change produced community structure collapse when relatively few (probably < 20% of species) were lost from well adapted systems as dryer conditions developed. However, fossil records show that such changes did not occur uniformly throughout the globe at the same time so that the Lycopod dominated swamp-forests were able to persist in China and Europe long after they had been replaced in America by a suite of plants adapted to more arid conditions which were perhaps induced by the carbon sequestering swamp forests themselves.

In general, if a central intrinsically adapted community is eliminated by physical change, then previously unsuccessful competitors may penetrate a re-established community if the original dominant species are either all extinct or in some way prevented from setting up dominance structures.

Where there has been rapid environmental change in the past it is always associated with enhanced rates of extinction, community and biosphere restructuring has, for terrestrial systems, 'required' prolonged recovery lasting more than a million years. The best documented discontinuity (a global catastrophe) of this type was at the end of Cretaceous, 65 million years ago, which was associated with change in global climate, long term vegetation restructuring, and a major change in the northern hemisphere biota, presumably resulting from a meteorite impact.

The first indication of such changes should be the elimination of dominance hierarchies through the removal of one or two "key-species" as in the case of recent massive sea-urchin die-backs in the Caribbean, with a resulting re-aggregation of the surviving species into new communities.

The wide-spread break-down of dominance hierarchies has yet to manifest itself on a broad basis in southeast Asia the present changes being maintained by the action of consistent although sometimes relatively constrained mortality patterns such as those found in Jakarta Bay. On the other hand, large areas of the Philippines reefs have been exposed to such intensive harvesting pressures that a depauperate structure is often wide-spread. We can however, ask if there are any preconditions that appear to be in place that would in turn impose the necessary adjustments to species patterns so permitting wide-spread community collapse. The overall effects of temperature change on the Pulau Seribu system are difficult to assess however; it would appear that even in Umbgrove's time (1929), a change was already underway both in the form of anthropogenic run-off and in temperature effects.

Recent Work

The UNESCO session at the 7th International Coral Reef Symposium in Guam (1992) entitled "Coral reef monitoring: what to do and how to do it" considered a number of assessment protocols for the determination of reef health. As previously explained, the method currently in general use for the evaluation of gross impact to coral reefs is known as the "growth-forms protocol" which is associated with a line-intercept technique and now used on a global scale. As indicated, the method has certain advantages in that the procedures are easily transmitted to students and the resulting data can be used to readily determine areas of gross damage, provided sampling transects are located strategically across degraded-structures.

As the result of recent work it has become apparent however, that a number of significant shortcomings are associated with the growth-forms assessment protocol. These are:

1. Fine structure-changes associated with marginal effects cannot be detected or mapped. Species-sensitive shifts within a given-growth form across different geographical and physical niche-boundaries appear as constants in the resulting data;

2. Poor replication and transect representation leads to gross errors interpretation with respect to intermediate areas. Work of this nature has been used recently to extend damage zones from around major cities in Southeast Asia to include all of the adjacent areas including relatively undamaged coral reefs in areas now being opened up to eco-tourism. This situation is particularly worrisome because the tourist-returns must be seen as providing the resources necessary to maintain the presently relatively healthy reefs. If all reefs in Southeast Asia are presumed to severely damaged beyond the point of attraction then local communities sitting on unique reef structures will find it very hard to attract the kinds of funding necessary to set up international tourist resorts and the reefs will slip further into decline.

In summary, the gross coral growth-forms assessment procedure fails at both the micro and macro levels while being adequate at the intermediate level.

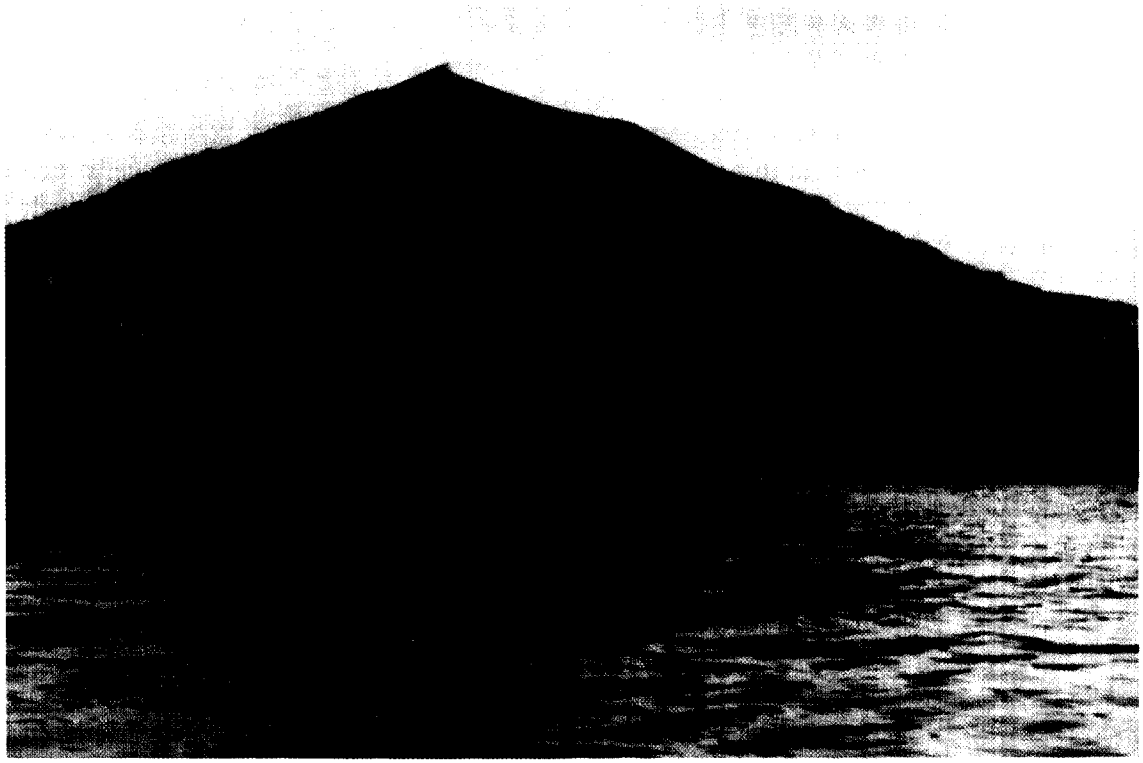
The center of coral species diversity from a global perspective is found in a limited area which includes eastern Indonesia. In order to search for and determine a new and broader assessment paradigm, UNESCO operated a 4-ay workshop in this high-species diversity region centered in the Banda Sea in east Indonesia during November 1994.

Corals in East Indonesia

The main study-site was centered on reefs around Gunung Api in the Banda Island group. In 1988 the volcano erupted pouring two sets of larva around 800 meters in width into the sea and destroying the coral reef. Since that time a spectacular recolonization event has occurred to the extent that up to 20 species of hard corals may be recorded on a single square meter of larva. Growth has also been extremely high by normal standards so that table-form corals have reached diameters of over 1 meter in around 4 years or so. In Jakarta Bay for instance such growth may be a mere 2-4 cm a year.

Surrounding undamaged reefs were observed to be dominated by relatively few species but the exact representation seems to change rapidly from one place to another in response to physical conditions. For instance, exposed regions tend to be dominated by sub-massive growth-forms represented by *Heliopora sp.*, quieter regions by tabulate *Acropora*,

particularly where there is water movement. Intermediate situations, for instance where there is some kind of shelter, by large Porites boulders. In locations between these kinds of situations there is a constant adjustment of different species representation over scales of just a few meters so that a very large array of representative formats may be seen in stretches of reef measuring only a few tens or hundreds of meters in extent. Quiet lagoons are dominated by dense thickets of branching and folios forms represented by comparatively few species (4-6) each dominating patches of tens of meters in extent.



Gunung Api, 1988. Photo: R.. Harger

Over 112 species have so far been recovered from the recolonized area alone along with two new species, giving some hope that similar healing can be coaxed into play in damaged areas next to major areas of human population if the primary mortality factors can be reduced. It is not known what exact combination of conditions in the surrounding reefs leads to this "healing effect" although initial lack of predators and a complex substrate have something to do with it in terms of initial survival. A further factor seems to involve the relatively abundant representation of corals in the reefs surrounding the impacted area together with the high through-flow of clean water within this comparatively unpolluted area. It is perhaps not to be wondered at that the giant hump-head parrot fish (1.5-2.0 meters in length), is also found in these "high diversity" waters.

Among other attributes, the region of east Indonesia is characterized by very high growth rates for hard-corals (*Scleractinia*) and, in specific circumstances, explosive settlement densities as well as a high number of species. Throughout the Indonesian and Philippines Archipelagos there may be perhaps as many as 400 species overall. In a relatively circumscribed region such at Spermonde archipelago of southwest Sulawesi (40 x 80 km) as many as 78 genera of *Scleractinia* have been recorded with 262 species. The environment in eastern Indonesia is a complex of semi-isolated seas and islands and also influenced directly by the "Western Pacific Warm Pool". This area of periodically fluctuating sea-water temperature apparently influences the strength of the "Western Pacific Dry Event"

associated with the El Nino - Southern Oscillation and the temperature-pulse involved, coupled with the associated drought appears to spread globally from the region under particular circumstances. There is currently some concern that El Nino-associated warm events are increasing in frequency and intensity as global warming proceeds. In Indonesia the two warmest and driest of such events for over 100 years have occurred in the last 13 years or so and the longest period containing such influences (5 years to the beginning of 1995) in the instrumental record.

The implications posed by this species-diversity-hot-spot include, but are not limited to, the following:

1. In aggregate all other coral reef areas on the globe are subject to continual low-level replenishment in species from this location and its immediate surroundings. If local structural diversity is held constant, then species diversity, with some variation, declines progressively to the north south, east and west;

2. The region in question represents a relict compliment of hard coral species which is now in decline and was more widespread in the past;

3. The high volcanic activity and constant flux of energy from the earth's interior generates conditions (new sub-strata regimes etc.) favouring and indeed promoting primary speciation over comparatively short time intervals;

4. The shifting sea-levels over recent geological time have engendered speciation through isolation and rejoining in the surrounding complex of inner-sea basins and trenches;

5. Fluctuating surface seawater temperatures due to the "Western Pacific Warm Pool", in part associated with El Nino generation may change in such a way as to promote maintenance of somewhat higher species diversity than would otherwise be the case;

6. Hot-spot features involve extremely high colonization and growth and which are part of a damage-repair-mechanism promoted by a somewhat "unstable" locale.

7. Species "drain" or migrate into the area from peripheral habitats where they arise in response to extreme conditions.

8. The area represents the modern derivative of the location in which multi-cellular marine life originated or perhaps at least the closest modern equivalent to the original setting.

arising from recovery of cultural knowledge concerning ecosystems and their management which is a strong UNESCO programme. The Australian Aboriginal belief (arising from as much as 60,000 or perhaps even 150,000 years of pondering the issue) is that species arise as the result of "expressed local potential". They arise directly from the alignments and energies generated by their particular locality. Humans, animals and plants are the "dream" of the landscape which in turn arises as an externalization of the essence generated and deposited by the "great ancestors". By this notion, the magnetic, volcanic, inter textural nature of the semi-enclosed and enclosed seas in the region of east Indonesia are the species-generating mechanisms. The earth itself is the dreamer and, among other things perhaps the geomagnetic field is the dreaming with animals, plants, humans the manifest results, themselves dreamers within the greater dream. This is not exactly a strange idea particularly if the fresh-water fish (*Cichlid*) species swarms of east Africa are considered and in particular the single-form crater-lake associations in Cameroon.

Students arriving at the UNESCO Coral Reef Assessmenr and Evaluation Workshop, Ambon. Photo: R. Harger

Participants examining coral reef over larva flow. Photo: R. Harger

Whatever the case, the extremely fine subdivision of ecological space in this area by organic form and function made it an ideal site for the evaluation of assessment approaches. There may indeed be some substance to the claim that all other coral reefs are derivative of those found in east Indonesia. If reef structures in this now comparatively healthy, but none-the-less significantly threatened diversity hot-spot are pushed into decline, then the reefs of the world may well be lost.

The UNESCO Coral Reef Assessment and Evaluation Workshop Ambon, 27 November 1994 and Banda Naira, Indonesia, 28 Nov.- 01 Dec. 1994 was aimed at a combination of senior coral reef specialists of world renown and regional experts. The workshop defined the major questions and factors to be considered in deciding how coral reefs should be assessed on a global scale. The conclusions and recommendations from the activity are presented below.

Major questions

1. Are the ecosystems of concern (coral reefs) dying ? where ? how much ? how many ?
2. How long does it take for the ecosystems under consideration to recover from damage such as that inflicted by: typhoons ? ship grounding ? Oil spills ? bleaching ? dynamite damage ? larva flows ? drought ? various aspects of damage induced by human action? etc.
3. What levels of disturbance can coral reef ecosystems stand resulting from: excess nutrients? fishing? sediments? specific forms of exploitation etc.
4. How can we bring back: corals ? fish ? or any other desirable species which has been"reduced" by excessive exploitation or other forms of abuse.

Coral reef ecosystem assessment.

1. The interpretation of data arising from the use of indices and aggregate measurements must be done with care. For instance, a low percentage ecosystem (coral) cover does not necessarily mean a damaged ecosystem.

2. Assessment of process involved with ecosystem change and transformation is important. Is a particular ecosystem or reef degrading or recruiting ?

3. Modes of assessment should be related to specific objectives, not every form of measurement will result in data that can be used to answer all questions. Measurements of diversity may not necessarily help in the estimation of productivity under different management systems.

4. Bulk assessment is required to relate local measurements to an overall pattern. Remote sensing should be made operational and used in conjunction with ground-truth mapping.

5. Ecological communities should be related to physical and environmental variables, i.e. aspects of topography, morphology as well as exposure etc.

6. The simple "growth forms" assessment protocol which uses simple categories such as branching, encrusting, massive, sub-massive, folios, solitary etc. to classify hard coral structure should be expanded. The question of what should be added is moot however, measurements of reef-repair responses and recolonization capacities are obviously required.

Sustainable use in coral reefs

This will involve answering the following forms of questions: What is sustainable use

for a coral reef "ecological system" ? What are the principal economic relationships and the major variables affecting the ecology ? the use-patterns and "demands" ? the existing community relationships ? the manageable components or adjustment that can be made by the human community ?

Assessment for sustainable use

The objective of any such global, regional or local evaluation is to determine the manner by which sustainable use of coral reef ecosystems or other natural-resource-systems can be obtained. In this regard, the following criteria for success may be specified:

1. Traditional uses and opportunities for economic development are sustained

2. Ecological values (biodiversity, productivity, biomass) are sustained

3. Community ownership and implementation is maintained.

4. Socio-political/legal aspects are satisfied or changed to permit sustainable natural resource exploitation

Methods for achieving objectives

Management should be focused at a scale of islands, naturally bounded systems, island-groups (e.g. in the Indonesian Archipelago Banda Naira, Ambon, north Sulawesi), etc. using ecologically significant units and appropriate spatial scales.

Management Information

Resource uses by humans should be determined and the effects of human verses natural influences on ecosystem structure and function should be evaluated. The major items involved are:

1. The total organisms captured or harvested (biomass) should be assessed.

2. Market catch assessment should be practiced at the local market - 20 (say) of the most abundant ecosystem species (key fish groups) should be counted. Key economic species, or predefined taxonomic categories should be prioritized and monitored.

3. Evaluation of the ratio of local use versus export market demand should be undertaken. Assess subsistence levels and household use of a fishery or other productive unit. Check landing and transfer points for harvest estimates.

4. Assess existing and potential income from tourism. Calculate cost/person involved and evaluate tourism/ecotourism leakage to the capital source. Account for different tourism options. Gather immigration data, count hotels, conduct personal expenditure interviews and so forth.

5. Asses and evaluate non-renewable resources

6. Evaluate: blast damage, pollution impact and other human induced and natural damage using census techniques.

Ecological values

1) Evaluate the area, extent and distribution of natural resource systems or other natural resources of interest. Map through use of aerial photography, remote sensing. Consult existing charts and evaluate local knowledge.

2) Assess condition of coral reef ecosystems and ecosystem communities (e.g. corals, fish, invertebrates, others). Map existing uses and impacts, land use patterns (run off, pollution, land, sea), key fish, trees or other useful organisms. Conduct ecosystem and video surveys use reef-crest as focus of survey. Assess damage, size frequency of organisms (midpoint to suitable distance towards beach and towards sea, down reef slopes). Take into account exposure, angle of slope, aspect, weather, currents etc. as appropriate.

3) Conduct rapid assessment and causal analysis, considering the following elements:

- size distributions and abundance of the main organisms as well as edible and useful life-forms together with identification of probable causes of observed distribution patterns (key species).
- size frequency distributions and patterns of damage in the ecological community and identification of causes (e.g., disease, anchor-damage, log-impact. etc.)
- quality of the physical environment (sediment, substratum, water quality etc.). For aquatic environments visibility (secci disk extinction depth) total suspended solids, light-transmission, salinity, oxygen, temperature and so forth.
- opinions obtained from users of the ecosystem (e.g. talk to divers, fisher-people, traditional people) concerning longer term status and trends.
- identification of critical sites and times of stock replenishment e.g., location of serranid (a kind of fish) spawning grounds, closed season for dredging (coral recruitment), closed season for tourists (mating cues and sequences), multi-species eco-system channels used for spawning, migration routes, current patterns, closed season for other sensitive areas etc.
- learn from the elders: How have things changed? Has the potential for resource use been exceeded? What are long-term trends?
- monitoring: Is the situation getting better or worse? (e.g. harvest of useful organisms, catch per unit effort, changes in abundance, size, and damage levels in ecosystems). The method used will depend on question asked. Permanent transects or observation sites should be established, replicate comparisons should be used to establish differences, use physical environmental gradients to investigate trends and influences from specific locations such as sewage etc. Use settlement plates or follow recovery of naturally damage areas to estimate capabilities for "ecosystem healing".
- estimate possible yield for important exploited species. Look at trends shown by census techniques, size distribution, landings, recruitment (in 20 major species). Back-off the recommended use-rate from what might be calculated as the exploitation plateau. Do not lump species in such assessments.
- calculate thresholds beyond which ecosystem populations do not recover, and recovery times for those which can. Research will often be required to answer such questions.
- develop a shared definition of terminology to enable information transfer among scientists, managers, policy makers and community leaders. Workshops are required i.e. the term "marine park" in Japan as opposed to Australia has a different meaning. Determine the meaning of percentage cover of living organisms for particular areas. Remove jargon from descriptive accounts but not the ideas. Run workshops for managers, scientists and anthropologists to correct language differences.

The human community

1) Ownership

- consultation with 'stake-holders' is required
- involvement of stake-holders and representatives is required for the formulation of "in draft" development plans
- information sharing requires the evolution of a common terminology
- Council of community leaders should be involved

2) Implementation

- Community use rights should be established
- Community leaders and environment managers should be in charge of any "Plan"
- Public education concerning goals and rationale for achieving sustainable use is required
- Enforcement should be considered and evaluated.

Socio-political aspects

- identify all relevant institutions
- identify legal framework for management
- involve all relevant agencies and stake-holders in planning.

CONCLUSIONS

It is clear that coral reefs are very important ecological communities throughout the world. For the reasons outlined above, UNESCO, through its Intergovernmental Oceanographic Commission, is now involved in developing a Global Coral Reef Monitoring System as described in Part II of this article. Because of the extensive community connections developed during the initial part of the project, an activity aiming to reverse some of the worst influences within the region of Jakarta Bay has now been mounted by UNESCO's recently formed Coastal Areas and Small Islands Unit. This activity is attempting to use community-action to help people understand the causes of the deterioration that has affected the coral reefs adjacent to Jakarta Bay. The project will also look into ways in which existing biodiversity can be maintained and used to re-invigorate some of the degraded systems.

REFERENCE

Umbgrove, J.H.F. 1929 De Koraalriffen der Duizend Eilanden, dienst mijnb. Ned. Indie, Wetensch. Meded. 7, 1-69.

Part II

GLOBAL TRAINING IN CORAL REEF ASSESSMENT TO MONITOR GLOBAL CLIMATE CHANGE

For a number of years UNESCO through its Intergovernmental Oceanographic Commission (IOC) has been expanding its activities in coral reef assessment and mapping for the purpose of developing marine resource management capabilities. Following initial efforts by the then UNESCO Division of Marine Science, to standardize such techniques, the Intergovernmental Oceanographic Commission has made giant steps forward in the transfer of such assessment protocols, on a global scale, particularly into developing countries. The effort has also benefited developed countries by providing them with some forms of assessment that can be widely used within their own boundaries in order to form a the basis of a global reference for coral reef structure and function. The earliest intervention by UNESCO took the form of a joint field workshop together with United Nations Environment Programme in Phuket, Thailand in 1982 entitled "Comparing Coral Reef Survey Methods". UNESCO then signaled the problem of systematic coral reef degradation to the 5th International Coral Reef Symposium (Tahiti, 1984) and since then the problem has become the focus of a number of global workshops and seminars.

In recent years the global capacity developed by UNESCO's Intergovernmental Oceanographic Commission has become of even greater use as the assessment techniques have been adapted for use in the realm of global climate change analysis. Since many species of hard corals are sensitive to rather small temperature fluctuations, it has been proposed that coral reefs may provide biological indication of global temperature changes that are proposed to be associated with global warming. Some have even gone so far as to designate coral reefs as the possible "canary in the global-warming coal-mine". The use of coral for this purpose is not without its dangers since the mere restriction of a particular coral or even a suite of species cannot be taken as evidence for global warming even though the forms in question may be demonstrably temperature sensitive.

Further information on this programme can be obtained from the Secretariat of the Intergovernmental Oceanographic Commission, UNESCO, 1 rue Miollis, 75732 Paris Cedex, France. Fax: + 33 1 45 68 5810. E-mail r.harger@unesco.org

The reason for this is that many forms also respond in a similar fashion to impact from common industrial pollution. Nevertheless, the development of simplified and common assessment techniques has been a necessary prerequisite in establishing the basis for a common global effort in attempting to monitor the effects of global warming.

The actual assessment method proposed and now in general use, is known as the "growth forms protocol" and was suggested by the Australian Institute of Marine Science and first tested in an International Programme in a 1985 UNESCO field workshop in Jakarta Bay, Indonesia. The procedure is associated with a line-intercept technique and, as the result of an intensive effort made by the Intergovernmental Oceanographic Commission, is now used on a global scale. The procedure has significant advantages in that the techniques are easily transmitted to students and the resulting data can be used to readily determine areas of gross damage, provided sampling transects are located strategically across degraded structures. The stages involved in expanding the technique across the globe and throughout a variety of international agencies on a co-operative basis are detailed below and surely may be counted as a significant success story for UNESCO as a whole.

UNESCO mounted a major assessment programme to evaluate the state of reefs adjacent to population centres as early as May 1985 with the implementation of the previously mentioned international workshop in Pulau Seribu, Indonesia as part of the interregional project on coastal marine systems. Information arising from that activity subsequently provided a focus for the development of assessment programmes world-wide.

In order to expand the overall capability for assessment of coral reefs, UNESCO and its Intergovernmental Oceanographic Commission in association with the United Nations Environment Programme (UNEP), the World Meteorological Organization (WMO), the World Conservation Union (IUCN), South Pacific Regional Environment Programme, The Scientific Committee on Oceanic Research, the UNESCO Networks for Caribbean Coastal Marine Productivity and Pacific Coastal Marine Productivity, conducted a session at the 7th International Coral Reef Symposium in Guam from 21 to 26 June 1992 and an international workshop discussed "A co-ordinated network of tropical marine labs to monitor reef at the 7th responses to global change" together with a parallel workshop "Coral Reef Assessment: what to do and how to do it". The main objective of these actions was to encourage the coordination of relevant regional and national activities within the framework of a coral reef monitoring scheme. The network workshop concluded that a global co-ordinated network of monitoring stations was necessary and agreed to work towards setting up such a capability. It was also noted that the methods to be employed by any monitoring programme were subject to change with time. UNESCO-Intergovernmental Oceanographic Commission as the implementing agency, then charged a global task team, jointly sponsored by the Intergovernmental Oceanographic Commissions, the United Nations Environment Programme, the Association of South-Pacific Environment Institutions and the World Conservaton Union, with the responsibility of providing scientific and technical advice concerning the implementation of the proposed coral reef monitoring pilot phase activity to monitor the impacts of climate change on coral reefs.

In 1990 the Intergovernmental Oceanographic Commission of UNESCO decided to initiate a pilot phase of the "System of Long-term Monitoring of Coastal and Near Shore Phenomena Related to Climate Change" as a contribution to the "Global Ocean Observing System" in cooperation with the United nations Environment Programme and the World Meteorological Organization. The "UNEP-IOC-WMO-IUCN Pilot Activity on Coral Reef

Ecosystems" is one of the initiatives supported by joint efforts of the agencies involved. The objectives are: (1) to secure commitment of member states to the initiation of this initial activity; (2) to ensure coordination between on-going and planned coral reef monitoring activities; (3) to implement initial monitoring of selected sites in the Caribbean and Indo-Pacific regions; (4) to extend the existing Caribbean network of institutions and individuals collecting coral reef monitoring bleaching observations to the Pacific and Indian Oceans; (5) to strengthen the existing regional networks of institutions collecting coral reef monitoring data by providing facilities for interregional and global collaboration in data handling and exchange.

An implementation plan was prepared by the meeting of experts of the Intergovernmental Oceanographic Commission, the United Nations Environment Programme, the World Meteorological Organization and the World Conservation Union in 1991 and some 30 countries expressed their interest and willingness to participate. A total of 40 institutions were nominated as participants or national points of contact for the project. A global task team on the "Implications of Climate Change on Coral Reefs" as a joint endeavour by the United Nations Environment Programme, the Intergovernmental Oceanographic Commission, Association of South-Pacific Environment Institutions and the World Conservation Union, provided advise on project implementation. The task team also prepared a global overview on the expected impacts of climate change on coral reefs published in 1994 by the World Conservation Union. The group produced a management-oriented report entitled "Reefs at Risk, a Programme for Action" also published by the World Conservation Union in 1993. This was followed in April of 1993 by the joint production of a methodology manual by the United Nations Environment Programme and the Australian Institute of Marine Science entitled "Monitoring coral reefs for global change" prepared in co-operation with the Association of South East Asian Nations-Australian Marine Science Project, the Association of South East Asian Nations, Australian International Development Bureau, the Intergovernmental Oceanographic Commission and the International Atomic Energy Agency. In 1994, the task team issued a further publication "Global Climate Change and Coral Reefs: Implications for People and Reefs" supported by the United Nations Environment Programme, UNESCO's Intergovernmental Oceanographic Commission, the Association of South-Pacific Environment Institutions and the World Conservation Union.

In Southeast Asia and the western Pacific, a regional covered by the UNESCO-Intergovernmental Oceanographic Commission Programme Group for the Western pacific (WESTPAC) a training course on coral reef monitoring and assessment, using the above assessment protocols, was sponsored by South Pacific Regional Environment Programme, the Intergovernmental Oceanographic Commission, and the United Nations Environment Programme in Rarotonga from 23 February to13 March 1994 for 15 participants from small island states in the region with instructors coming from Australia and Singapore. The objectives of the field training were to: (1) train participants from the Pacific in the standard methods adopted by The United Nations Environment Programme, the Intergovernmental Oceanographic Commission, the World Meteorological Organization, and the World Conservation Union for assessing coral reef benthic communities and reef fish populations; (2) emphasize the importance of constructing a database to ensure accuracy and enable basic statistical analyses; (3) assess the status of the reefs around Rarotonga for the Cook Island Conservation Service; (4) develop a training procedure for the global programme of monitoring coral reefs and assess the effectiveness of such an activity. Parallel efforts were also undertaken by the UNESCO interregional project on coastal marine systems and the UNESCO marine science training and education programmes which focused on teacher-training and high school level field actions within the WESTPAC region.

Participants attained a solid grasp of the mechanics of applying the line intercept transect technique and were able to identify the major categories of life-forms and physical conditions outside the assemblage of hard-corals. The continuum of growth-forms within the category of hard corals proved to be a harder concept to transfer although ready success has been obtained previously with high school teachers in the Pacific and in Southeast Asia as well as classes of senior high school students. A basic difference here is that the Rarotonga activity involved SCUBA equipment whereas the other actions were all taken with snorkel capability only. The advantage being for the latter that instruction is easily given on the surface with maximum feedback. After experience is gained with surface techniques and free-diving the, SCUBA transfer is easily obtained.

An expert meeting on coral reef monitoring, research and management was later organized by the Intergovernmental Oceanographic Commission, the World Conservation Union and the Land-Ocean Interaction in the Coastal Zone Programme from 23 to 27 October 1994 at the Bermuda Biological Station for Research to review the pilot activity. The group prepared a work plan for the development of a "Global Coral Reef Monitoring Network" activity as part of the Global Ocean Observing System coastal zone module. The meeting also determined that the following objectives must be met for the monitoring network to become fully operational: (1) a "Global Coral Reef Monitoring Network" to be implemented within the Global Ocean Observing System to assess global change; (2) an office for the network to be organized to enable data collected in a standardized manner world-wide to be compiled, analyzed and distributed; (3) developing countries to be involved and assisted in the planning and implementation of activities carried out as part of the monitoring system.

The Global Ocean Observing System initiative which also encompasses monitoring of reefs for global change, was initiated and developed by the Intergovernmental Oceanographic Commission. The World Meteorological Commission and the United Nations Environment Programme as well as the International Council of Scientific Union) have all agreed to cooperate and co-sponsor this endeavour. In this regard, the Global Ocean Observing System also received support from the Second World Climate Conference and the United Nations Conference of Environment and Development (Rio de Janeiro, 1992) and the coral reef monitoring programme with its standardized techniques will go a long way towards providing some of the in situ observational data so necessary for giving advanced and objective warning of impending global change. Many countries will benefit from the information as they contend with the problems inherent in trying to make sure of food security in the face of expected changes in local productivity.

Individual countries have also successfully reacted to the initial impetus in different ways. In Indonesia , the Indonesian Institute of Sciences has divided the country into 7 areas for the purposes of conducting its own assessment programmes for coral reefs. Training in the agreed assessment technique has now been provided to a number of young experts. For instance, in 1992 a total of 46 people were trained, in 1993 (48 people), 1994 a national workshop on the "Criteria for evaluation of coral reefs" was held with 24 participants, for 1995-1996 actions in five different localities were held and 210 participants involved. In addition, other institutions such as Tropical Biological Institute (Bogor, Indonesia), the Asian Wetland Bureau as well as the former UNESCO coastal marine systems project have been involved in training courses dealing with coral reef management in cooperation with the Indonesian Institute of Science.

Other countries in the WESTPAC region, particularly those in Southeast Asia including Thailand, Malaysia, Singapore and the Philippines have also undertaken extensive surveys of their coral reefs using the growth-forms protocol. Many of these countries first

started to carry out assessments as the result of the push received from UNESCO in the early and mid eighties. In large part under UNESCO influence, this impetus was subsequently taken up seriously by the Association of South East Asian Nations-Australia Marine Science Project: Living Coastal Resources, funded by the Australian International development Bureau. Finally, the programmes are currently being actively expanded at the purely national level, with the help of the educational materials generated by the UNESCO's Intergovernmental Oceanographic Commission output, with an eye to also providing eventual contributions to the global monitoring effort.

The UNESCO-Intergovernmental Oceanographic Commission International Coral Reef Evaluation Workshop, Seribu Islands, Jakarta, Indonesia, 11-20 September 1995, re-surveyed 28 island reefs using replicated methods (with some additions) similar to those employed in 1985 (see section I). Reefs ranged from within Jakarta Bay in close proximity to Jakarta to the outer end of the Pulau Seribu chain.

The first survey under the programme was carried out in 1985, 10 years previously when it was found that reefs in the Jakarta Bay area had been severely degraded by discharges into the ocean of sewage and other pollutants. On the early survey, it was also observed that reefs beyond around 20 km from Jakarta improved rapidly with distance up to point where they supported between 40-50% coral cover. Experts from Indonesia, Australia, the Netherlands, United Kingdom, USA, the Philippines, Thailand, Vietnam, Cambodia as well as from UNESCO took part in the 1995 operation.

The new survey presented an entirely different picture with the inner Jakarta Bay reefs had having not changed appreciably in coral cover although species richness appeared to have declined in some cases. The reefs marginal to Jakarta Bay itself however, appeared to have improved somewhat.

A great surprise awaited the survey teams when they looked at coral cover, fish inhabitants, starfish, sea lilies and other organisms in that reefs beyond the 20 Km mark were found to display simplification and a gross reduction of coral cover and representation by fish species. By far the majority of islands now show coral cover equivalent to that previously found only in Jakarta Bay i.e. only 5%-10% of the reef area was occupied by living hard corals. The remainder were either dead and still in place or had been broken by wave action into sad rubble-banks. In concert with this startling ecosystem collapse(?), fish species were reduced in numbers and representation by individuals and larger predators such as the Napoleon Wrass were almost entirely absent.

The major factor accounting for the reduction was found to be an increase in pressures primarily of a human related nature particularly over fishing and over-use. Other elements playing a part were held to be global-warming as manifested by increased frequency and duration of El Nino warm events which lead to long hot "dry-seasons" in Indonesia. These events apparently heat shallow reef-flat waters which may then spill-out over the reef-face as toxic increased salinity discharges helping to kill sensitive corals. Rubbish on island strand-lines was double that observed in 1985, thereby leading researchers to conclude that pollutants carried within the water column itself had also increased. Presumably the dead coral had also exacerbated an already sorry condition by contributing an increased load of fine calcium carbonate particles helping to reduce penetration of the sun light which corals must have to survive and grow.

The last and most immediate causal agent of the destruction was found to be the

crown-of-thorns starfish which was present in outbreak numbers on at least one island and in apparently declining populations on all those showing the most massive destruction.

In this regard, the dynamics of the destructive event are as follows:

First, human populations remove large predatory fish as food items. Following this small starfish usually eaten by the predatory fish are able to survive more readily with the result that more and more corals are killed. "Crown-of- thorns" eats living coral animals leaving only the dead skeleton. As a concurrent event, the increased pollution load has probably also resulted in enhanced survival of predatory starfish since the larval stages of the starfish are heavily dependent on their planktonic food source which is itself elevated in response to higher nutrient concentrations.

With guidance provided by the Intergovernmental Oceanographic Commission, a Coral Reef Management Workshop, Jakarta Bay, Indonesia was subsequently organized by UNESCO-Jakarta in April 1996 as part of the new UNESCO "Coastal Areas and Small Islands Programme". Participating agencies included ANTARA (The Indonesian News Agency) and P3O-LIPI (The Centre for Oceanological Research & Development - Indonesian Institute of Sciences). The objective of the workshop was to strengthen management of the Seribu Islands and it was aimed at management officials, resort-owners, dive-shop owners and managers including government agency staff. Managers, teachers, fishermen and journalists also attended and a field trip was included in the programme.

The workshop concluded that if the UNESCO-Intergovernmental Oceanographic Commission programme was able to save the Pulau Seribu region then the problems facing Indonesia with regard to the sustainable management of coral reefs throughout the archipelago would be solved. This would also necessarily cover coral reef health, biodiversity maintenance, education, welfare of fishers and so forth. It was further pointed out that in some islands, fishers have a most destructive attitude in their practice of catching aquarium fish since the demand offered by the market is very high and this has occasioned the use of potassium cyanide. It was suggested that training programmes be offered to fishers to teach them how to catch aquarium fish without recourse to the use of cyanide since this had already been done in the Philippines.

In order to properly meet the challenges posed by global change it is necessary to continually upgrade the efforts undertaken to date. It is now essential to design a monitoring programme which will identify trends and detect changes in coral reefs, differentiate changes attributable to natural processes from those due to human activities, discriminate among the anthropogenic, climatic and other components of global change, and determine the true potential of reefs and reef organisms as early warning indicators of global change. The products of this activity should facilitate prediction of future trends and help governments manage their reef resources more effectively. The activities to be carried out in order to meet the objectives of making such a monitoring network fully operational are: (1) effective implementation of a Global Coral Reef Monitoring Network within the Global Ocean Observing System; (2) organization of a centralized secretariat for the compilation and redistribution of data; (3) further involvement of countries in the planning and participation within activities associated with the monitoring system; (4) facilitation of intergovernmental cooperation in monitoring and assessment; (5) facilitation of access to and exchange of data with other relevant programmes and activities.

Currently the following global sub-regions, programmes and organizations have been recognized as having relevance to the global coral reef monitoring programme:

Wider Caribbean:	Caribbean Coastal marine Productivity and some related programmes.
East Pacific:	No networks; Isolated reef monitoring activity.
Oceania:	South Pacific Regional Environment Programme; Association of South-Pacific Environment Institutions; Pacific Coastal Marine Productivity; Institut francais de recherche scientifique pour le développement en coopération.
South western Pacific:	Institutional monitoring programmes.
Asia:	UNESCO-Interregional Project on Coastal Marine Sciences; South-East Asian Marine Scientists
Indian Ocean:	Regional Organization for the Protection of the Marine Environment, Red Sea and Gulf of Aden Environmental Programme, Western Indian Ocean Marine Science Association, Isolated monitoring programmes.

The existing development plan is being implemented with the help of an "International Coordinator" to solicit interest and action from member states within each of these above regions, identify monitoring sites, select monitoring parameters, decide on training requirements and identify the requirements for a data management system. A global network will then be constructed from the aforementioned building-blocks.

In contributing towards the further development of a Global Coral Reef Monitoring Network, the Intergovernmental Oceanographic Commission supported a workshop in association with the 8th International Coral Reef Symposium 24-29 June, 1996, Panama City, Republic of Panama. Assistance was provided to over 12 scientists to participate in the congress from both the developing world and elsewhere (resource-persons). The workshop was held on June 27th and it was operated in two sections with the morning session looking at the information provided by long-term monitoring records in relation to desirable monitoring strategies (Chaired by Dr Joe Connell) and at the same time considering the input generated by some of the available techniques. In the afternoon the group looked at individual country presentations particularly from the Indian Ocean and the region of east Africa. Country-papers dealing with the nature and disposition of coral reefs together with an outline of how individual countries might be able to function in a global coral reef monitoring network were presented. A concerted effort was made to identify shortcomings and to find ways of working together. Over 80 participants attended the workshops.

The Chair summed-up the morning session by pointing out that the type of monitoring that might be implemented by a global network really depended on the nature of the changes that were anticipated and moreover monitoring frequency should also be tied into the kinds of management problems faced by the participating countries. The afternoon session concluded that innate capacities of participating countries would determine the kinds of monitoring programmes that could be implemented but in any case these would have to be justified by their ability to provide information that could be used to solve local problems. Training was regarded as a major requirement for many countries and the area of the Indian Ocean was identified as requiring immediate attention by the Intergovernmental Oceanographic Commission in order to build-up the capacity for wide-spread coral reef monitoring.

Many countries have already expressed their needs for training of their specialists on coral reef monitoring and assessment. All groups involved in coral reef studies as well as monitoring emphasized the need for development of long-term training programmes as important components of the "Global Coral Reef Monitoring Network".

A particular call was made to include assessments of the sociological factors that affect reefs.

The International Oceanographic Commission
Sub-Commission for the Western Pacific
(WESTPAC)

This Sub-Commission was formally established by the International Oceanographic Commission Assembly in 1989 following a recommendation by the Regional Committee for WESTPAC in 1987. This was based on a review of regional efforts and capacities in ocean research and observations which showed very considerable advances during the 1980's, including with respect to regional co-operative programmes.

The objective of the Sub-Commission is to promote, develop and co-ordinate the regional co-operative programme, taking into account the specific interests of the Member States in the region. The Sub-Commission operates within the framework of the general policy of the Intergovernmental Oceanographic Commission. The Sub-Commission has an IOC regional secretariat, established in Bangkok, Thailand, housed at the National Research Council of Thailand, following the kind invitation of the Government of Thailand to create a secretariat in Bangkok and a formal agreement between UNESCO and the Government of Thailand.

The Sub-Commission held its Third Session in Tokyo, Japan, at the end of February 1996. The programme was reviewed and a revised programme adopted, covering the following major elements:

***Ocean Science and Living Resources**, in particular Harmful Algal Blooms research monitoring, training and public awareness creation. This includes toxicity, taxonomy, provision of reference material;*

***Marine Pollution Research and Monitoring**, including assessments of river inputs of substances, atmospheric inputs, regional component of the International Mussel Watch;*

***Ocean Dynamics**, in particular interactions Western Pacific and Indian Ocean; and Monsoon Oceanography;*

***Ocean Mapping**, to prepare a regional bathymetric map through a co-operative effort;*

***Co-operative Study of the Gulf of Thailand**, including modelling, field observations, data and information exchange, training and technology transfer;*

***North East Asian Regional-Global Ocean Observing System,** including initiation of an operational observing system with near-real time data exchange, involving initially the Republic of Korea, China and Japan.*

The Sub-Commission co-operates through its programmes with other regional bodies or regional programmes, such as those of UNEP, GEF-IMO, CCOP, SOPAC, SPREP.

The Sub-Commission convenes regularly a scientific Symposium. The next one is planned for early 1998 in Okinawa, Japan, inter alia to highlight regional aspects of 1998 International Year of the Ocean.

Further information on WESTPAC can be obtained from the Secretariat of the Intergovernmental Oceanographic Commission, UNESCO, 1 rue Miollis, 75732 Paris Cedex, France. Fax: + 33 1 45 68 5810

THE UNESCO MANGROVE PROGRAMME

The success or value of any project, be it the construction of the pyramids of ancient Egypt or the nursing of a baby, can only be gauged after as long a time as possible; the pyramids have endured centuries of weathering and man's destructive activities, the health of the grown up human being is greatly the result of infant care.

The productivity of any ecosystem is taken for granted, until when the system begins to deteriorate and perceptive people sound an alarm. This happened with the mangroves; as early as the seventies UNESCO sounded the alarm. It took some ten years of persuasion to convince funding agencies that mangroves far from being wastelands, provide directly and indirectly for the livelihood of millions of people of the coastal area of the tropical belt. Obvious and hidden services and benefits provided by the mangrove ecosystem had always been taken for granted by the local people, but the same mangrove swamps had been hotly condemned as hazards to navigation and unhealthy places for humans, by the early European navigators of the age of discoveries and others after them.

Implementation of the UNESCO/UNDP Mangrove projects started in January 1982 and were officially concluded in December 1990. The 538 pages long Report of the First Project was released in March 1987 and it honoured its title: "Status and Management of the Mangroves of Asia and the Pacific", The Final Report of the second project entitled "Research and its application to mangrove ecosystems management in Asia and the Pacific" was released on 15 October 1991. The second project banking on the achievements of the first, had enlarged scope and greater geographic representation,

During implementation of the projects world wide awareness was elicited on the important ecological role that mangroves play, especially the hidden benefits they offer free of cost to mankind, though these benefits are difficult to quantify. UNESCO worked with National Mangrove Committees, institutions and national scientists, professionals, decision makers, health officers and, above all, the coastal dwellers themselves.

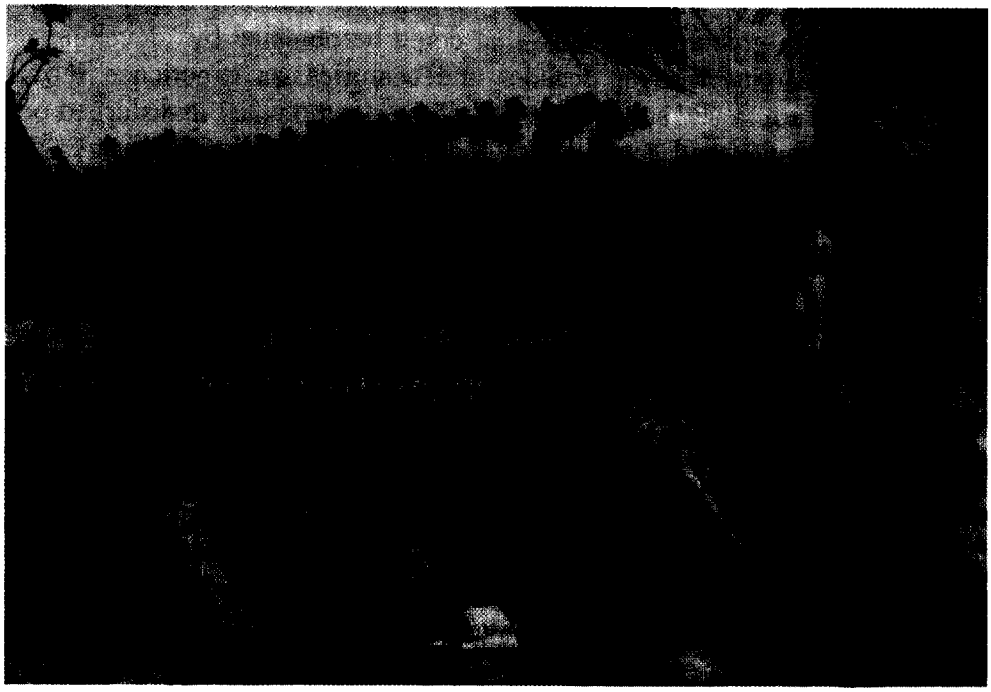
The story of the UNESCO Mangrove Programme was contributed by Dr M. Vannucci of the International Society for Mangrove Ecosystems and former UNESCO staff member at the UNESCO New Delhi Office. Further information may be obtained from the Secretariat of the International Society for Mangrove Ecosystems, c/o College of Agriculture, University of the Ryukyus, Nishihara, Okinawa 903-1 Japan or the Unit on Coastal Areas and Small Islands, UNESCO, 1 rue Miollis, 75732 Paris Cedex 15, France. Fax: +33 1 45 68 5808. E-mail: d.troost@unesc.org

Noted scientists specialized in particular fields of knowledge related to mangroves, such as microbiology, nutrient cycling, palynology, hydrology, remote sensing, social studies and others were also invited to offer lectures, give training for field work, contribute papers, offer advice and discuss mangrove matters with other professionals, decision makers, the media and, above all, the villagers themselves. With time a multidisciplinary integrated approach for a better understanding of the structure and function of mangrove ecosystems for sustainable use and management gradually took shape. This approach was tested by a two year long programme of research and field work at Ranong, Thailand.

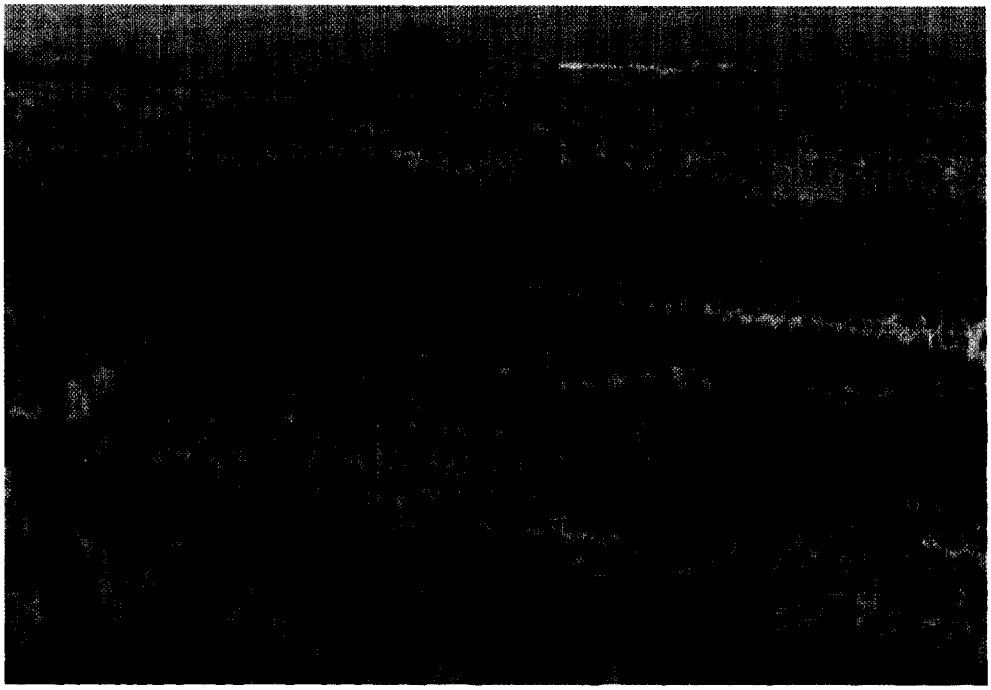
One of the most noticeable success of UNESCO's Asia and Pacific Mangrove Project is the interest that they elicited in the mangroves of the world. Country reports, specific studies of mangrove areas and assessment of mangrove resources, experiments on use and management appropriate to each site, seminars, symposia, lectures, active involvement of national mangrove committees, improved legislation, national and international training courses have mushroomed over the past ten years or so, world-wide. Awareness of the ecological cost of destructive uses has to some extent been successful in restraining harmful practices; for instances in the island of Bali, Indonesia, conversion of mangroves to shrimp ponds is now forbidden by law. In Thailand, the establishment of an "International Coastal and marine Biosphere Reserve" which includes the mangroves of Ranong, has been discussed and approved under the Regional Participation Programme of UNESCO and with the invaluable aid and support of the Royal forest Department and other Thai bodies, such as Fisheries and Agriculture Departments, local governments, Wildlife Sanctuaries and World Heritage Areas.

As knowledge of the significant role that mangrove ecosystems play in the tropical coastal zone grew world wide, it also became clear that mangroves are marginal ecosystems, vulnerable to sudden or drastic changes in the environment. Mangroves do not recover spontaneously after the impact of natural or manmade catastrophic events such as cyclones or total felling of the mangrove forests.

Mangrove ecosystems throughout the world have in common only the fact that they are tidally inundated by brackish or saline waters at regular intervals that may vary from twice daily to seasonal flooding in monsoonal areas. Practically all other ecological and socio-economic factors vary from place to place, and socio-economics can be regarded as a measure of human ecology. Only few species of higher plants have over the course of geologic time, become adapted to demanding conditions such as ample fluctuations of water and soil temperature and salinity, of air humidity and temperature; thus, because it is the forest that creates the mangrove ecosystem and the forest is constituted by only a few species at any site, the system as a whole is marginal and fragile, vulnerable to sudden or drastic changes. On the other hand, developers saw only the negative aspects of those dreaded swamps; total clearing, or turning the mangroves over to agriculture, for instance sugar cane after building sea walls to cut out encroachment by sea water, was seen as improvement, without realising that after felling the forest, degradation sets in, quickly followed by desertification, productivity of the waters decreases, and fish and shrimp larvae and fry find no nursery facilities for their growth.



Mangroves totally converted into fish and shrimp ponds
Photo: Dr M. Vannucci



Pakistan: A thriving nursery in the desert. The Avicennia seedling beds appear to be dead, but they are alive and growing; their colour is due to the reflection of sunlight from the silvery underside of the leaves. Photo: Dr M. Vannucci.

6. The second project set itself the difficult task for proving the point that over and above the obvious benefits, the hidden benefits are substantial and may in the long run be even greater than those that could be obtained by "development". Benefits are sustainable over decades and centuries, as experience shows in many places of south and south-east Asia, if the swamp is left undisturbed or if it is appropriately managed according to local environmental determinants. Man-made engineering structures and aquacultural high energy input farms on the other hand, have a short life of a few years at most. By the time shrimp farms stop being economically viable, the irreversible damage caused by indiscriminate felling of forests for ponds or timber extraction or others becomes visible, it grows at an alarming rate and remedial action is at best time and money consuming, if not impossible.

During the second project the activities of the first project were continued; in addition a unique project was launched that became known as the "Ranong project", or, the "Ranong experiment", from the place in Thailand where it was located. It was entitled: "Integrated multidisciplinary survey and research programme of the Ranong mangrove ecosystem" An area near Ranong city was designated by the National Research Council of Thailand to be the experimental area, with the purpose of developing recommendations for rational sustainable use and management of mangroves. We also aimed at developing a model that would enable decision makers to estimate the potential returns of a well managed mangrove ecosystems including forestry, captive and capture fisheries and other human activities. We hoped that this would help compare returns from the natural system with returns sought to be had from development of the same area.

Needless to say, we could not, as desired, develop a model that could become a world model for the use and management of mangroves. Obviously well developed, highly productive forests growing in suitable environmental conditions would produce much more than others growing under stress in extreme environmental conditions of temperature, dryness, lack of sediment input, pollution or other stressful conditions. Scrubby mangroves might produce nothing more than some fuel wood, some coastal stabilisation or some fodder for cattle and camels, shelter for fish and crustaceans or even only some of this in a reduced quantity, sufficient or not to satisfy the needs of local men and animals. Nevertheless, because mangroves grow where nothing else grows, they are always useful, even where they cannot be managed as productive forests. The enrichment of brackish and coastal waters provided by the mangrove vegetation may be substantial and should not be overlooked.

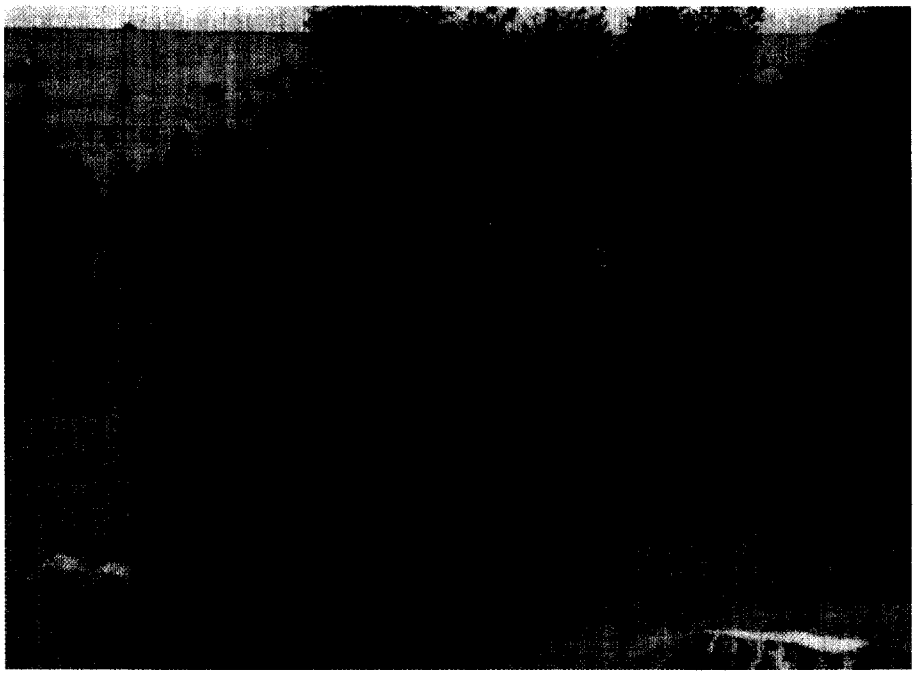
How did the UNESCO programme work? Through regular introductory and specialised training courses and workshops on topics as varied and important as palynology, remote sensing, microbiology, nutrient cycling, human health and others as applicable to the understanding of structure and function of mangrove ecosystems. The UNESCO Mangrove Programme started with 8 countries, and by the time it was concluded in 1990, there was a well knit network of 22 countries. The programme contributed efficiently to develop a binding sense of responsibility among people interested in mangroves in one way or another.

It worked by publishing reports, manuals, nine specialised "Occasional Papers", detailed reports, totalling over 40 publications and a book for the general public. The second project worked essentially along the same lines except that much effort was concentrated in the 2-year long Ranong project, This was possible

thanks to the foresight of Professor Sanga Sabhasri of Thailand, of the logistic support given by the National Research Council of Thailand and the financial support offered by Thailand, of about US$700,000, Royal Forest Department and Chulalongkom University also participated actively in the programme. Senior and junior scientists from Thailand and the other countries of the project worked along with renowned scientists from the international scientific community who freely participated in such an entreprise. Two special reports, two of the "Occasional Papers", the "Manual for Fish Eggs and Larvae from Mangrove Waters" were the outcome of the Ranong Project. The Reports are a short concise 16 pp "Executive Report" and a longer more detailed 183 pp Final Report. In addition, scientific papers based on the Ranong work are being published in scientific journals.

There were many hidden benefits from the project; they are enduring benefits from which we are still reaping fruits, as could be witnessed recently at Hat Yai where about 150 persons gathered to discuss the most important theme of the whole exercise: "Significance of mangroves for coastal people", under the aegis of International Society for Mangrove Ecosystems, Prince of Songkla University, National Research Council of Thailand and Royal Forest Department of Thailand, and Non-Governmental Organizations Assistance Division, Economic Co-operation Bureau, Ministry of Foreign Affairs.

During the second project, in Ranong, over a period of two years specialists in relevant disciplines of science and management worked together for mutual training and understanding. As we could witness in Hat Yai, the best way of doing research in the mangroves - the interdisciplinary holistic approach - is not only still alive, but is becoming stronger and stronger.



Malaysia: Spontaneous regrowth on a prograding beach.
Photo: Dr. M. Vannucci

At present, two books on mangroves, one with over 30 papers from Latin America, the Caribbean and Africa, and another giving line drawings and description of the developmental stages of over 60 species of mangrove fish, are under press and will be released soon by UNESCO. The International Society for Mangrove Ecosystems publishes a Technical Series, a series of Proceedings of professional meetings, and tries to keep the series of Mangrove Occasional Papers alive in spite of financial constraints.

During the UNESCO projects, the greatest and most valuable contribution came from each and every participant, and others involved, school teachers in villages, university professors, students, scientists, researchers, media persons and many mangrove dwellers are all responsible for the success of the project. Time is the best test of quality and value; this was obvious at the seminar at Hat Yai (20 August 1996) and in the enthusiasm of all present, many of them "old timers" of the "good old days". It was especially rewarding to see a large number of young people actively engaged in mangrove matters, many having worked as volunteers for replanting an area selected for the purpose by the Centre for Mangroves at Satun, near Hat Yai, and many more participants belonging to local or national non-governmental organizations.

But the UNESCO project was not without hazards, one of our best lecturers, field worker and devoted companion and colleague, Dr. G. Thanikaimoni fell victim of international terrorism while on a flight from India to New York, to discuss with other palynologists the work that he was doing for the posthumously published Palynology Manual. He left behind him a first class work that is a benchmark for the identification of pollen from species of mangrove plants of ages past, and many fond memories full of respect and appreciation.

One of the most important achievements of the UNESCO projects was that it made sure that the progress accrued should not end abruptly when finances were drained: on 23rd August 1990, the International Society for Mangrove Ecosystems was formally inaugurated in
Japan thanks to the unremitting efforts of a few persons participating in UNESCO's project. At present the International Society for Mangrove Ecosystems has about 700 individual and institutional members and great financial problems for the simple reason that there is so much to be done.

Maybe this is the greatest success of this story: faithful to its raison d'être, UNESCO identified a major problem, worked towards understanding the root causes of the problem, proposed remedial actions and stimulated willing people, institutions and governments to endorse the action needed to face the perilous situation of the tropical coastal zone. Recommendations and management plans continue to be improved upon, refined, adapted to specific places, ecological and socio-economic conditions; this we call eco-eco-use and management practices, meaning ecologically sound and economically rewarding use and management of mangroves. But, in a changing world and under intensive environmental exploitation and degradation, we know that there is no reason for complacency, it will always be an upward task and we must keep at it with no pause. The International Society for Mangrove Ecosystems follows on UNESCO's footsteps, faces the challenges and requests the help of all willing people, institutions and funding agencies.

The International Society for Mangrove Ecosystems is an international non-

governmental organization and many of its members come from countries that do not have mangroves, a sure sign that people are now aware of the ecological significance, of the mangroves world-wide. The Okinawa Prefectural Government, where the International Society for Mangrove Ecosystems is based, covers the running costs of the Secretariat and has sponsored several activities at home and abroad. Also several Government and non governmental organisations of Japan have sponsored many of the Society's activities and projects in many countries. To quote but one now coming to and end, in Pakistan, was a project to combat coastal desertification due to over exploitation, reduction of Indus River water flow and pollution that ran ever a period of three years and has successfully reforested an area of 1,800 ha. of coastal land. The project was funded by the Ministry of Post & Telecommunications of Japan with well over US$200,000 since 1994. Most of the projects that the International Society for Mangrove Ecosystems runs in the field, have, the value of experiments that can be applied elsewhere in the world in addition to their intrinsic value for the improvement of local ecological and socio-economic conditions of the coastal people, the International Society for Mangrove Ecosystems continues UNESCO's tradition of publishing technical papers for the benefit of professionals and of holding workshops for discussion of specific aspects of rational use and management. Thanks to financial support from JICA (Japan International Co-operation Agency), the International Society for Mangrove Ecosystems yearly holds two-month long training courses at the Okinawa International Centre. Japan Fund for Global Environment contributed about US$200,000 since 1993 for slides and video programmes to enhance public awareness of the ecological and socio-economic role of mangrove ecosystems. None of this, and much more however, would be possible without the understanding and support in kind and space, and above all in time, expertise, experience and collaboration of so many persons from so many countries, in Thailand, Malaysia, Indonesia, Vietnam and other Asian countries, Fiji and Pacific Ocean nations, Senegal and other African states and people, Brazil and other Latin American and Caribbean countries, as well as Australia, and France, the United Kingdom and other European countries, and so many others who individually and collectively are contributing towards the greening of degraded tropical coastal areas.

Projects come to an end either because the planned task has been completed or because funds are exhausted. Projects in the biological and ecological field cannot come to a close, because all living systems are in a continuous irretrievable process of evolution, often difficult to predict in its outcome and best analysed periodically as time progresses, For this reason the International Society for Mangrove Ecosystems was created and opportunities such as the Hat Yai Conference are profitably sought for exchange of information, for updating techniques and redress what may have gone astray,

Our reward comes in glory when a smile of mutual understanding shines on the face of villagers of all ages who now agree, against traditional habits, to fence camels off natural regrowth areas and for purposes of rotation forestry. Local people are the most thorough co-workers, happier even than ourselves with whatever success we reap in the field. UNESCO was born and nurtured to take care of the people of the world through education, science and culture: the mangrove programme is an important brick contributing to the strength and durability of the edifice.