

25TH ANNIVERSARY CELEBRATIONS
OF THE
NATURAL RESOURCES, ENERGY AND SCIENCE AUTHORITY
OF SRI LANKA
(NARESA)



PROCEEDINGS OF THE SEMINAR
ON
NEW DIRECTIONS IN SCIENCE & TECHNOLOGY
IN SRI LANKA

4-5 December 1993
4-5 December 1993
NARESA
COLOMBO

NA-5T

NARESA
NARESA Place
47/5, Maitland Place
Colombo 7.



**PROCEEDINGS OF THE SEMINAR
ON
"NEW DIRECTIONS
IN SCIENCE AND TECHNOLOGY
IN SRI LANKA"**

PART I

FUNDING RESEARCH - PRIORITIES AND POLICIES

**4-5 December 1993
NARESA
COLOMBO
SRI LANKA**

NA-51

CONTENTS

	Page
Welcome Address - Prof. Priyani E. Soysa, Director General, NARESA	1
Chief Guest's Address - Hon. Sarathchandra Gunaratne, Project M.P. Science & Technology	3
Keynote Address - Prof. K.K.Y.W. Perera, Chairman, Task Force on Science & Technology	5
Ministry of Industries, S & T - Mr. Austin Perera, Secretary, Ministry of Industries, Science & Technology	7

FUNDING RESEARCH - PRIORITIES & POLICIES

SAREC - (Ms) Ann Marie Fallenius Director (Administration)	9
USAID - Mr Gary Alex Deputy Director - Agriculture & Natural Resources	13
CIDA - Mr Julian Murray Counsellor- Development	15
IDRC - Read by Mr Julian Murray on behalf of Dr Ravi Maitheh Principal Programme Officer	17
WHO - Dr Aung Myint Representative for Sri Lanka	20
British Council - Mr Richard Jarvis Director	25
JICA - Mr Y. Sakamaki Resident Representative/Director	27
UNICEF - Mr David Baker	32
IUCN - Mr L.C.A. de S. Wijesinghe Country Representative	33
ODA - Mr Peter Neil Team Leader - Forestry Research & Information Project	36
AEA - Dr W.P. Dias Chairman	40

SEMINAR ON 'NEW DIRECTIONS IN SCIENCE & TECHNOLOGY IN SRI LANKA'

Welcome Address By The Director General - Prof. Priyani E. Soysa

Let us stand for the lighting of the lamp of knowledge dispersing the gloom of ignorance:

Today, we in NARESA have organised this seminar on 'New Directions in Science and Technology'. We have a gathering of science experts who have to take note of the changes in priorities and policies of the different research funding agencies. It is necessary to match our priorities with those agencies that could offer us appropriate assistance. I welcome one and all.

We have with us this morning, Hon. Sarathchandra Gunaratne the Project MP, Ministry of Industries Science and Technology. As Director General of NARESA I welcome you Sir, and await to hear your views on this new direction in Science and Technology in Sri Lanka. I understand that you have helped to guide the drafting of the new act and would appraise us of the new priorities and Science Policy especially on the eve of this New Act in Science and Technology going through Parliament.

Prof. K.K.Y.W. Perera who sat for many months with his team of experts on the Task Force on Science and Technology has been invited to give the key note address. He would know and will tell us in a few minutes the turn that Sri Lanka should take in this direction. I welcome you on behalf of NARESA and await your enunciation of the principle recommendations in taking these new steps and directions.

Mr Austin Perera, whilst welcoming you this morning we look forward to your very important presentation of the government's funding priorities and policies. We hope that you have in the first place increased our funding from the very low 0.18% of budget to even 0.9% as in India.

I welcome all you good people whom we have listed to speak on Funding Research. We have reached a time in history when international understanding and action are needed to use S & T not only for the benefit of individual countries but for the very survival of the human race on earth. In this endeavour, Sri Lanka has a limited capital and capacity to improve the standard of living for our people. This is where collaborative effort to modify ideas, to assist and advise authorities becomes essential. We hope to hear of exchanges and support systems during the course of the day. In the new era of science policy, the National Science Foundation, the successor to NARESA will require more funding. NSF has to muster more support for research.

With these opening remarks and words of welcome, I invite our chief guest Hon. Sarathchandra Gunaratne to give his address.

SEMINAR ON NEW DIRECTIONS IN S & T IN SRI LANKA

Address of the Chief Guest - Hon. Sarathchandra Gunaratne

Prof. Priyani Soysa, the Director General of NARESA, distinguished participants, distinguished guests, ladies and gentlemen:

It is with great pleasure that I address this seminar today, on the occasion of the 25th Anniversary of NARESA. NARESA had been instituted by an act of parliament in 1981 as the legal successor to the National Science Council (NSC) which was set up in 1968. Since 1968 this institution has served the scientific community by promoting research and development, with dedication.

With the objective of promoting scientific and technological research in the country, the Research Grants scheme had been initiated at the very inception of this institution, which provides funds to enable researchers to obtain equipment, consumables and personnel to help them in research work and also facilities to travel to field sites. Many research assistants have acquired post-graduate degrees on these research grants enabling them to secure places in research establishments in the country. Considering the importance of developing competent manpower compliment which is one of the key factors for sustainable development of Science and Technology, the contribution made by NARESA to human resource development through this scheme deserves recognition. In addition the contribution made through its activities to science and technology is praiseworthy since science and technology have proved to be powerful tools, which used appropriately can lead to rapid economic growth. I hope that in the future NARESA will get the necessary support in order to organise, plan and coordinate science and technology for a common perspective and meaning in their quest for the ultimate good of man.

Besides NARESA's own research grants scheme, indigenous research has also received support from several foreign agencies. The distinguished participants present here today represent many of these organizations which have supported S & T activities through NARESA. I wish to express my gratitude to all of them for their invaluable contribution to science and technology and through science and technology to the economic development of our country.

My sincere thanks for your support.

I wish to express my appreciation to NARESA for its service to the scientific community in the country.

Thank you for giving me this opportunity to be here on this occasion and I wish you success in your endeavours in the future.

NEW DIRECTIONS IN SCIENCE AND TECHNOLOGY IN SRI LANKA

Keynote Address by Prof. K.K.Y.W. Perera

Any Government would like to view the development of Science and Technology from the point of view of the well-being of the people. Thus Science and Technology policy has to be oriented towards this aim, not only for the immediate but also for the medium term and long term future so that the fruits of Science and Technology are enjoyed by the people living in the country.

For Sri Lanka to achieve the level of development that currently exists in the newly industrialized economies, industrial production has to be remarkably increased in diversity, quantity and quality while agriculture will have to be diversified, modernized and made sustainable. These achievements will have to be linked to job creations, income re-distribution and conservation of the environment in order to improve the quality of life of the people in Sri Lanka. Science and Technology is a strategic determinant in the growth and transformation of the national economies.

The directed drive of Science and Technology that is needed for development can only be achieved through commitment and adherence to a well considered and a balanced Science and Technology policy, strategies and programmes.

Science and Technology involves a wide range of activities, eg: education, training and building up of adequate cadres of scientific and technical persons, investment in the infrastructure required for teaching, training and research, investment in research and development activities, technology transfers etc.

The total expenditure on Science and Technology in Sri Lanka both by the Government and Industry amounting approximately to 0.16% of GNP is well below the minimum recommended value of 1% of GNP for developing countries, such as Sri Lanka. The expenditure on Science and Technology may actually be categorized as an "investment" if policies and programmes are properly oriented. Funding levels for Science and Technology in Sri Lanka should be increased at least by five folds.

The 'brain drain', or more appropriately the inability to accumulate S&T expertise in adequate numbers at appropriate levels, is an acute problem affecting S&T development and thereby, the industrial, agricultural and economic development of the country itself. Besides scientists and technologists, there is also a shortage of entrepreneurs and managers and support staff. The accumulation of adequate numbers of high quality S&T people is the balanced result of three processes; of education and training of such persons, of the numbers leaving the shores of Sri Lanka and the numbers coming into Sri Lanka. The numbers leaving Sri Lanka far exceed the numbers coming into Sri Lanka. It is often advocated that more and more S&T persons should be produced through education and training to counter the out-flow. While this is a partial solution, there are two serious drawbacks. Firstly, the production of high level S&T people required a very high input of funds and other resources. Secondly, and perhaps more important, is the fact that scientific and technological talent of the highest calibre is not replaceable by training larger numbers. Unless S&T persons are also recruited on the basis of market value, the equipment, materials and sometimes buildings, all acquired at high cost, will only become idle assets. A conceptual change, where market forces recognized as operative for the procurement of scientists and technologists also is therefore important.

The current school education system teaches Science as a subject in the curriculum, and for eight years (Year 4 to 11) all students are made to formally study Science. However, there is a lack of emphasis throughout on the practical applications of Science. As a consequence, Science is studied as an academic subject, and practical skills and aptitudes are not adequately developed.

Laboratory work in Science has to be brought back into the schools, together with practically oriented field work. Adopting mechanisms for retaining and attracting experienced and competent scientists and technologists is also required.

Research and Development (R&D) work in the majority of the present industries is generally confined to incremental innovations at the shop floor level. No formal R&D is conducted in most industries. Many small and medium industries have not felt a serious need for R&D due to the low technological component in their products and processes. Consequently, there has been little demand for industrial R&D. On the other hand, the existing state sector R&D institutions lack industry orientation and a goal oriented approach. The following are also observed.

- (a) Lack of a mechanism for strategy formulation through technology assessment, technology forecasting, and monitoring of world technological trends for the benefit of Sri Lankan industry.
- (b) Governing Boards, Institute administrators, and other matters brought about by Government directives which are more appropriate to the operation of stereotyped Government departments than to effective functioning of R&D institutions. Important policy matters and research directions are, therefore, often neglected.
- (c) There is also a lack of mechanisms in most R&D institutions whereby research findings can be transferred to entrepreneurs, manufacturers and products for commercialization.

The above aspects need to be taken into account to orient new directions in Science and Technology.

Mr. K. Austin Perera
Secretary
Ministry of Industries, Science & Technology

Let me first take this opportunity to congratulate NARESA on its 25th anniversary, and thank the Institution for the valuable services it has rendered to our country specially in the promotion of science and technology capability. I have no doubt that NARESA will through its endeavors, continue to influence the future of this island nation because it plays a key role in determining the health of the Science and technology base of Sri Lanka. And in the hands of a leading medical personality, I am sure this is assured.

The subject of this part of the Seminar is "Funding Research - Priorities & Policies". I represent the Ministry of Industries, Science and Technology as its Secretary. There are wide areas of research coming within the purview of Institutions outside our Ministry. And linked with funding, I feel these opening remarks would have been a more appropriate subject for some one in authority in the Ministries of Finance and Planning and Policy Planning and Implementation. It is in those Ministries that final decisions relating to funding and strategic planning regard to research are taken or at least should be taken. The Industries Ministry too does have an important role in the process, specially, as it is charged with responsibilities relating to Science and Technology. I shall therefore make some remarks in the light of my rather limited experience from my Ministry's end and attempt to place it in a wider context.

In order to provide a flexible and competitive research system in the country which can stimulate research including basic research and allow the creativity of researchers to improve and to foster an excellent research environment some of the facilities to which we should give attention are:

- a) increasing the mobility of researchers by improving institutions for promoting research exchange among industrial and academic communities;
- b) enlarging the chances of communication among researchers from various fields;
- c) expanding various types of research funds offered under a competitive system and promoting the smooth deployment of these funds;
- d) promoting the deployment of funds from private enterprises;
- e) promoting employment of persons, including foreigners, excellent in research ability;
- f) promoting better treatment of brilliant researchers based on a proper evaluation.

In Sri Lanka a fair infrastructure has been built covering a broad spectrum of disciplines, and capabilities have been built up in our educational and research institutions. However, it has been felt that S & T has not made the kind of impact it ought to have, possibly because the crucial role that science and technology can play in planning for growth was not realised fully. Serious efforts have to be made to deploy the S & T resources available for achieving the national objectives of providing the basic needs such as food, shelter, clothing, health, education, etc. At the same time we must build and modernise our infrastructure in the major service sectors such as transport, communications and energy which are vital to the socio economic growth of our country. The funds provided for research then should be channelled towards programmes in these fields. The service areas mentioned above are crucial for progress and development and only judicious planning will be able to meet the developmental objectives and cherished goals of the nation.

In utilising the funds provided for research, scientific institutions and agencies need to place greater emphasis on nurturing quality and excellence so that their research efforts would be in the front line of new and emerging areas of science and technology. Discovery oriented research needs to be encouraged. Expertise available with us has to be geared towards solving the problems of our economic and industrial sectors. The technological needs of industry for obtaining productivity enhancement, quality improvement, product differentiation and product value addition have to be addressed. Attention has already been drawn to the emphasis placed on demand driven research. Time bound and mission oriented projects would be considered rather than those having only academic value.

If science and technology research efforts are to provide useful inputs, it is necessary to devote adequate attention to ensure a planned growth for science and technology. The Task Force on science and technology estimated that Sri Lanka provides only 0.18% of GNP towards overall science and technology activities. This figure has come down still further since then. There is no gainsaying the fact that this is an unsatisfactory situation. The Task Force recommended that this be increased to 1% of GNP. We cannot get to this overnight. But if science and technology has to play an increasing role in the economic growth of the country, we have to work towards a progressive increase, aiming to reach the targeted 1% of GNP within the next few years.

Agencies engaged in scientific research look to both government and foreign funding for implementing their projects. In respect of funding by Government, the process adopted is for each agency to submit its annual requirements through the relevant Ministry to the Ministry of Finance, at the stage of preparation of estimates for the coming year. The Ministry of Finance appraises them primarily from a financial point of view taking into consideration allocations made in previous years and actual expenditures incurred. Once decisions are made at this level they become part of the annual appropriations that are placed before parliament and finally sanctioned after debate in parliament, as we see happening during the past few weeks.

I would like to refer to a few salient features emerging from this exercise. First, is a tendency in more recent years, towards limitations on allocations requested by agencies, in the light of competing demands particularly for defence expenditures and for certain other priority areas. NARESA itself had this experience this year. I need not labour the point of recognizing the importance of investments in science and technology, while of course acknowledging the need for according primacy to particular areas in the context of national exigencies and stages of development. Every effort needs to and must be made to ensure that projects in the area of science and technology will not be hampered due to this consideration. In this context, funding from international agencies has assisted scientific agencies greatly in continuing with their programmes and we are indeed very grateful to these agencies which are also represented here today.

Next, the process as adopted, tends to result in decision on funding being based more on the absorptive capacity of the agencies concerned than by consideration of the economic and social importance of the fields of research. The absorptive capacity of the different agencies and institutions vary widely. Part of the reason for this variation is the nature of the technologies handled by the different agencies but it also relates to a range of factors external to the nature of the technology and to whether the scientists were capable and up to their task. The result of this with regard to allocation for funds has been to some extent a mismatch between the distribution of funds for scientific activities and the economic and social importance of the areas of funding.

Another aspect of the system as it operates today is the absence of national planning in the area of science and technology. The system, as I have described it, is centered around individual Ministries and agencies. Even though at these levels through various mechanisms such as Research Committees efforts are made to take into consideration what are perceived as national priorities, the system as such misses a total national focus and strategic planning for the future which should receive attention at a central level.

The difficulties I have outlined could be overcome and remedied to a great extent with the passing of the Science and Technology Act. The proposed Science and Technology Act has provision for establishment of a National Science and Technology Commission (NASTEC) which will be an autonomous body providing general direction on matters pertaining to Science and Technology. It will continuously monitor and review the development of science and technology in Sri Lanka. It will also consider priorities for scientific research and advise the Government on the use of Science and Technology for stimulating economic growth and ways to improve the quality of life of the people.

FUNDING RESEARCH, PRIORITIES AND POLICIES: SAREC's Experience

Address by Ann Marie Fallenius, Director of Administration, SAREC

Prof. Priyani Soysa, Dear seminar participants, ladies and gentlemen,

I am glad and very much honoured to participate in the celebrations of NARESA's silver jubilee seminar. I am also pleased to have the opportunity - on this occasion - to present some thoughts on support to research capacity building in developing countries in general, and in Sri Lanka in particular. I think it is a good initiative of NARESA to invite so many donors and other officials to this seminar in order to discuss policies and priorities for funding research.

In my contribution, I will first give an overview of the development of SAREC's policy for support to research capacity building in developing countries and present SAREC's model of institutional cooperation that is an integral part of our bilateral programmes. This will be followed by some reflections on our experience of cooperation with Sri Lanka and on NARESA's role as a counterpart for handling our grants in some projects. I will then deal with our plans for future support and raise some critical issues for debate.

When SAREC started its activities in 1975, support to the building of research capacity in developing countries was the central task and objective of the new organization. Strengthening of national research was seen as a prerequisite for self-reliance and national development and essential if developing countries were to participate in international, scientific cooperation.

SAREC's support to research in developing countries has from the very beginning been channelled through four major programmes:

1. Bilateral research cooperation
2. International research programmes
3. Regional research programmes and special initiatives
4. Support for development research at Swedish universities

SAREC's support has changed in both form and scope since its beginning in 1975. Eighteen years ago almost 90 per cent of our budget went to the support of international research programmes. Today the emphasis is on support to bilateral research cooperation and to regional research programmes and special initiatives. Right now SAREC has bilateral agreements with fifteen countries, mainly in Africa.

I will deal mainly with the bilateral cooperation, which is focused on research capacity building, primarily in selected least developed countries. Some of SAREC's regional and special programmes have a similar focus. As somewhat of a contrast the international programmes are usually oriented towards generating research results of central importance to the developing countries and not primarily towards capacity building.

SAREC's bilateral programmes developed fast, especially during the 80's. The model for bilateral support in the early years was to channel support through research councils responsible for setting national priorities. The focus was on strengthening research environments and promoting research projects. Our scope has, from the very start, been wide in the sense that all major disciplines have received attention and support.

In 1985 SAREC's work was evaluated. One major conclusion of the evaluation was that closer cooperation between institutions in the developing countries and in Sweden could be a good model for research capacity building. SAREC's own experience of the bilateral programmes pointed in the same direction. Research training has now been given priority in various programmes and projects. Training at MSc as well as PhD level is supported, if possible in the countries concerned. A successful programme for the support of MSc and/or PhD research projects has been developed in most of our bilateral projects.

Institutional cooperation: model for bilateral cooperation

One important way of building research capacity in developing countries is through institutional cooperation between researchers in departments and institutions in developing countries and those in Swedish university departments. Institutional cooperation as part of SAREC's bilateral programmes developed during the 1980's. The number of Swedish departments participating in such cooperation has grown from 40 different departments in 1982 to around 130 in 1993. At the same time a total of 211 institutions in developing countries participate in the bilateral programmes.

Decades of experience indicates that neither expatriate recruitment for staffing local institutions, nor the research training of students for long periods abroad, by themselves can achieve the goal of sustainability in capacity building. SAREC has therefore chosen a model that on the one hand firmly establish the capacity building process in the institution or research department of the developing country itself, and that on the other hand encourage the forging of links with Swedish institutions.

Training of researchers is planned by the cooperating institutions within the framework of joint research projects. SAREC's main approach to research capacity building is thus to make it an integral part of a research project work preferably at Ph D or MSc level. Research candidates have to be trained in the identification, formulation and analysis of research problems. They should also be introduced to the latest research techniques and methods in their field of work.

The training programmes usually follows the "sandwich model". This means that the training period is "sandwiched" between the home country and Sweden. Part of the year is spent in the developing country, doing field research, and part in Sweden taking courses, etc. Research students are jointly supervised by senior scientists from both sides. SAREC also supports the development of national capacity for training of researchers, in the form of setting up MA and MSc courses in various fields. The institutional cooperation usually means that the Swedish departments also assist their collaborating institutions in developing countries to purchase scientific equipment and literature.

SAREC model is based on the premise that Swedish university departments have the capability of handling the various elements that make up the capacity-building effort, i.e.

- * to participate in joint research projects and supervise research training on a sandwich basis;
- * to assist in organising the procurement and installation of scientific equipment;
- * to facilitate attendance at international scientific meetings for their collaborating partners.

An effort of this character and magnitude requires long-term commitments on the part of all parties involved. The links between institutions are durable and beneficial, only if the two cooperating institutions have something to "gain". For the individual researchers, most important is to work on research problems which are of high relevance to them.

However, it is often difficult to reach consensus on what constitutes research that has high relevance for a country's development. A close dialogue between policy makers, researchers and universities is needed and should be encouraged. It is SAREC's policy that the initiative in making the choices should always remain with the developing country and not end up at the Swedish side.

One problem with the model is the relatively high costs for the participation of Swedish institutions. The cost effectiveness of institutional cooperation and particularly the training of researchers is an important question for comparative studies. Training is usually provided according to the "sandwich model" with short periods in Sweden and the main field work carried out in the home country. This mode of training should be compared with 1) traditional scholarship programmes for extensive training abroad, 2) training

provided by universities or faculties in the developing country and 3) training in the region at centres for advanced studies and research.

However, we feel quite confident that our model for institutional cooperation works reasonably well. But - and this is important - we must be very open to change. The reasons, of course, are that the environment in which we work changes all the time, that we learn more and more about what the role of the donor should be and that we also learn more about the enormous complexity characterising the processes of development.

Research Cooperation with Sri Lanka

The research cooperation between Sri Lanka and Sweden, sponsored by SAREC, is almost as old as SAREC itself. The cooperation started in 1976, one year after SAREC was founded and three years before SAREC became an independent government agency.

Since then the scope of the cooperation has successively been enlarged both in terms of number of projects undertaken and in terms of new scientific fields added to old ones. Gradually, the cooperation has come to include research projects both in the biomedical and agricultural fields as well as in the fields of the technical, natural and social sciences. Up to now a total of approximately 55 million Swedish kronor has been allocated to the programme - a sum that is equivalent to about 350-400 million Sri Lankan rupees at the current exchange rate.

Since 1976 a total of 50 different projects or programmes have been supported by SAREC involving more than 100 researchers. Ten different Swedish institutions have been involved in the cooperation and about 30 Sri Lankan institutions or research departments have been engaged, one way or another, in those 50 research projects.

During these past eighteen years the development of the scientific collaboration between Sri Lanka and Sweden can be said to mirror the development of SAREC's policy for bilateral research support to developing countries.

The focus and aim of the cooperation is to strengthen Sri Lanka's national research capacity in some selected fields. Consequently, the support has been focused on establishing and maintaining a critical mass within research groups and strengthening their international contacts. The institutional cooperation has made it possible to give students from Sri Lanka opportunities for research training in Sweden or third world countries at MSc and PhD levels. The Swedish departments involved in the cooperation also have assisted their Sri Lankan counterparts in purchasing relevant equipment, literature and other research infrastructure.

What then has been accomplished in the joint collaboration? Some 50 Sri Lankans have visited or carried out research at different departments in Sweden. Around 15 Sri Lankans have been able to accomplish their PhD and around 30 their MSc research training under the programme. To this can be added that during the current 3 years agreement another 10 PhDs and 25 MScs are expected to result from the cooperation.

Publications in peer reviewed journals also indicate the level of achievements in our joint research cooperation, supported by SAREC. Under the programme about 300 books and articles have been published in international and national scientific publications. To this may be added, that in some of the SAREC-supported projects scientific results of an international calibre have been achieved, for example in the molecular biology and archaeology projects.

A substantial part of SAREC's research programme in Sri Lanka is focused on support to research infrastructure i.e. library support, support for purchase of spare parts for instruments and support for international contacts and meetings. Through this support, on an average about 50 researchers have been

able to attend international conferences and seminars annually and even initiated cooperation with other scientists abroad. SAREC is, in principle, the only external sponsor that supports purchase of scientific literature in the country.

NARESA's role in SAREC's support to Sri Lanka

The current agreement between Sri Lanka and SAREC is valid until the 31st of December next year. The Swedish contribution amounts to about SEK 8 million or about 48 million Sri Lankan rupees per year, divided into 8 different projects or programmes. Since the latter part of the eighties, about half of SAREC's support to Sri Lanka has been channelled through NARESA and the other half granted directly to various institutions in Sri Lanka.

SAREC was among the early donors to National Science Council (NSC), the predecessor of NARESA, and was later followed by Canadian CIDA and by USAID to NARESA in the eighties.

There are three major reasons why SAREC has chosen to support research in Sri Lanka through NARESA:

- (1) NARESA is able to put the proposed projects in the right context from the point of view of the country's priorities in a proper manner,
- (2) Financial management and monitoring of individual programmes/projects is much easier to accomplish for an organization within the country than directly from Sweden, and finally,
- (3) In order to achieve the aim and objectives of the research cooperation, SAREC needs a knowledgeable partner within the country for policy and priority discussions.

These three rationales for our support through NARESA have been discussed thoroughly with NARESA during our present visit and we expect that our cooperation will become even more fruitful in the future.

SAREC's collaboration with NARESA has developed over the past 10 years - as far as I understand - with great confidence and trust on both sides. There has been a continuity in the policies and routines and the cooperation has worked smoothly. Before coming to Sri Lanka, and as a preparation for this trip, I had discussions with quite a few of SAREC staff who have been working as coordinators of our bilateral cooperation with Sri Lanka either as research officers or in other capacities. Happily I can tell you that all of them have been unanimous in their assessments of both the smooth running and the good accomplishments of the different programmes.

Questions for debate

Looking towards the future, I would like to raise a few questions concerning capacity building and development of relevant knowledge for development in Sri Lanka.

1. How can we develop our methods of evaluation and of measuring the results? Linked to this is of course the question when and how to discontinue giving support to a programme, project or an institution.
2. What comments do other agencies have as regards SAREC's support to Sri Lanka. Is our approach for bilateral and institutional cooperation effective and efficient? What advice do you have as regards implementation? Would other donors be interested in joint ventures?
3. One important pre-condition for greater involvement on the side is a strong and genuine interest and commitment on behalf of host governments. How can we accomplish a more efficient coordination of donor participation on the receiving end?
4. How do we support the dissemination and application of research results?

Mr. Gary Alex
USAID

Mr Secretary, Prof. Priyani Soysa, Ladies & Gentlemen,

I appreciate the opportunity to be here today and to share with you some of USAID priorities and policies on funding research.

USAID worldwide has long recognized the importance of research in addressing development problems worldwide. In 1991 and 1992 USAID funding for research amounted to approximately \$375 million annually. This funding was spread over 80 countries in which AID operates and in the United States.

The major areas of funding have been agriculture, amounting to approximately 22% of the total, social sciences 18% and bio-medical research 13%. Over the years we count some major successes from AID funded research. These include increased agricultural production, rehydration and immunization technology, family planning methods and understanding of development and economic structural adjustment processes. Much of the USAID funding and effort has gone to strengthening research institutions in developing countries.

In Sri Lanka also, over the past 15 years, we have contributed to research institution building within the University and Department of Agriculture. We have also provided grants for operational costs of research to various institutions, including several successful projects with NARESA.

During the course of 1993 USAID has taken some new directions and seen some shift in priorities. Emphasis is now on two aspects of development. These are sustainability of development activities and increasing efficiency and effectiveness of development activities. These derive partially from an increased understanding of development and increased emphasis on equitable development. It derives also to a large extent from the fact of declining financial resources for development programs. AID assistance levels are currently being reduced by 10-25 percent.

Within the new directions of USAID programs four major themes arise. Economic growth, environmental protection, democracy, and population and health. Research funding may in limited cases go to activities outside of these broad areas but will be most forthcoming for research programs that support these development themes.

Within Sri Lanka over the coming few years we would expect to see some continued financing for research activities. Most of this would be operational costs and very limited, if any would be in support of institutional development of research institutions.

Planned assistance in establishing an INTERNET linkage is one exception and an example of institution support which will hopefully be accessible to all Sri Lankan researchers. There are three programs which may provide support to research in Sri Lanka.

The first of these would involve research of an applied nature to support private sector technology development, two USAID projects, technology Initiative for the Private Sector (TIPs), and Agro Enterprises Development (AgEnt) provide grants to private companies for research and development work. These grants must involve cost sharing by the private sector collaborators. They support development or application of new technology in manufacturing, processing and production techniques. The research/development topics funded by these projects are demand-driven, in that proposals are initiated by entrepreneurs. These grants do offer opportunity for Sri Lankan researchers to obtain funding and apply skills to address commercially viable and practical research topics.

The second potential source of funding for Sri Lankan researchers is the AID Science Grant Program. This is a program administered in Washington which provides grants worldwide for research and scientific collaboration in developing countries. Approximately 80 grants are awarded annually from an average annual budget of \$8-9 million per year. The average amount per grant is \$100,000 and the maximum amount is \$150,000. Priorities for funding of the AID Science Grant program goes to six areas. They are biotechnology and immunology, plant biotechnology, agricultural chemistry for world food needs, bio mass conversion technology, integrated pest management and biodiversity. A seventh area, engineering technology is also considered but given lower priority. Sri Lanka has fared well in this program and has over the years won twelve grants. A companion project the "Israel Science Grant Project" is also based on worldwide competition but does not currently award grants in Sri Lanka.

The third source of funding, the biodiversity support program also provides grants for research on ecology, economics, anthropology, and sociology as related to maintenance of biodiversity. These grants are awarded based on worldwide competition by a consortium of World Wild Life Fund, Nature Conservancy and World Resources Institute. Individual grants may not exceed \$15,000 nor more than one year duration. Emphasis is on four topic areas including management of biological resources, social influences on bio conservation, economic incentives for biodiversity conservation and monitoring and assessment of bio diversity.

Application procedures for the various research grants vary but interested researchers may contact the USAID office in Colombo.

Mr Julian Murray
CIDA

Ladies and Gentleman,
Thank you for inviting me to address you today.

Sri Lanka was historically one of the earliest recipients of Canadian development assistance. Since 1952 Sri Lanka has received more than 500m dollars in bilateral aid from Canada. This has contributed significantly to institutional and infra-structure development, agricultural diversification and to human resource development.

About 85 million of this was fertiliser commodity aid. This was where we had our closest relationship with NARESA, who from 1983 implemented a (1.3) program of research on potassium fertiliser as an input to increasing the productivity of Sri Lanka's agricultural crops. This programme is now completed. However, I am confident that the objectives continue to be achieved as you further widen and deepen the information base on potash fertiliser, strengthen the agro-based research institutes, and ultimately guide farmers and extension workers on appropriate fertiliser use for maximum production. This is a necessity for sustainable development, and I know that this will continue as will the links established with colleagues and institutions in Canada and in other countries in Asia.

Regrettably for both Canada and Sri Lanka, that era of large-scale development assistance to Sri Lanka is now over. Our programme is now much smaller.

Mainly as a consequence of mounting domestic instability in Sri Lanka, combined with reductions in CDN foreign aid resulting from attempts to curb our own fiscal deficit, CIDA's country to country disbursements declined from a peak of 46.5 million dollars in 1982/83 to under 14 million dollars in 1991/92.

In June 1990 a new Canadian foreign policy framework for Sri Lanka was approved following a foreign policy review that included an assessment of the situation and a review of Canadian interests. Canadian policy for Sri Lanka was modified to reflect the reality of the political situation the requirements for a fundamental restructuring of Sri Lanka's economy, Canada's concern over continuing serious human rights abuses by all parties in the conflict and the priority Canada attached to the need for the fundamental changes on the part of the government of Sri Lanka, so as to achieve political and economic stability. This includes, as highlighted by Secretary, Mr Austin Perera, the need to resolve the conflict in order to free Sri Lanka resources for Sri Lanka Development priorities including S & T.

The new Canadian foreign policy framework also acknowledged Canada's commitment to a Commonwealth partner, to a people facing severe economic hardship and to a friendly government caught in a vicious cycle of violence.

In parallel, the development assistance programme was revised to focus on the root causes of civil conflict. The policy framework would :

- a. Target support to those key institutions which can play a role in economic reform and in promoting human rights and democratic values.
- b. Promote community level economic activity and employment creation among those whose unfulfilled aspirations have fuelled the conflict.
- c. Assist in providing basic social services through multilateral organisations or NGOs.
- d. As circumstances permit, assist in reconstruction and rehabilitation.

It is unfortunate that other, more pressing issues of poverty and governance do not allow S & T to be an explicit element of our Development Assistance strategy.

However, implicit in CIDA's view of Sri Lanka is the conviction that Sri Lanka should continue a programme of policy review and economic and role restructuring.

This is where, in our view, NARESA has a critical role to play. Even though Canada is no longer in a position to directly support NARESA, we still recognise the value of NARESA in helping shape Sri Lanka's policy in the area of Natural Resources, Energy & Science & Technology, areas that are critical elements of sustainable development. While we are not able to provide material support to NARESA, we would like you to receive all of our encouragement and moral support in fulfilling this important national role.

IDRC : Current position of projects in Sri Lanka. 3.9 million divided between :

Energy & Natural Resources	-	1.3 m
Health Sciences	-	1.3 m
Information Sciences	-	800 m
Social Sciences	-	360 m

Thanks.

FUNDING RESEARCH PRIORITIES AND POLICIES OF IDRC IN SRI LANKA

Dr Ravi Maithel - Presented by Julian Murray
IDRC

Before I go into the specific funding priorities and policies, it may be useful to say a few words about IDRC and its approach.

Established in 1970 by an Act of Canadian Parliament, IDRC has helped third world researchers to develop new technologies to treat local grain, improve land yield and agricultural production, develop economic policies, find original solutions to the desertification or to the transmission of the most common diseases. This work has responded to a complex range of problems through a variety of scientific disciplines. As most of you know, IDRC's philosophy is that all research projects are initiated in the developing countries themselves by researchers who are most familiar with the special conditions of these countries. Sometimes, IDRC identifies Canadian researchers to work with researchers from the South to exchange information and share knowledge.

In some ways, IDRC is a unique Canadian innovation. Its board, consisting of eleven Canadians and ten members from foreign countries including developing countries sets the overall direction of the organization. The multi cultural board directs the programs and approves the main research budgets. However, the board has also given IDRC the necessary latitude and decision making independence to support its work worldwide. Further, aid given by IDRC is not "tied". Which means that the institutions (universities, research centres, private organizations) receiving IDRC assistance are not expected to purchase Canadian equipment or services. The major portion of IDRC assistance goes to pay for expertise rather than equipment. The latter is often provided by the recipients to contribute to research that will make them independent of outside assistance.

IDRC maintains special links with Canadian International Development Agency (CIDA).

IDRC's Corporate Program Framework (1993-1996)

In March 1993, the board of IDRC approved a new corporate program framework for years 1993 - 1996. The context within which program decisions and choices are made is provided by the strategy developed by the Centre and approved by the Board of directors in 1991. The announcement made by the Prime Minister of Canada at the United Nations Conference on Environment and Development (UNCED) in June 1992 that IDRC would be a lead organization in the implementation of Agenda 21 reinforced the role that IDRC will play in contributing to sustainable and equitable development.

This sharpening of the focus has however not changed the IDRC mission "Empowerment Through Knowledge". As the IDRC strategy document of 1991 states, first and foremost, development concerns people and "should mean above all giving people the power, defined in terms of adequate knowledge and capacity, to decide what is best for them and to act accordingly in fulfilling their own destinies".

The IDRC Program Framework is expressed in terms of an over-arching Program for Sustainable and Equitable Development, six Core Themes and a New Initiatives Program. Let me deal with them in some detail.

1. Sustainable and Equitable Development

IDRC has accepted the definition of Sustainable Development used by Bruntland Commission. "Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Within the definition of sustainable and

equitable development, IDRC has several divisions which have been reconstituted to address research problems falling within different expertise and which can be addressed through a combination of these expertise. These programs grouped according to subject areas are:

- i. **Social Sciences** - Macro Economic Policy, Regional Integration, Learning Systems for change, Industrial and Agricultural Policy and Social Policy.
- ii. **Environment and Natural Resources** - Low Input Sustainable Agriculture. Water Resources Management. Urban Environment Management and Green Technologies.
- iii. **Health Sciences** - Global Threats to Health, Health Policies, Priorities and Programs.
- iv. **Information Sciences** - Information Policy and Research. Software development and Applications and Information Capacity Building.
- v. **Corporate** - Gender Issues, Innovation Systems Management, Public Information, Evaluation, Human-Resource Development, Canadian Partnerships and Library.

In addition to the Sustainable and Equitable Development, the Centre has adopted six core themes on environment and development from Agenda 21. They are:

1. Integrating Environmental Social and Economic Policies

To quote from "Chapter 8 of Agenda 21. Prevailing systems of decision making tend to separate economic, social and environmental factors: This influences the actions of all groups and society and has important implications for the efficiency and sustainability of development and adjustment or even a fundamental reshaping of decision making may be necessary. The theme will support research on the issues: related to the theme. Policy and planning tools, policy making processes and capacity building.

2. Technology and Environment

The focus of this theme will be on alternative institutional and policy frame works for transfer, adoption and development of environmentally sound technologies. The theme will support research in technology development and diffusion, improving information on technology needs and resources, promoting access to technology, policy evaluation and design and developing technology management and innovation capacities in small and medium sized enterprises and intermediary institutions.

3. Food Systems under Stress

There are between 340 and 370 million, mostly poor people who are food insecure. IDRC will support systems based interdisciplinary research in food systems in ecological fragile regions. Some of the components of the program will include desertification (specially in Africa), fragile high land areas and coastal areas (specially in South and South East Asia).

4. Information and Communication for Environment and Development

UNCED and Agenda 21 make frequent references to the information gap and the constraints caused by this lack of access to relevant, accurate and timely information. The research supported by IDRC will include information management, information and communication technologies, information for decision making and development communications.

5. Health and Environment

This theme will focus on research that addresses the physical, chemical, biological and social environmental factors that affect human health. IDRC will support research in areas of impact of development and production activities on health, occupational environments, agricultural environments, environmental health impact assessment, minimizing the health effects of environmental pollution; water pollution, population growth and environmental management of vector borne and zoonotic diseases.

6. Biodiversity

This theme focuses on the special needs of developing countries in both research and training programs that provide the conditions for sustainable use. The research areas supported will include biodiversity and indigenous knowledge, support for indigenous knowledge networks, common property management institutions, wild biodiversity, utilization evaluation and protection of natural biodiversity, habitat protection, domesticated biodiversity, institute germplasm conservation and indigenous knowledge, aquatic biodiversity, biodiversity and biotechnology, intellectual property rights and biosafety and access to biotechnology.

Before closing, I should say a word about how IDRC handles requests for support. IDRC has a staff of five Program Officers serving the South Asia Region through an office in New Delhi. I am sure some of you have met them during their travels to Sri Lanka.

In addition, IDRC has staff of Program Officer from Ottawa who also develop projects in the region.

The overall objective of the process is to give expression to the corporate program framework within the realities of each country in each region.

I hope I have been able to describe to you in some detail the scope of research that IDRC is willing to fund.

Should you require more information or details, please let me have your business card and I will forward to IDRC for their attention and action.

Thank you.

Dr Aung Myint
Representative
World Health Organization (WHO)

I am very happy to be associated at this Seminar on "New Directions in Science and Technology in Sri Lanka" organised on the occasion of the twentyfifth anniversary of NARESA.

This particular session, attended by the representatives of several United Nations Agencies and other organizations is devoted to a consideration of the priorities and policies of these organizations in funding research.

I shall, in my presentation, explain to you the general philosophy of WHO on matters pertaining to health research and then provide you with some details of the current health research strategies of the WHO South-East Asia Region. It is these beliefs and strategies that determine our health research funding policies.

One of the constitutional functions of WHO is to promote and conduct research in the field of health. The vital role of health research in health development which has been recognized by WHO from its inception was succinctly stated more recently in the preamble to Resolution 43.19 on "The Role of Health Research" adopted by the Member States, including Sri Lanka at the Forty-third World Health Assembly in 1990. It observed that all national health policies should be based on valid scientific evidence, and that such evidence requires health research. The resolution also recognized the significant potential of research in promoting health and its vital role in improving health through the application of solutions that are already available and the generation of new knowledge for the development of new solutions.

An important method by which WHO promotes health research is by developing global and regional health research strategies based on health needs. The research strategies of WHO influence and are in turn influenced in an interactive manner by national health research strategies in support of specific country needs. Accordingly, WHO in the South-East Asia Region has from time to time developed and updated the research strategies of the Region and also helped countries to develop their own national health research strategies.

In order to place the matter in its correct historical perspective it is necessary for me to go back to the early stages of the regional research programme, albeit briefly.

The **South-East Asia Advisory Committee on Medical Research**, at its first meeting in January 1976, after reviewing the status of health research in the Region identified the priorities and delineated those areas in which research should be promoted and supported. These priorities at that time were primarily based on the prevalence and severity of the disease patterns that occurred in the countries of the Region - i.e. the research priorities were mainly disease oriented.

The Regional research objectives and strategies were revised in 1982 following the resolution of the thirtieth World Health Assembly in 1977 which affirmed that the goal of all governments and WHO during the coming decades should be the attainment of a higher quality of life by all the peoples in the world by the year 2000 - i.e., a quality of life that would enable them to lead socially and economically productive lives. Taking into consideration the Alma Ata Declaration as well, it was decided in 1982 that the research strategies and the specific activities of WHO should focus on the priority problems whose solution would contribute towards national and regional strategies and plans of action related to the attainment of the goal of Health for All. It was also noted that research efforts do not constitute an isolated entity, but that they are essential supportive elements of each of the separate sub-systems that make up the total developmental programme.

The world has not remained static since 1982. Major changes have taken place in the global political, economic and social structures. There have also been distinct changes in the epidemiological patterns of disease due to changes in life-style, the environment and the population structure. Many countries of our Region are beginning to, if not already facing, the double-burden of the communicable diseases as well as the increasing incidence of the chronic and degenerative diseases. The situation is further aggravated by the AIDS pandemic and the resurgence of old problems such as malaria, tuberculosis and cholera. The developments in technology have also posed problems regarding resource allocation, quality assurance and ethics.

The WHO South-East Asia Advisory Committee on Health Research responded to this changing situation by reviewing and revising the health research strategies of the Region during the early part of this year (1993). The Committee reiterated that the overall objective and the strategies for health research formulated in 1982 are still generally valid today. That is, the research objective and strategies should be related to the attainment of Health for All goals through Primary Health Care and eight essential elements of Primary Health Care should be the framework in which researchable areas are identified and research priorities determined.

However, in order to respond to the emerging challenges of the changing health scenario described before there need to be a shift in emphasis with respect to the **researchable areas** and the **types of research**. In doing so it would be important to maintain an optimal balance between the researchable areas, and between research of the health systems type, clinical research and basic research. Any research portfolio should have a balanced mix in research areas all of which together should contribute optimally to the attainment of HFA goals through PHC.

The Committee also observed that in accordance with the concept that "**health is a state of complete physical, mental and social well-being and not merely the absence of diseases or infirmity**" the strategic aims should include the promotion of the positive aspects of health as well as the control and treatment of diseases and ill health.

Further the roots of many health problems extend beyond the health sector and factors beyond the health domain are basic to attainment of a healthy life. Research by scientists and institutions in other sectors beyond the health domain is also necessary to produce the knowledge and technology that will accelerate progress towards HFA goals in countries of the Region.

The Advisory Committee, accordingly, formulated the following strategic approaches for the Regional research programme:

- (1) Research should be related to the eight elements of Primary Health Care and researchable areas should be identified and prioritized within the framework of the eighth elements of Primary Health Care.
- (2) The types of research should be given differential emphasis with the main emphasis being on Health Systems Research.
- (3) The health research system should be developed as a whole and linked to the health care system.
- (4) Intersectoral research and research beyond the health domain in matters affecting health is to be promoted.

With respect to the priority areas for research, the current position is as follows:

Research related to all eight essential elements of Primary Health Care would continue to be important. The eight essential elements are:

1. Education concerning prevailing health problems and the methods of preventing and controlling them.
2. Promotion of food supply and proper nutrition.
3. Provision of an adequate supply of safe water and basic sanitation.
4. Maternal and child health care including family planning.
5. Immunization against the major infectious diseases.
6. Prevention and control of locally endemic diseases.
7. Appropriate treatment of common diseases and injuries.
8. Provision of essential drugs.

However, there was a change in the emphasis, with an increased recognition of the double burden of illnesses and the socio-behavioral and economic determinants of health; there will also be an increased emphasis on the positive aspects of health in addition to control and treatment of diseases and illnesses; furthermore, determinants of the health of women and other vulnerable groups and measures to effect desirable changes would receive increased attention as well as measures to enhance women's potential in promoting health.

As an example, research related to prevention and control of locally endemic diseases and research related to immunization against the major infectious diseases will continue to be important. However, as the pattern and prevalence of the infective diseases change as a result of changing demographic structure, urbanization, migration and also due to gains made in the control of some of the tropical diseases and in the immunizable diseases of childhood, so will the research priorities reflect such changes. Examples of the changing pattern of infection are the decline in leprosy as a public health problem and the increased importance of tuberculosis under adverse urban living conditions and when doubly infected with AIDS.

As the immunizable child-hood diseases decline with increasing efficacy of vaccine and coverage, the focus for research related to vaccines will shift to the remaining challenges - testing of vaccines against malaria, AIDS, cancers caused by viral agents as well as improvement of efficacy, stability and cost-effectiveness of existing vaccines.

As better tools for controlling the common infective diseases become available, the emphasis of research will, more than ever before, be on operational research and research into more effective and efficient delivery systems especially those which will penetrate to the undeserved, underprivileged and vulnerable groups of both the rural and expanding urban populations.

The AIDS pandemic which now threatens most countries of the South-East Asia will require research in both preventive and curative aspects with emphasis on epidemiological, social and behavioral types of research. The emergence of AIDS warns the countries of the need to maintain the capability to recognize new disease entities/syndromes that may be caused by unknown new microorganisms and new causative agents.

There should be a discernible relative shift in emphasis towards research on non-communicable diseases - especially research related to the cardiovascular diseases, degenerative diseases, mental illness, injuries and chemical poisoning, which are emerging as additional disease burdens and gaining relative prominence. The emphasis should be on early detection and prevention and require epidemiological research, health systems research (HSR), as well as intervention studies.

Research related to endemic diseases will be influenced by the new health problems arising out of emerging societal changes. The epidemiological transition that is taking place as a result of demographic changes, rapid urbanization, industrialization and the changes in life-styles will inevitably create social problems and health problems of a different nature and dimension. Injuries, toxic chemicals and social factors will increasingly become as important as micro-organisms in causing ill-health and diseases. New social illnesses, physical, psychological, and social trauma and chemical poisoning will become as common as the conventional infectious diseases. Research will be needed to understand and diagnose them, describe their epidemiology, recognize new clinical entities and syndromes, and develop appropriate methods of preventing and controlling them.

Abnormal genes responsible for Thalassaemia and Haemoglobinopathies are highly prevalent in the region and diseases due to such genetic defects will become relatively important as infections decline. Gains in scientific knowledge such as from the Human Genome Project will reveal the genetic basis of many common diseases, and together with advances in bio-technology will bring nearer the prospect of effective gene manipulation, gene therapy and genetic counselling. Greater attention to research on clinical genetics and population genetics will be necessary to better utilize such scientific advances in our countries.

I dealt with research related to the first of the eight essential elements in some detail to indicate the shift in emphasis with respect to the priority areas for future research activities. Similar shifts in emphasis have been identified for research related to the other essential elements of primary health care as well.

I wish to next indicate to you briefly the type of research related activity that will be supported by the WHO Regional Office. The predominant role that will be played by WHO/SEARO is that of a technical agency promoting research development more through technical support than as a funding agency providing financial support for research projects.

WHO/SEARO will continue to strengthen national medical research councils and analogous bodies or other national mechanisms for promoting and coordinating research in countries. In this respect I may mention that we, in WHO consider NARESA to be such a mechanism. Hence it is pertinent for me to state that we provide support to these national bodies or mechanisms to enable them to strengthen their capacity to develop national research strategies and programmes to coordinate and manage research and to provide research training.

WHO/SEARO also puts major efforts into Research Capability Strengthening i.e. the development of researchers and human resources and measures to access scientific literature will be two principal activities in this respect. It will also promote the development of clinical research units, social science research units, field research stations and field research areas.

WHO/SEARO will continue to pay greater emphasis to the development of Health Systems Research with particular attention being paid to promoting health policy research, health economics research, health behavioral research and research on human resources for health. Within the context of health systems research, attention will be paid to establishing and strengthening linkages between the health sciences and the social behavioral and economic sciences and between researchers and institutions in these disciplines.

Basic biomedical research which is an integral part of research programmes directly related to priority health problems will also be considered for support.

The emphasis of WHO/SEARO support in the ensuing years will be more on promoting commissioned research on critical areas of existing and emerging health problems. However, an opening will be left for providing direct catalytic support to investigator-originated research projects which have potential for making important breakthroughs in the priority research areas.

I have so far dealt with the role played by the WHO Regional Office for South-East Asia in the promotion and development of health research. However, another important source of both technical and financial support for research are the special and global programmes of WHO Headquarters. In this respect, particular mention must be made of the Special Programmes on Tropical Disease Research and Research on Human Reproduction. As many of you are aware, these two Special Programmes have provided substantial support to Sri Lanka for research in the areas of malaria, and filaria in the field of Tropical Diseases and in the areas of isolation of anti-fertility agents from plant sources, as well as in epidemiological, socio-economic and clinical research in the field of Human Reproduction. Support for research in these fields in Sri Lanka is still being provided by these two special Programmes.

Before I conclude, I must offer on behalf of WHO/SEARO, as well as on my own behalf, our felicitations to NARESA on its twentyfifth anniversary. We are well aware of the very valuable contribution made by NARESA towards the promotion and development of not only health research but also research in other scientific and social science disciplines in Sri Lanka. WHO looks forward to much more closer collaboration with NARESA in the coming years - and of course such collaboration would be easy because we have a dynamic Director-General in the person of Professor Priyani Soysa. Future collaboration between NARESA and WHO/SEARO would be facilitated even further, as Professor Priyani Soysa will be one of the distinguished members of the WHO South-East Asia Advisory Committee on Health Research from 1994. I wish NARESA all success in its future endeavours and look forward to a period of fruitful collaboration between our Organizations.

Mr Richard Jarvis
Director
British Council

Prof. Priyani E. Soysa, Prof. K.K.Y.W. Perera, Ladies and Gentlemen:

The British Council has been around since 1949 and many people have a pretty fair idea of what we do. We are not perhaps very big players anyway in the Science and Technology area.

The Council is a very difficult organization to describe to other people. We are thought of very often as a cultural organization but we are different from analogue organizations such as the Goethe Institute and the Alliance Francaise or USIS, principally for one major reason: that is because we are the channel for British Government aid programme in educational and technical co-operation.

The apparent complexity of the British Council as an organization to deal with is a reflection, I suppose, of its funding sources. We have three different sources of funding. We have a core grant which comes from the Foreign and Commonwealth Office and from the ODA and secondly we spend a substantial amount of agency money. These funds are given to us to run programmes of the ODA, of Commonwealth Organizations, of the United Nations Offices and of other international lending agencies, and thirdly, we have certain revenue streams. Since the core grant comes from the British Government through these two administrations, we have to follow their policy guidelines in our spending plans. Exactly in the same way as USAID, our sponsors have identified certain cross-cutting issues which they focus on globally and which guide programmes. USAID refers to "democratic government". We prefer "open and accountable government". The other themes are health and population, economic liberalization, the environment and human resources development.

These five areas very much determine what the Council is doing with its core grant. In addition within each country there are certain ODA sectoral priorities. In Sri Lanka these have included natural resources, power and energy and particularly forestry. All this means that principally we are able to spend the money we have on various areas related to issues in government, to the environment, and to certain community-based health areas like AIDS, preventive medicine, but not training doctors for example. It should be clear that a great deal of our funding goes to non-scientific areas.

Let me now outline the various schemes we run. We give various ad hoc grants, for example; to enable people to come out to Sri Lanka to do specific jobs, or to enable Sri Lankans to attend conferences and courses overseas. Secondly, there are agency-funded projects in the area of S & T managed by the Council for example:

- 1) A project involving Silsoe and the Open University of Sri Lanka in Agricultural Engineering to develop a new programme at OUSL to bridge the gap between those who come up in agriculture and those who come up in engineering fields.
- 2) Another large aid project for the ODA has been with the Faculty of Agriculture of the University of Peradeniya over the past 5 years or so. It has involved inputs from many different UK institutions, for example, the Wolverhampton Polytechnic, Birmingham University, and most recently, the Indian Institute of Management in Ahmedabad. These are essentially institution building projects funded under the British aid programme.

The third area is the type of programme we call "academic links", rather like the SAREC programmes but not perhaps following a fixed model in quite the same way. We provide a small amount of funding in a flexible way to departments within the tertiary or research sectors to link up with similar departments in the UK. The focus of those links may be research, curriculum development, or training for either academics or

technicians. We provide a relatively low level of funding to provide 2 or 3 visits in each direction per year covering travel, accommodation, and sometimes books or equipment. To give some examples, we have a link between Moratuwa University and Imperial College in coastal erosion problems; an environmental programme in pesticides pollution in agriculture between Kelaniya and Glasgow; a link between Peradeniya and the Liverpool School of Tropical Medicine in entomology and mosquito-borne diseases. Yet there are others which do not fall under this science and technology umbrella. For example, we are just setting one up with the Open University and the University of Manchester on gender sensitisation issues in university curricula.

Let me finish with a couple of brief notes on other things the Council does. We do of course, have the libraries which are fairly well known with about 60,000 books in the library in Colombo and about 30,000 books in the Kandy library; quite a lot of material there which is in science and technology. Also, we have CD ROM data bases, and plan to obtain new ones on women's issues - women in development - surveys of the so called "grey literature" in this area. We also intend to obtain a new agricultural data base which for obvious reasons will be located in the Kandy library. We are members of AGRINET, we will discuss the choice with them.

Finally, let me say a word in training. Most people think of us as very much involved in that area. This again is for the most part an Overseas Development Administration programme: basically training nowadays is directly linked to British aid projects. And so it falls into the two or three priority areas as I mentioned: agriculture, energy or forestry together, of course, with many other awards tied to projects and programmes which fall outside the area of science and technology, for example, in English Language teaching. Finally, there really is the occasional genuinely 'scientific' award. For example, there is one award for a Ph.D next year which is for a study of - I'm not too sure what it means - "Fluidized gasification and combustion of biomass particulates". So perhaps we are a player after all !

Thank you very much.

JICA'S ROLE IN JAPANESE ODA

Mr Y. Sakamaki
JICA

Japan's ODA - Some of the developing countries have achieved remarkable economic progress however, most of them are still under economic stagnation due to accumulated debts, poverty and other problems. Nowadays support for economic policy reform, promotion of participatory development, and development of human resources in developing countries are considered important. The question of how we should address such global development issues as WID and environmental protection have also become crucial for more effective development assistance. Active involvement in these key development issues is becoming more and more important for Japan as one of the biggest donor countries.

Japan became an aid donor by joining the Colombo Plan in 1954 with an initial aid budget of Y18 million (\$ 50000). From 1953 to 1966, it borrowed \$860 million in development funds from the World Bank to finance the projects, the Bullet Train and Kurobe Dam. It was a net borrower on the one hand, and gave aid on the other hand. In July 1990, it finished paying off these debts, and at roughly the same time it was learned that Japan had surpassed the United States in 1989 to become the world's largest ODA donor. This was a historic event for Japanese aid programs.

In 1991, the total amount of ODA given by the twenty DAC (Development Assistance Committee) member countries was estimated \$58.272 billion. Japan was the largest contributor to this total, accounting for 18.8 percent, or ODA of Y1,473 billion (\$10.951 billion), and the ratio of ODA to GNP was 0.32 percent.

Japan's ODA is divided into three categories by type:

1. Bilateral grants;
2. Bilateral loans;
3. Financial subscriptions and contributions to international organizations.

Bilateral grants are divided into grant aid (funds provided to developing countries without imposing an obligation of repayment) and technical cooperation.

Under grant aid, funds are provided to build schools, hospitals, laboratories, and other facilities, to provide educational and training materials and medical equipment and supplies, and to relieve debts. Grant aid is divided into six categories : i) general grant aid; ii) grant aid for fisheries; iii) grant aid for disaster-relief; iv) grant aid for cultural activities; v) food aid; and vi) grant aid for increased food production.

Of these, the Japan International Cooperation Agency (JICA) is involved in i) general grant aid; ii) grant aid for fisheries; and iii) grant aid for increased food production. It is in charge of drawing up the basic designs and specifications needed to procure materials and supplies as well as to build facilities (called "basic design study work") and of undertaking studies and providing services (including liaison services) needed to build facilities and smoothly carry out the procurement of materials and supplies (called "expediting of execution work"). About 60 percent of all grant aid requires basic design study work and expediting of execution work.

Technical cooperation is intended 1) to transfer new technologies, skills and knowledge, 2) to improve their technology inviting technical personnel from the developing countries to Japan for training and dispatching experts from Japan to the developing countries to cooperate with them in human resources development and in the planning and preparation of development programmes. Necessary equipment is also provided to support these activities.

Performance in the field of Science & Technology in Sri Lanka

JICA Sri Lanka office is mainly implementing: Technical Cooperation Programmes such as:

1. Acceptance of participants,
2. Despatch of Technical Experts,
3. Equipment supply,
4. Project-type Technical Cooperation and
5. Development studies

besides, Grant aid, Despatch of Japan Overseas Cooperation Volunteers (JOCV) and Development Cooperation.

Due to the time limitation given to me, I would like to introduce our activities in Sri Lanka focusing on Project-type Technical Cooperation and Grant aid, in the field of scientific research works.

Institute of Fundamental Studies

When I review in this field, it reminds me at first of the project for the improvement of the Institute of Fundamental Studies (IFS) in Kandy. In order to contribute to implementation of the supreme objective such as to promote research of national importance, to bring local scientists together and foster the public understanding of science, Japanese Government donated the equipment amounting to about 400 million rupees in 1987.

Among the equipment, NMR-Nuclear Magnetic Resonance - Apparatus is included. As the sole equipment in Sri Lanka, it is expected to play an important role in the identification of the structure of substances such as chemical compounds in the field of bio-chemistry and medicine, etc.

I hope these equipment will be used fully continuously.

Plant Genetic Resources Centre

Establishment of the Plant Genetic Resources Centre (PGRC) was completed under the Japanese Grant aid Program in February, 1989. Project-type of Technical Cooperation, for five years, started on the 1st of April, 1988, based on the agreement.

The objectives of this project are to strengthen the research capability of plant genetic resources (mainly rice and grain legumes), and to contribute for the improvement of plant breeding technology in Sri Lanka. The centre also aims to formulate a countrywide research network among 9 Regional Agricultural Research Centres and Stations through technical exchange and training.

Upto 1991, 578 research officers and students have received training through the training programmes conducted by the PGRC.

Japanese experts who are dispatched to PGRC provided technical guidance on plant genetic resources to Sri Lankan counterparts in the following aspects;

1. Exploration and collection
2. Classification and evaluation
3. Conservation and multiplication
4. Data processing and management

So far six Japanese long-term and fifteen short-term experts have been dispatched. Nineteen Sri Lankan counterparts received training in Japan and provided equipment amounting to 157 million yen. (Rs.71 million).

The Exploration and Collection section of the PGRC has made twenty-four exploration trips and has collected 1,655 accessions in total upto October, 1992 in addition, 1,415 of various crop species have been introduced by foreign research institutes to PGRC. 3,899 accessions have been classified by the evaluation section. 6,203 accessions of germplasm have been multiplied by the multiplication section.

In December 1992, a Joint Evaluation Mission sent by JICA studied the overall performance of the project. It has concluded that the project accomplished most of the initial targets in spite of some constraints, but has recommended the project period be extended for another two years in the following fields; (1) exploration, collection and introduction, (2) evaluation and multiplication.

Medical Research Institute

Construction of new building of the Medical Research Institute was completed in April 1990, under the grant aid cooperation of Japanese Government. Technical cooperation started on 1st of January 1991, based on the agreement. The objective of the project is to develop the various functions of MRI and to enable it to play a more active role in the control of diseases in Sri Lanka.

In order to achieve the above mentioned objective, the following functions of MRI was planned to be strengthened through the Japanese Technical Cooperation:

1. Diagnosis;
2. Education;
3. Reference;
4. Biological Production;
5. Basic Research

Japanese Technical Cooperation was implemented in the following seven departments, three centres, one unit (electronmicroscopy) upon the agreement of both sides.

1. Department of Bacteriology and Mycology
2. Department of Virology
3. Department of Pathology and Immunology
4. Department of Bio-chemistry and Nutrition
5. Department of Natural Products and Pharmacology
6. Department of Entomology and Parasitology
7. Department of Biological Production
8. Centre for Medical Instrumentation
9. Experimental Animal Centre
10. Centre for Education and Training
11. Electronmicroscopy Unit

JICA has dispatched nine long-term experts and sixty-one short-term experts, and nineteen Sri Lankan counterpart personnel have been sent to Japan for either observation or technical training, so far.

Between 1988 and 1993, equipment worth about 138 million yen (Rs.63 million was donated by the Government of Japan).

The Japanese evaluation panel members, organized by JICA in order to study the conducts and achievements supported by the JICA MRI project. The evaluation was done in Sri Lanka in July - August

1993. The members recognized a smooth promotion and development in their functions and activities as a whole.

Among these promotions, some marked features are cited as follows:

1. Diagnosis was markedly improved in the quality in particular, but the supplementation with facilities and reagents.
2. Reference works also promoted by the supplementation.
3. Surveillance works commenced in the fields bacteriology, virology and nutrition.
4. Research works also promoted in the field of natural products in particular.
5. Educational conducts were reinforced markedly by the implementation for the facilities and personnel recruitment in excellence.

As a result of joint evaluation, both sides reached conclusion to recommend that the technical cooperation should be carried out for another additional two years after 1st of January 1994.

In the period of extension, specific activities will be implemented such as;

1. Surveillance of infectious diseases in Sri Lanka with particular emphasis on
 - a. Acute respiratory diseases in infants and children
 - b. Outbreaks of diarrhoea caused by bacterial and viral agents.
2. Analytical studies on the causative factors of coronary artery sclerosis in Sri Lanka, based on the nation-wide lipid profile survey.
3. Basic studies on snake venoms which can contribute to the future production of anti-venins to snake species specific to Sri Lanka.

Guideline of Implementation of JICA's Assistance

We would like to cooperate with Sri Lankan Government to extend our assistance to agriculture, industries and rural development with the aim of poverty alleviation and mitigating the socio-economic and regional disparity that could arise in the process of achieving higher economic growth, while looking forward to the establishment of a sustained economic and social system in the long-run.

Principle objectives are as follows:

1. Improve the condition of external resources
2. Achieving continuous economic growth with active participation of private sector enterprises
3. Mitigate the regional disparity
4. Poverty alleviation by creation of employment opportunities

Finally, let me introduce one cooperation scheme directly contribute to promote NARESA's activities. that is called a joint study project. Under this arrangement, researchers from Japan and from developing countries do joint research on a topic contributing to the social and economic development of the recipient

country; begun in fiscal 1977, research in fiscal 1991 was conducted by 95 experts (76 new, 19 from previous years) on twelve topics in nine countries, including strengthening research on diseases of Industrial Crops in Indonesia, land and building use controls in Thailand, and seismic design structure in Chile.

Unfortunately, in Sri Lanka so far there were no joint study projects. If you could be interested in this cooperation scheme, please contact me. I'll be able to give some suggestions.

Thank you.

Mr D. Baker
UNICEF

Major UNICEF activities in Sri Lanka:

- **nutrition**
micronutrients, behavioral changes, breastfeeding
- **immunisation**
- **basic literacy**
- **area based development**

UNICEF a user of low cost, simple technologies, not a producer of technologies, does not do or support basic research - but some programme evaluation.

Areas of interest to UNICEF where more work could be done:

- **low cost salt iodation, easy testing measure**
- **easily prepared complementary foods (weaning foods)**
- **Dry zone agriculture, plant types, efficient irrigation - drip systems/low cost**
- **environmental sanitation, effective human waste disposal (CDD)(diarrhoea cases increasing in Sri Lanka).**

Mr L.C.A. de S. Wijesinghe
I.U.C.N.

Let me say how happy I am to be present here today, and I am most grateful to you, Madam Director General, for having invited me to speak at this seminar which is being held to celebrate the 25th anniversary of NARESA.

NARESA has been very close to me. I had, for a little more than half of its period of existence, 13 years to be exact, been working in NARESA and seen the rapid growth of the institution. I could claim to have played some part in its growth and development into an institution which became the focal point for promoting scientific research in this country. Let me wish steady progress to NARESA so that when it comes to celebrate its 50th anniversary it will be an outstanding scientific institution in the country.

I have been asked to speak about IUCN. Now, the theme of the session under which this particular talk was listed is "Funding Research". My first reaction, and hence my reply to the organizers, was that IUCN is not a funding institution. I was, nevertheless, asked to speak about IUCN and its activities. And when I saw the broad theme of this seminar which is "New Directions in Science and Technology in Sri Lanka", I thought it would be appropriate for me to speak a few words on IUCN and its activities worldwide as well as in Sri Lanka.

IUCN stands for the International Union for the Conservation of Nature and Natural Resources. It was established in 1948. Since recently it has been called The World Conservation Union, but still retains the abbreviation IUCN. IUCN is a union of sovereign states, government agencies, non-governmental organizations, and even individuals. IUCN is primarily concerned with the promotion of scientific activities that will ensure the perpetuation of the natural environment. More specially, it provides international leadership for the conservation and management of living resources. With the changing perceptions of the concept of conservation, to mean not merely preservation but also wise and sustainable use of natural resources, IUCN has drafted a new mission statement that reads "To influence, encourage and assist societies throughout the world to conserve the integrity, and diversity of nature and to ensure that any use of natural resources is equitable and sustainable".

IUCN has its headquarters in Gland, Switzerland, and it has a large number of country offices all over the world. It has field programmes in many parts of the world, particularly in the developing countries.

At headquarters there are six Commissions focusing on six broad areas which denote the main thrusts of IUCN. These are:

- Commission on Ecology
- Commission on Education and Communication
- Commission on Environmental Law
- Commission on Environmental Strategies and Planning
- Commission on National Parks on Protected Areas
- Commission on Species Survival

I have not listed these in any particular order. The Species survival Commission is considered to be one of the more important Commissions and so also is the Commission on National Parks on Protected Areas. In the context of what is happening in the world today - widespread deforestation, erosion of genetic diversity, despoliation of natural habitats, and so on, the work of these Commissions assumes a place of considerable importance. The Species Survival Commission has within its network a large number of specialists groups focusing on particular endangered species. This Commission, as well as all the others, work through a network of scientists based in all parts of the world. Most of the scientists participate

voluntarily and give of their expertise and knowledge for furthering the activities of the different Commissions.

Besides the Commissions there are Thematic Programmes within IUCN. There is the biodiversity programme, the forest conservation programme, wetlands conservation, the marine and coastal areas programme, and so on.

In addition to the activities carried out with the focal point at headquarters, there is a whole range of field activities in all parts of the world. They deal with conservation of forests and wetlands, protection of endangered species, and so on.

I have been speaking about IUCN's activities in a general way. I would also like to refer to some specific activities of global significance that IUCN has been involved in. One of these is the preparation of the World Conservation Strategy (WCS) in collaboration with the World Wildlife Fund and UNEP. This document was published in 1980. The WCS alerted the world of the need to address not only the proximate causes of environmental degradation but also the underlying causes. Following WCS also triggered international action on conservation that culminated in the holding of UNCED, the Earth summit, in 1991.

Another global initiative of IUCN was the holding of the Fourth World Congress on National Parks and Protected areas. The report on the Congress titled "Parks for Life" summarises the proceedings and provides valuable information on the conservation and protection of protected areas.

A third activity of global significance is the presentation of a comprehensive publication: Global Biodiversity - the Status of the Earth's Living Resources. It was prepared by the World Conservation Monitoring Centre in collaboration with IUCN and other organizations.

IUCN has also collaborated with the United Nations in the preparation of international agreements, notably the Convention on the Conservation of Biological Diversity.

Now let us see what activities IUCN has been involved in, in Sri Lanka.

IUCN Sri Lanka was established in 1988 with the appointment of a coordinator and the setting up of a small unit. This was raised to the status of a country office in 1990. At present IUCN has 09 members from Sri Lanka: The Ministry of Forestry, Irrigation and Mahaweli Development is the State member, and the Forest Department and the Department of Wildlife Conservation are State Agency members. There are six environmental NGOs who are members.

One of the earliest activities of IUCN in Sri Lanka was its support to the CEA for assisting in the preparation of the National Conservation Strategy. This was in the early 1980s prior to the appointment of an IUCN Coordinator in Sri Lanka.

In 1988, IUCN provided support to the Forest Department in developing conservation management programmes for the Sinharaja forest. Until then, conservation was thought of as total protection of the forest. IUCN support towards the conservation of Sinharaja brought in a new dimension to the concept of conservation management. It focused on participation in conservation efforts by the peripheral communities living around the forest. A series of activities were carried out in Sinharaja in the years that followed. Then, in 1993, IUCN assisted the Forest Department in the preparation of a comprehensive conservation management plan for Sinharaja forest.

IUCN is also involved in the preparation of conservation management plans for several other forests that have been set apart for conservation of biological diversity and hydrology. These include the knuckles

forest and 13 forest reserves in the wet zone. Funding for these activities have been provided by NORAD and the World Bank.

In the mid 1980s the government put out its forestry Master Plan. There was public criticism of the fact that the Plan was overly concerned with production while very little attention was paid to aspects of conservation. This was a time when attention was being focused worldwide on the need for conserving the biological resources of the earth, and the failure of the Master Plan to address to this issue resulted in the planners being taken to task.

As a response to protests from scientists, environmentalist and the concerned public, the government suspended exploitation of natural forests in the wet zone and requested IUCN to provide technical support for carrying out an Accelerated Conservation Review of the forests that had been earmarked for exploitation. Following this review the Forest Sector Development Project was revamped to bring in a strong environmental management component, and IUCN was invited to provide technical support for several activities under the environmental management component. Funding for these activities is being provided by UNDP.

IUCN Sri Lanka is also providing support for the conservation management of mangrove ecosystems. These are ecologically important coastal wetlands that have hitherto been neglected. Through IUCN's international expertise in mangrove management, technical support is being provided to the national mangrove management programme.

On environmental issues of global significance, IUCN Sri Lanka is providing technical support to the relevant local agencies on the implementation of the Convention on the Conservation of Biological Diversity.

From what I have described it would be clear that what IUCN does in field programmes is to provide technical support, where ever the need arises, to local institutions in areas concerning the conservation of biological resources. IUCN does not attempt to implement projects but only to support local institutions which in turn are expected to strengthen their own capabilities. It is in this role that we would like to see a steady growth in IUCN's activities *vis-a-vis* the work of national scientific institutions like NARESA.

Peter Neil

Team Leader - Forestry Research & Information (FORRI) Project

Prof Priyani Soysa, Ladies & Gentlemen,

May I start this presentation by thanking you, Prof. Soysa, on behalf of the ODA for inviting me to participate in this seminar today which celebrates 25 years of NARESA's efforts in Sri Lanka. Congratulations on this considerable achievement!

I am sure that you are well aware of the British government's past assistance to Sri Lanka and, more recently, the role it has played in the development of the Mahaweli catchment and the construction of the Victoria dam. British aid to the island continues today, but has re-oriented away from major capital projects and moved more towards the areas of training and institution building in an attempt to tackle some of the more fundamental problems linked to development. In this context, Britain's current input is directed at:

- * forestry and forestry-related issues (which I will discuss in more detail shortly),
- * education and training (including English language training, teacher training and assistance to the Open University),
- * institution building and "good" government/democratic administration etc. (eg. its involvement with the Colombo Municipal Council), and
- * assisting with the rehabilitation of war victims (through the auspices of the Save the Children Fund - UK and Oxfam).

The Overseas Development Administration (ODA) is the British government's international aid agency and, as an example of its policies on funding in Sri Lanka, I would like to base this presentation on its forestry project. The ODA is presently funding a five-year programme of institutional strengthening and operational support for the country's forestry sector. It is an integral part of the Forestry Sector Development project, which is coordinated by the Forestry Planning Unit of the Ministry of Forestry, Irrigation and Mahaweli Development. This programme is co- and parallel-financed by the ODA, World Bank, FINNIDA and the UNDP whose common objectives, as defined in the Forestry Master Plan, are briefly:

- better management of the natural forest resource;
- increased production of wood;
- greater protection of the environment;
- and the creation of rural employment.

ODA's programme aims to strengthen the research, information and forest planting and management activities of the Forest Department and to support forestry education at the Universities of Peradeniya and Sri Jayewardenepura. The projects that fall under the auspices of this programme are:

- the Forestry Research & Information (FORRI) Project
- the Forest Management and Plantation (FORMP) Project
- the University of Peradeniya/Oxford Forestry Institute Link
- and the University of Sri Jayewardenepura/University College of North Wales, Bangor, Link

In addition, there is another project outside this immediate programme - the Forest/Land Use Mapping Project (FORLUMP), which works closely with the Forest & Environment Division of the Mahaweli Authority

of Sri Lanka. Its role has been to produce a 1:10,000 scale map series of the land use, slopes and vegetation types of the upper Mahaweli catchment. Recently, it has been using this information along with other relevant data in a geographical information system (GIS) to look at land use issues, particularly in tea estates in the up-country, the project is also helping to monitor the levels of siltation in the Mahaweli reservoirs using echo sounding and other instrumentation.

The various Sri Lankan institutions involved with the forestry programme include:

Ministry of Forestry, Irrigation & Mahaweli Development (the Forestry Planning Unit, Forestry Department, Mahaweli Authority),

Ministry of Agricultural Development & Research (the Royal Botanic Gardens and National Herbarium),

the Universities of Peradeniya, Sri Jayewardenepura and Colombo

the Ministry of Education & Higher Education

the Ministry of Environment & Parliamentary Affairs

and, not least, our hosts today, the Natural Resources, energy & Science Authority of Sri Lanka (NARESA).

The ODA projects use science and technology in various ways and in a number of cases are advancing our knowledge of them in Sri Lanka. Here are some examples.

Forest Management & Planning Projects - involves assisting with the management of the Forest Department's existing plantations, the development of a forestry plantation database to provide information on which to base management decisions, and conservation tree plantings in areas of vulnerable watersheds. It is also involved in using satellite imagery to produce forest cover maps of the country - a 1:2.5 million scale map of the island is already available and currently island-wide coverage at a scale of 1:50,000 is being produced.

Concentrating on the research side of the programme we have under the Forestry Research & Information (FORRI) Project:

- * support to the Forest Department's research branch - which involves development of infrastructure and research capabilities within the department.
- * the development of a Forestry Research Master Plan for the country as a whole. This was preceded by carrying out a review of forestry and forestry-related research over the last century and using these findings as a basis to the master plan. A database on research was created which included some inputs from NARESA's own research databases on work in which they are involved.
- * the establishment of an active Forestry Information Service (FIS) using computerized desk-top publishing facilities. It has also provided access to CD-TREE- the CD-ROM disk which contains all CAB-International Forestry Abstracts and Forest Product Abstracts from 1930 to date.
- * socioeconomic and floristic studies of the Peak Wilderness Sanctuary to assist with the development of management plans for the area. Aspects included in these studies were medical plants and non-wood forest products.

- * support to the Royal Botanic Gardens - Peradeniya which, similar to the work with the Forest Department, includes infrastructure development and support for research activities including the construction of a tissue culture laboratory for floriculture activities.
- * the promotion of environmental education - largely concentrating on the upper Mahaweli catchment area in both the formal schools sector, but also in less formal education within communities and faith groups, in part through the medium of radio.
- * the completion of the revision of the Flora of Ceylon. the latter is closely associated with NARESA and the National Herbarium, who along with other local botanists and international botanists from the Royal Botanic Gardens - Kew, are well on their way to finalizing this revision work based on Trimen's original flora published a century ago. The flora of Ceylon is knowledge base that underpins all future work on the development of plant resources and the environment in the island. This current revision was first started back in 1968 with funding from the American Smithsonian Institution. To date, seven volumes of the revised flora have been published and volumes eight and nine are with the publisher. The ODA agreed to complete the work when funding from the Smithsonian Institution came to an end. This programme now involves the revision of some 850 species of flowering plants, with an additional 350 species of the ferns. Recently a new species - *Gordonia dassanayakii* (Wadhwa & Weerasooriya) - was named in honour of the Sri Lankan editor of the revised flora - Prof. M.D. Dasanayake. It is anticipated that the flora will have been completely revised and published by early 1997.

The links with the universities of Peradeniya and Sri Jayewardenepura not only provide opportunities for Sri Lankan students to go to British universities for postgraduate studies, but also to assist them to undertake pragmatic research in relevant topics here in Sri Lanka. Currently, research topics involve:

natural forest ecology and management - including studies on the fire resistance of indigenous plant communities (eg. at Randenigala);

agroforestry - investigating the use of participatory methods to work with farmers and rural communities;

hydrology - studying the water relations between natural vegetation types and plantations along with the effects of altitude and cloud interception/deposition;

and plant genetics research, including studies on varieties of jak fruit and possible breeding regimes.

These are just a few examples of the research activities the ODA is supporting at present.

In the longer term and overall, the ODA's policy is to support the efforts of individual governments by building up the capacity of their institutions to sustain development. Promoting sustainable development is a central concern of ODA's aid programme. New elements involved with this are the many global environmental problems - including the threat of climatic change from the so-called "green-house effect", ozone depletion, deforestation and the loss of biodiversity. Developing countries will need assistance to deal with these problems. Research in science and technology will continue to play an important role in helping us to understand the problems faced. Britain's current commitments in the forestry and forestry-related sector are some 200 projects worldwide involving some £200 million of funding. In Sri Lanka, the current forestry Programme involves some £15 million over 5 years. The recognized importance of research is one of the reasons why the ODA is currently assisting with the formulation of a Forestry Research Master Plan for Sri Lanka. This, however, can only be successfully achieved with close cooperation between the British and Sri Lankan governments as well as appropriate institutions within Sri Lanka. It should be observed that aid is often criticised in the popular press as being only or mainly to serve the interests of the donor country - that is, for donor country companies or institutions - science and technologically oriented projects regularly feature in this criticism. It cannot be denied that there are few

human activities where some degree of self-interest is not involved. However, these comments notwithstanding, I hope that from what I have said it is clear that the ODA is working in a programme in close consultation with Sri Lanka and with Sri Lankan interests in mind. Only in this way can we hope to provide useful assistance in Sri Lanka's efforts at sustainable future development.

As to the future, Britain's overseas aid budget is coming under additional pressure with the protracted recession and the opening up of Eastern Europe. Both have caused tight money to become even tighter. However, I believe that funding will continue to Sri Lanka, if only in an extension to the current programmes. This funding will almost certainly continue to have strong scientific and technological bases.

SOURCES OF FUNDING RESEARCH USING NUCLEAR TECHNIQUES

Dr W.P. Dias

Atomic Energy Authority

Nuclear Technology is a powerful tool which can be used in a number of different areas of research. Examples of research conducted in Sri Lanka using nuclear techniques are identification of the cause of decline in yield in tea plants with ageing, research on effectiveness of fertilizers, development of a low cost method for identification of hepatitis B virus in donor blood, vulcanization of natural rubber latex, and development of a food supplement to improving calving in cattle.

The main source of funding for these activities is the International Atomic Energy Agency (IAEA). Biannually, the IAEA provides about 1 million US \$ worth of technical assistance for about 10 projects in Sri Lanka under its Technical Cooperation (TC) Programme. The assistance provided is in the form of equipment, fellowship training and expert services. The IAEA TC projects are implemented through the Atomic Energy Authority which is the focal point for all IAEA activities in Sri Lanka. A list of IAEA projects implemented in 1993 and 1994 are given in **Appendix 1**.

The main criteria for IAEA funding are, the importance of the project for national development, availability of manpower and other facilities required for successful implementation, sustainability of the projects and the benefits of the projects to the end users.

Applications for funding for TC projects should be submitted to the IAEA through the Atomic Energy Authority. The applications for assistance for the 1997/98 cycle should be submitted to the IAEA before the end of 1995 and the AEA will call for initial proposals in or around April 1995.

TC projects need not be purely research oriented.

The IAEA also provides funding for research through its Research Contract (RC) Programme. Under this programme, the institutes that already have the necessary equipment and trained manpower can obtain about US \$ 5,000 to meet the expenses. A list of ongoing RC projects is given in **Appendix 2**.

The IAEA under the Regional Co-operative Agreement (RCA) Programme, provides assistance for certain projects of regional interest. 16 countries in the Asia-Pacific region are members of the RCA. The assistance is mainly in the form of regional training courses and expert services. Priority areas are decided at the annually held working group meetings of the RCA countries.

A P P E N D I X I

1. Nuclear instrument maintenance and repair.
2. Nuclear medicine (phase II).
3. X-ray fluorescence analysis in industry.
4. Tracer and NDT techniques in the petroleum industry.
5. Biological nitrogen fixation in trees.
6. Nuclear techniques in animal science.

7. Isotope techniques for sustainable increased tea production.
8. Training in nuclear techniques.
9. Manpower development.

APPENDIX 11

- 1) The biological discrimination of hormone sensitive and insensitive breast cancer by radioimmunoassay in Sri Lanka - General Hospital, Colombo.
- 2) Study of nutritional status and reproductive parameters of dairy cattle in mid country small holder farms of Sri Lanka - Faculty of Agriculture, University of Peradeniya.
- 3) Use of radioisotopes in studying iron metabolism in humans - faculty of medicine, University of Ruhuna.
- 4) Variation in nitrogen fixing potential and the effect of frequency vs. intensity of pruning in the nitrogen fixation of *Gliricidia sepium* and *Leucaena leucocephala* - Coconut Research Institute, Lunuwila.
- 5) Rapid diagnosis of tuberculosis by amplification of mycobacterial deoxyribonucleic acid (DNA) - Faculty of Medicine, University of Colombo.
- 6) Improvement of nitrogen fixation of cowpea - Faculty of Agriculture, University of Ruhuna.

PART II

PRESENTATIONS BY RESEARCHERS

CONTENTS

	Page
NARESA 25 years in S & T <i>Prof. Priyani E. Soysa</i> <i>Director General, NARESA</i>	47
PRESENTATIONS BY RESEARCHERS	
Chemical investigations of some plant and insect derived attractants and defensive secretions and their possible uses <i>Dr(Ms) Neelakanthi Gunawardene</i> <i>University of Kelaniya</i>	50
Chemistry and bio-activity of Sri Lankan plants of the Menispermaceae and Rubiaceae <i>Prof. G.P. Wannigama</i> <i>University of Peradeniya</i>	51
Hydraulic and structural investigations on coastal structures armoured with concrete hollow blocks <i>Dr S.S.L. Hettiarachchi and W.P.S. Dias</i> <i>University of Moratuwa</i>	52
A pharmacodynamic evaluation of <i>Momordica charantia</i> and <i>M. dioica</i> <i>Dr(Ms) B.M.R. Fernandopulle</i> <i>University of Colombo</i>	64
Study of solid electrolytes and cathode materials for solid state electrochemical cells <i>Dr H.M.N. Bandara, Dr. M.A.K.L. Dissanayake and DR. J.S.H.Q. Perera</i> <i>University of Peradeniya</i>	65
Management strategies for the reservoir fishery of Sri Lanka <i>Dr Upali Amarasinghe</i> <i>University of Kelaniya</i>	67
Coastal environmental research programme - an overview <i>Dr(Ms) Pauline Dayaratne</i> <i>SAREC project</i>	77
The buffalo research programme - an overview <i>Dr S.S.E. Ranawara</i> <i>SAREC project</i>	83

NARESA - 25 years in S & T

Prof. Priyani E. Soysa
Director General, NARESA

The National Science Council was inaugurated in 1968 with Sir Nicholas Attygalle as the first Chairman of the Council. This was the result of various representations made by the CAAS, the predecessor to SLAAS.

In 1982, the Natural Resources, Energy & Science Authority became the legal successor to the NSC, under the President of Sri Lanka His Excellency J.R. Jayewardene.

NARESA has over the years functioned through Steering Committees of Experts in the different scientific disciplines. Their recommendations go up to the Authority which is in effect a Board of Management.

This governing Board consists of the Director General and members nominated by His Excellency The President of Sri Lanka.

The functions of NARESA are the following:

- 1) To advice the government on policies concerning science, natural resources development and energy;
- 2) to initiate and sponsor research in these areas;
- 3) to collect and disseminate scientific information.

Although in the past, the National Science Council had formulated a Science Policy with a sub-committee comprising of Dr G. Ponnampereuma, Dr Gamini Corea, Dr S. Gnanalingam, Prof. B.A. Abeywickrema and Mr B.J.P. Alles, there is no record of any further actions by the Government of that time.

However, the National Science Council had a series of seminars on Science Policy.

What is happening now ? NARESA has in the recent past sent recommendations and protests to policy makers on various items based on matters that the Working & Steering Committees recommended for scientific action. 28 policy statements commissioned study reports have been submitted to various Ministries as part of a consultative function.

The main activity is the research grants scheme. This is not merely the funding of projects but includes the regular monitoring and evaluation of reports submitted by the research grantees.

There is public advertising for research proposals through the daily press. Proposals submitted to NARESA are channelled through the Steering Committees of experts who study the proposals and choices are made according to the funding available.

Finally, the Authority decides on these approvals before the grantee is called up to sign an agreement.

Sri Lanka government has funded via NARESA research up to about Rs. 50 million in the last two decades or so. Foreign funding has been over a Rs. 100 million.

SAREC has considered NARESA as their focal point since 1982. The main SAREC funding has been on the Buffalo Research Programme, and the Coastal Ecology Programme.

At one time in 1982 USAID invited NARESA to coordinate and assist in the selection of R & D projects funding by USAID. In 1983 CIDA invited NARESA to coordinate the Canadian Potash Grant to Sri Lanka.

NARESA has initiated and sponsored 1269 research grants of which 1119 were from NARESA funds amounting to Rs.51.04 million and the balance from foreign funds Rs.132.02 million.

This has enabled 207 young researchers to obtain masters degrees, 33 scientists to obtain doctoral degrees. The cost has been estimated at about 48,000 per PG amounting to much saving of foreign exchange.

317 scientific publications have come out of this research grants scheme, 50% of which have been in international journals.

NARESA has sponsored and organised 162 national and international meetings. 70 of these were training seminars and workshops.

In 1977, the Sri Lanka Scientific and Technical Information Centre was established in NARESA. 117 science libraries are linked into this network. We hope to expand this with external resources.

The printing press has been functioning since 1984. Recently most of the publications printed here have been produced on time which are of highest quality.

The National Science Journal comes out on time. A Journal of Social Science too has come out regularly.

A science bulletin, The Vidurava in Sinhala, Tamil and English has been published since 1978. It is distributed free to schools and also available on sale. This is akin to a monograph on a subject, with contributions by 3 or 4 experts. Besides this, 34 monographs in English, Sinhalese and Tamil have been distributed to schools in a science education series.

55 major scientific reports and 19 checklists of flora and fauna of Sri Lanka have been published. Outside of this, our press also undertakes private or public printing on a commercial basis.

This year, we have improved our library service, providing more space for users by introducing a mezzanine floor to display our journals in a better manner.

We have also a sales point at the entrance to the building to ease the sales on our publications; thereby, sales have improved.

The souvenir that we have published gives all these historical details and is available on sale for only Rs.50/-. It should be useful information for your libraries.

In 1992, we commenced press briefings on information from research grantees which would help the public on the following subjects:

- 1) Access Mobility in Industrial location
- 2) Landslides of Sri Lanka with information on early warning signs
- 3) In Peradeniya - On production of buffalo curd
- 4) Several aspects of the Buffalo Research Programme including the intensive farming system
- 5) On coastal ecology; as coast conservation armoured with natural rock and concrete armour units
- 6) On the successful biological control of *Salvinia* - which has now been taken over by the Department of Agriculture.

Awards for scientific achievement have been given from time to time.

Research huts have been built in Sinharaja and Horton Plains by the Forest Department and the Department of Wild Life with finances from NARESA.

Among the workshops which were held recently were;

- I) On medical ethics
- II) On a list of priority areas in scientific research
- III) On women and AIDS
- IV) Training workshops for teachers for forest conservation through March for Conservation
- V) Agricultural research

The explosive progress of S & T in recent times has led to a new scientific revolution in the 20th century. This seminar was planned in that context. The next year will be a turning point not only for NARESA but for many other scientific institutions in the Ministry of Industries, Science and Technology. The unprecedented impact of science in a world torn by a widening gap between the rich and the poor, could have disastrous effects on economic and human development. Mass Media has to provide widespread coverage to bring the general public to a heightened awareness of science for every day life.

There have to be governmental and other structures and management systems to facilitate, encourage and fund science education, research and development. The situation is truly depressing in the background of the current status of institutions like NARESA.

Yesterday, Prof. Perera showed an index to demonstrate the expert human resource available in Sri Lanka as opposed to the developed world i.e. the number of engineers/population.

There has to be better organisation namely a right mix of people and opinions to maximise productivity. NARESA needs resources for research which could be done in well equipped laboratories in Universities, there must be information exchange with press, access to more libraries, data banks and computer systems. Whatever limited assets and resources in humans and material must be put to the best use to provide the foundation for the larger needs of the country and our people.

We heard yesterday that prominent scientists are needed to provide national leadership. Excellence must be nurtured, recognised and protected. Our scientists should undertake research on country specific situations applying multidisciplinary expertise at the same time, there must be special training in journalism and the use of radio and television in innovative methods delivering science information. Literature must be available. The reading habit - a critical habit is badly neglected. The emphasis is on learning by rote and passing examinations.

There is an acceptance in principle by the Ministry of Industries, Science & Technology for the need to increase funding for research. In addition we need South - South cooperation and North-South cooperation as well as regional cooperation for a favourable climate for research. We discussed this yesterday. A national policy has been framed.

The work in the coming years should be based on the successes and weaknesses of the present system.

Precautionary and anticipatory action plans need to be developed so that one is not caught unawares.

In spite of all this gloom, let us have hope that with new directions, NSF will grow stronger in the years to come.

CHEMICAL INVESTIGATIONS OF SOME PLANT AND INSECT DERIVED ATTRACTANTS AND DEFENSIVE SECRETIONS AND THEIR POSSIBLE USES

Neelakanthi E. Gunawardena,
Department of Chemistry,
University of Kelaniya.

Summary

Defensive secretions of two local insects, *Coridius janus* Fabricius. (Hemiptera : Pentatomidae) and *Leptocoris oratorius* (Hemiptera: Coriidae) were evaluated as potential toxicants/repellents. Combined gas chromatographic-mass spectrometric (GC-MS) analysis revealed that each secretion consist of a carbonyl compound a known deterrent, and an accompanying compound, a neutral compound which amounts to 90% of the volatiles *trans*-2-hexenal and n-tridecane were found to be the major volatiles in the defensive secretion of *C. janus* whereas t-2-octenal and n-octylacetate were found as major volatiles in the defensive secretion of *L. oratorius*.

Above defensive secretions were shown to possess insecticidal activity by fumigant action. In a toxicity and repellency assay using three selected test insects *Anoplolepis longipes*, *Sitotoga cerealella* and *Culex quinquefasciatus* LC₅₀ values of 0.197, 0.003 and 0.002 ppm respectively and repellencies of 63%, 55% and 65% respectively were obtained for the defensive secretion of *C. janus*. Under the same conditions the defensive secretion of *L. oratorius* gave for *A. longipes* and *S. cerealella* LC₅₀ values of 0.24 and 0.14 ppm respectively and repellencies of 63% and 58% respectively. Comparing the toxic and repellent values, it was apparent that the secretion of *C. janus* has a potential as a toxicant and a repellent whereas that of *L. oratorius* has a potential only as a repellent.

Further investigations on the defensive secretion of *C. janus* were carried out using a synthetic equivalent. Thus a toxicity assay on a series of combinations of t-2-hexenal/n-tridecane (ratios varying from 100:00, 80:20, 60:40, 40:60, 20:80, to 000:100 w/w) revealed the presence of synergism in the mixture. Of all combinations the one with the ratio 60:40 (w/w) of t-2-hexenal; n-tridecane respectively was shown to possess the highest toxicity towards all three test insects. Using the above combination further evaluations on the accompanying compound, were made. n-tridecane, the naturally occurring accompanying compound was shown by comparison with longer and shorter n-alkanes to be optimally suited to enhance toxic/repellent properties of t-2-hexenal.

A CHEMICAL STUDY OF TWO PLANTS OF THE FAMILY MENISPERMACEAE

G.P. Wannigama
Department of Chemistry
University of Peradeniya.

The presentation describes a chemical study, coupled with bio-assays, of two plants of the family Menispermaceae. The plants are *Diploclisia glaucescens* (B1.) Diels (Sinh: ඇට නික්කලු) and *Anamirta cocculus* (L.) Wight et Arn. (Sinh: නික්කලු). Both are creepers, growing in Sri Lanka, Central and South India and in other regions of South East Asia.

The mature stem of each plant was processed for non-quaternary alkaloids. The total alkaloid content of *D. glaucescens* was much greater than in *A. cocculus*, but much more of the latter plant was used. Both plants gave stepharine. *A. cocculus* gave in addition, (-)-8-oxotetrahydropalmatine and oxypalmatine. Stepbarine showed moderate spermicidal activity and weak hypotensive activity.

The stem of each plant was defatted with petroleum ether and extracted with methanol. The n-butanol partitions of each methanol extract gave froth and hemolysis tests for saponins and showed marginal activity as molluscicides.

Chromatographic separation of the methanol extract of *D. glaucescens* gave eleven compounds, stigmasterol, ecdysterone, two triterpenoid acids, serjanic acid and phytolaccagenic acid, a glucopyranoside of phytolaccagenic acid and the glucopyranosyl ester of the glucopyranoside, a sugar alcohol, vibo-quercitol and four highly polar saponins. Two of the latter are monodesmosidic while two are bidesmosidic. The monodesmosidic saponins are glucuronopyranosides of serjanic acid and phytolaccagenic acid. The bidesmosidic saponins are glucopyranosyl esters of these glucuronopyranosides.

Ecdysterone is an arthropod moulting hormone. Its isolation in a record yield of 3.2% from *D. glaucescens* offers potential practical use. It has proven insecticidal activity and significant spermicidal activity. Out of the six saponins isolated only one, the glucuronopyranoside of serjanic acid has the activity required of a natural molluscicide. However the low yield (0.04%) and use of the stem for extraction would stand in the way of any commercial exploitation.

Chromatographic separation of the n-butanol partition of the methanol extract of *A. cocculus* gave two triterpenoids and three isomeric triterpenoid glycosides. The major triterpenoid was arjunolic acid. Derivatives of arjunolic acid offer promise in the treatment of skin cancer. However *A. cocculus* is not as good a source of arjunolic acid as *Terminalis arjuna* (Sinh: කුඹුක්).

The other triterpenoid was shown to be an epoxy lactone. It was chemically interrelated to arjunolic acid. Two of the three glycosides were glycosides of arjunolic acid, whereas the third was a glycoside of bayogenin, an epimer of arjunolic acid. None of the isolated compounds showed any molluscicidal activity.

HYDRAULIC AND STRUCTURAL INVESTIGATIONS ON COASTAL STRUCTURES ARMoured WITH CONCRETE HOLLOW BLOCKS

S.S.L. Hettiarachchi and W.P.S. Dias
Department of Civil Engineering
University of Moratuwa.

A. Introduction

Coastal erosion is a major natural hazard faced by Sri Lanka. Due to the fragile nature of the coastal belt, pressure from human activities together with unfavorable wave climate have had adverse effects on the coastal environment. In economic terms the consequences of erosion on private and public spending have reached very high proportions.

Remedial measures for coastal erosion could either be undertaken by adopting a soft solution such as sand nourishment of the eroding area or by applying a hard solution such as the construction of groynes, revetments and offshore breakwaters or an appropriate combination of both solutions. When a hard solution has to be adopted for a given situation, local environmental conditions together with wave loading characteristics play a vital role in determining the most appropriate type of coast protection structure. Coastal structures are usually constructed with rock armour or artificial concrete armour.

This paper summarises the principal findings of a project which investigated the performance of coastal structures armoured with natural rock and concrete armour units. In particular, attention was focused on single layer hollow block armour units, a concept of more recent origin which provides a cost effective solution in the construction of coastal structures that need to be armoured with artificial concrete units.

Although natural rock is available at a reasonable price in Sri Lanka, there are instances where the hydraulic performance could be improved greatly by the use of concrete armour units. In addition to coastal protection works, the need for structures to be located in deep exposed areas such as for breakwaters for fishery and commercial ports have resulted in a demand for large and heavier units in great quantities, a need which is not easily satisfied by natural rock. However, if concrete armour units are to be used, it is essential that such structures should be constructed by adopting armour units which optimize the use of concrete. In this respect the use of single layer hollow block armour units represents the most optimum use of concrete thus providing the most economical solution.

B. Rubble Mound Structures

B.1. *Types of Porous Slopes*

Porous slopes may be constructed in three main forms:

- a) rubble mound breakwaters
- b) rubble revetments
- c) rubble protection mounds

Rubble mound structures are formed of granular material, usually quarry rock, although other materials may be used. A number of granular layers are formed between the inner core material and the outer armour layers. Rubble revetments also use outer armouring layers over a number of underlayers, but these are laid in turn upon an impermeable or relatively so, core or embankment material.

In the case of both rubble mound breakwaters and rubble revetments, wave induced flows will penetrate to some considerable depth into the structure. Much of the incident wave energy will be dissipated both in

flow over the outer surface and within the voids in the various armour and underlayers. These structures are therefore much more effective in absorbing waves than the equivalent non-porous slopes, for both long and short period waves. Rubble revetments, with their smaller total porosity, will not absorb as great a proportion of long waves, and hence will reflect rather higher proportions as the incident wave length increases. Rubble revetments, if armoured with similar armour layers as rubble mounds, will generally offer comparable performance for shorter waves.

The third type of armoured slope that is of interest is the protective armour mound placed in front of a vertical or other solid wall. Such a protection mound has often been used specifically to reduce the influence of wave reflections, where beach levels have fallen as a result of scour. Scouring in the immediate vicinity of the structure undermines its overall stability.

In general, porous sloping structures will dissipate significantly more wave energy than the equivalent non-porous slope. The important parameters which contribute to increased dissipation and reduced levels of reflections are the void characteristics and the permeability of the armour, underlayer and the core and the angle of slope of the front face.

B.2 Rock armour

The principal material used for armouring rubble slopes is quarried rock, used either as rock armour or rip rap. Rock armour consists of large pieces of rock each of generally similar weight. In contrast rip rap will include a much wider range of sizes. As a result of the wider grading rip rap armour systems are somewhat less porous and permeable to wave action than single size armour.

In turn, this may yield slightly higher reflections. The smaller sizes in rip rap may be moved at lower wave heights than for rock of similar median weight. For good stability and hydraulic performance, armour layers should be formed in thickness equivalent to at least two layers of material, although thicker armour layers may be used. In general, rock armour will be laid on steeper slopes whilst rip rap slopes are commonly shallower.

B.3 Concrete armour

In some circumstances, when rock of appropriate size and/or quality is not easily available, other armour systems may be more economical. In these situations concrete armour units provide an acceptable solution. A wide variety of such armour units have been developed, some offering particular advantages.

The different types of artificial armour units used in practice can be broadly classified into three types, namely:

- 1) Bulky
- 2) Slender interlocking
- 3) Single layer hollow blocks

Bulky armour units rely mainly on their weight for stability and are usually placed at random. The slender interlocking type of units have the advantage of greater stability due to interlocking effects. However, armour units of this type develop greater static and dynamic forces under wave action. These armour units, which have a relatively reduced block weight, are usually placed at random. There are instances when predetermined laying arrangements are used. It is important to note that, in the case of both bulky and slender interlocking type of units, the voids which contribute to the dissipation of wave energy are established between the armour units in a random manner. On most occasions, at least two layers of units are used for the primary armour.

Hollow block armour units are of more recent origin and are somewhat different to the other two types in that the voids are built into the individual units in the required form. Armour units belonging to this type are usually placed as a single layer to a predetermined form. Thus the resulting voids matrix of the primary armour is geometrically well defined in contrast to that of the other two types. The unique characteristic of the hollow block concept is the systematic analysis of the voids matrix of the primary armour layer. This allows absolute control of the geometry of the voids within the confined boundaries of effective primary armour layer which is very efficient with respect to wave energy dissipation. The stability of a coastal structure consisting of hollow block armour units does not depend on the degree of interlocking between the units and as a result, the weight of individual armour units can be reduced considerably. These units have been produced in various external shapes of which the cubic form has been more popular. The volumetric porosity of the primary armour is in the order of 60% and most of the energy is dissipated within their internal voids, thereby reducing the net drag force acting on the unit.

C. Hydraulic model testing of hollow block armour units

Hydraulic model testing was conducted on different types of single layer hollow block armour units including scale models of those used in practice. The objectives of conducting these tests were to assess the hydraulic performance and to understand the characteristics of wave induced loads acting on armour units.

One of the main difficulties in using single layer hollow block armour units is establishing an appropriate design criterion. Unlike other types of armour units they have proved to be extremely stable during hydraulic model tests and the definition of a stability coefficient as applicable to other types of armour units cannot be used to define the stability of these units. The external geometry of the unit and the predetermined packing arrangement restricts the movement of individual armour units to a minimum. One of the possible failure mechanisms for this type of armour units is for units to be lifted from the assembly during wave action on the slope. Although the armour units are placed one beside the other to a predetermined layout which restricts the movement of individual armour units to a minimum, there is the possibility of units striking each other under wave action. Such collisions can contribute to the cracking of units leading to further damage. In this respect the study of the influence of dynamic forces and the capability of armour units to withstand such loads in a hostile marine environment is justified. The study of loads can be achieved experimentally by incorporating instrumentation in model units. On this occasion strain gauges were mounted on model units as a force measuring device. The hydraulic model testing was carried out in the Hydraulics Laboratory of Imperial College, London.

An intensive test programme conducted on different types of hollow block armour units provided information of fundamental importance on the mechanics of wave action on coastal structures armoured with such units and on forces acting on a typical hollow block armour unit.

The energy dissipation characteristics of a hollow block armour slope were dependent to a high degree on the external and internal structure of the individual hollow block armour unit. An armour slope consisting of units having lateral porosity and an interconnected voids matrix was found to be most effective in dissipating energy. By the proper selection of governing parameters, it is possible to design cost-effective single layer hollow block armour units having increased porosity while optimising reflection, run-up and run-down and transmission. Fig: 1 illustrates reflection characteristics for different types of hollow block armour units. It is important that within this design framework due attention should be focused on the structural integrity of units.

With respect to the structural integrity of units, the study identified the types of loads acting on armour units and in the case of cubic hollow block, along-slope and lift forces were considered the characteristic loading criteria. Results from tests using regular waves indicated that for a given armour unit - depending on its relative position and incident wave conditions - impact loads were superimposed on gradually varying quasi-static loads. Impact forces increased with increasing steepness. The relative magnitude of the positive lift forces was found to be within acceptable limits for the experimental conditions investigated

K_r vs $\tan \alpha / (H/L)^{0.5}$

FOR SLOPES (1:1 1/3) OF VARYING ARMOUR

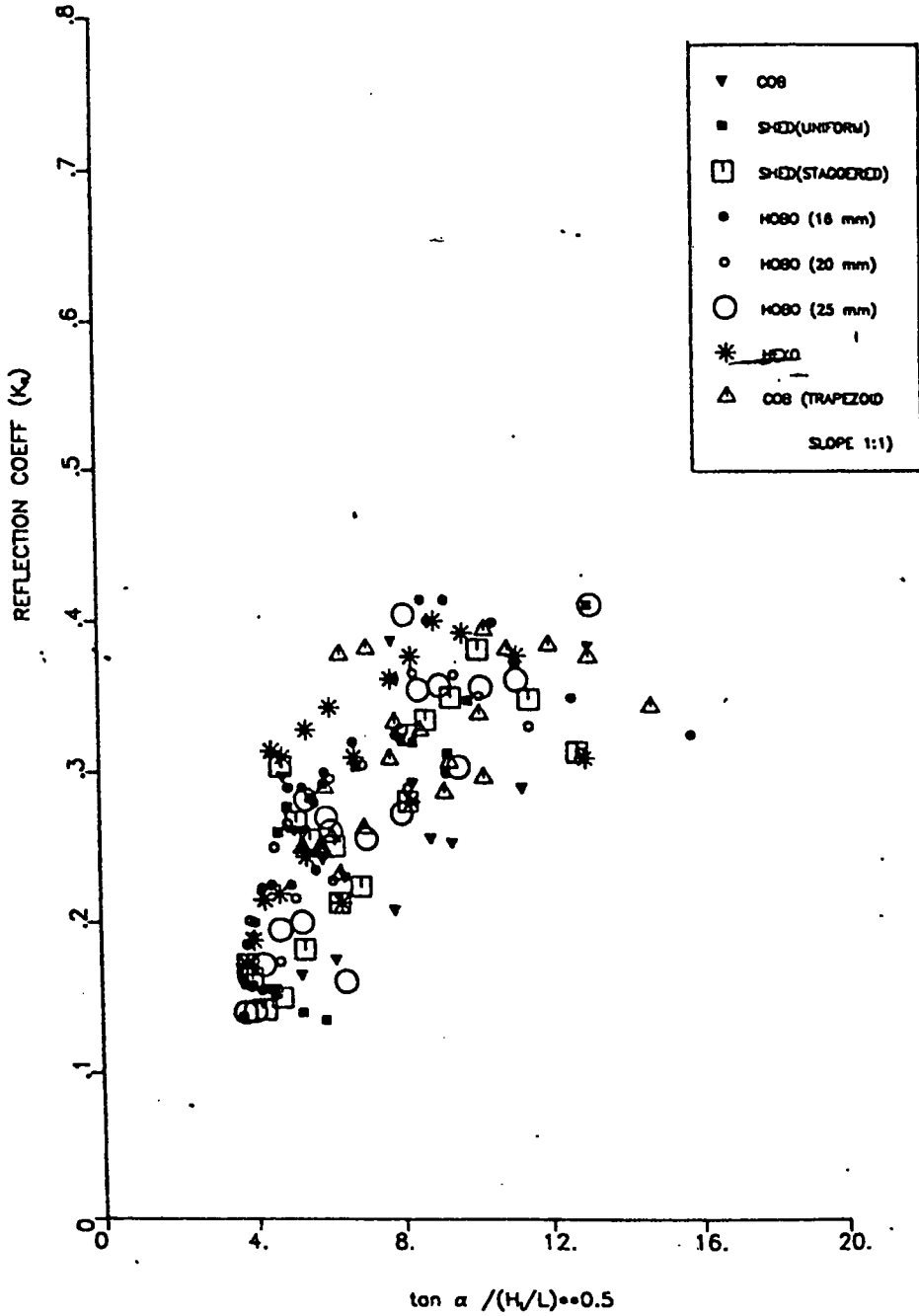


Figure 1: Reflection characteristics of hollow block armour units.

and the hydrodynamic forces were not sufficient to extract the unit from the armour slope. In reality, this force component will be resisted additionally by frictional forces between adjacent armour units. Fig: 2 illustrates the results from typical force measurements.

From these investigations, it was evident that single layer hollow block armour units offer a hydraulically efficient, cost effective solution on the construction of coastal structures and breakwaters. The overall porosity of the order of 60% for individual units offers attractive cost competitiveness. A high level of hydraulic efficiency will no doubt produce very favourable long term effects.

D. Durability of armour unit concrete

Since the concrete armour units would be subjected to very severe exposure conditions, tests were carried out to establish the durability of the concrete itself. Six concrete mixes were used for this purpose, as indicated in Table 1. Mix A was a control mix, having a water/cement ratio of 0.4 and a cement content of 400 kg/m³ (Burdall and Sharp 1986). Mixes B and D were used to investigate the effect of increasing the water/cement ratio, while Mix C was used to study the effect of increasing the cement content (for the purpose of improving workability). Mix E incorporated 0.6 % (by volume) of short (50 mm) chopped coir fibre, which was expected to improve the impact resistance of the concrete, while Mix F contained fine gneissic quarry dust (under 0.15 mm in size), which may contribute pozzolanic action (Dias 1992). It must be emphasised that the mixes did not use water reducing admixtures, polypropylene fibres or the more conventional pozzolans from industrial processes, as these would have imposed cost penalties in a developing country such as Sri Lanka (Dias 1991).

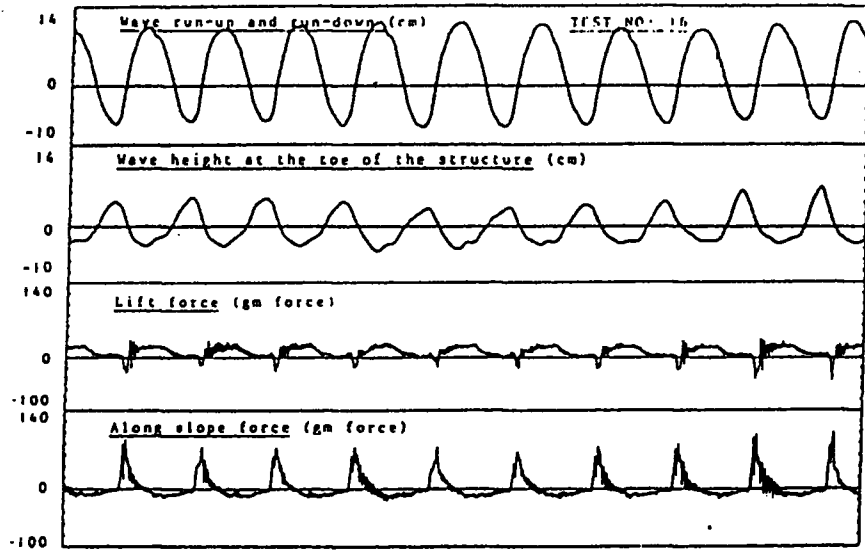
Table 1: Details of Concrete Mixes

Series	cement (kg/m ³)	sand (kg/m ³)	quarry dust (kg/m ³)	coarse agg (kg/m ³)	water (kg/m ³)	fibre (% v/v)	slump (mm)	VB time (secs)
A	400	700	-	1190	160	-	0	10
B	400	700	-	967	240	-	170	1
C	600	646	-	839	240	-	60	2
D	300	776	-	1009	240	-	90	0.5
E	400	700	-	1190	160	0.6	0	8
F	400	525	-	1260	160	-	0	13

Durability was measured primarily by the use of the indicators shown in Table 2. The specimens were cylinders of 100 mm diameter x 100 mm length, that were cast on a vibrating table and cured under water for 28 days, after which they were stored in the laboratory. The weight loss in air (at both stability and 2 weeks) is a measure of the volume of pore space in the specimens. The weight loss at 2 weeks is well correlated to that at stability (Dias 1993a), and hence the former could be used as a very simple and convenient index of durability.

Sorptivity testing (Hall 1989) was carried out after the specimens had reached weight stability with the surrounding air. The specimens were made to absorb water uniaxially by sealing the curved surfaces of the cylinders and placing them on sponges placed in shallow trays of water. The weight changes were monitored and the sorption obtained as volume per unit area of absorbing surface. Sorptivity is defined as the gradient of the linear plot between sorption and the square root of time - See figure 3.

In addition to the indicators given in Table 2, chloride ingress profiles were also obtained, to test the resistance of the concretes to chlorides. These results, shown in Figure 4, would acquire great significance if the concrete armour units were reinforced with steel, as chlorides would promote corrosion.



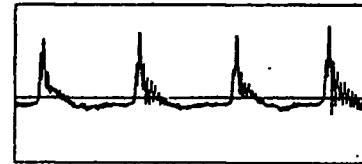
For breakwater section with an impermeable underlayer
 $T=1.0$ sec, $H_c=9.34$ cm

WAVE HEIGHT AND FORCE MEASUREMENTS (MEASURED VALUES)

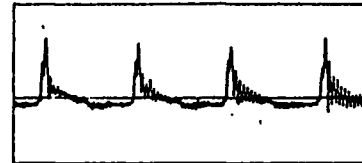
Profiles of along slope force (measured values)

T (sec)
wave period

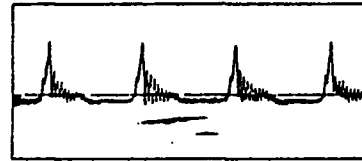
H (cm)
wave height at the toe



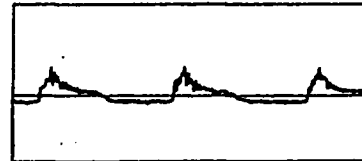
1.0 8.04



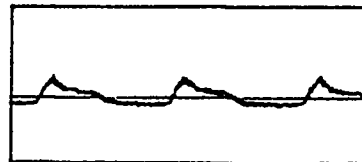
1.0 6.91



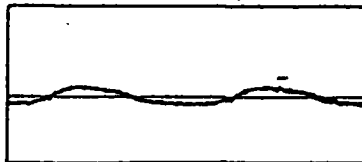
1.0 5.72



1.5 3.63



1.5 3.41



2.0 4.34

still water depth=24 cm

VARIATION OF ALONG SLOPE FORCE (MEASURED VALUES) FOR DIFFERENT INCIDENT WAVE CONDITIONS

Figure 2: Force measurements of hollow block armour units.

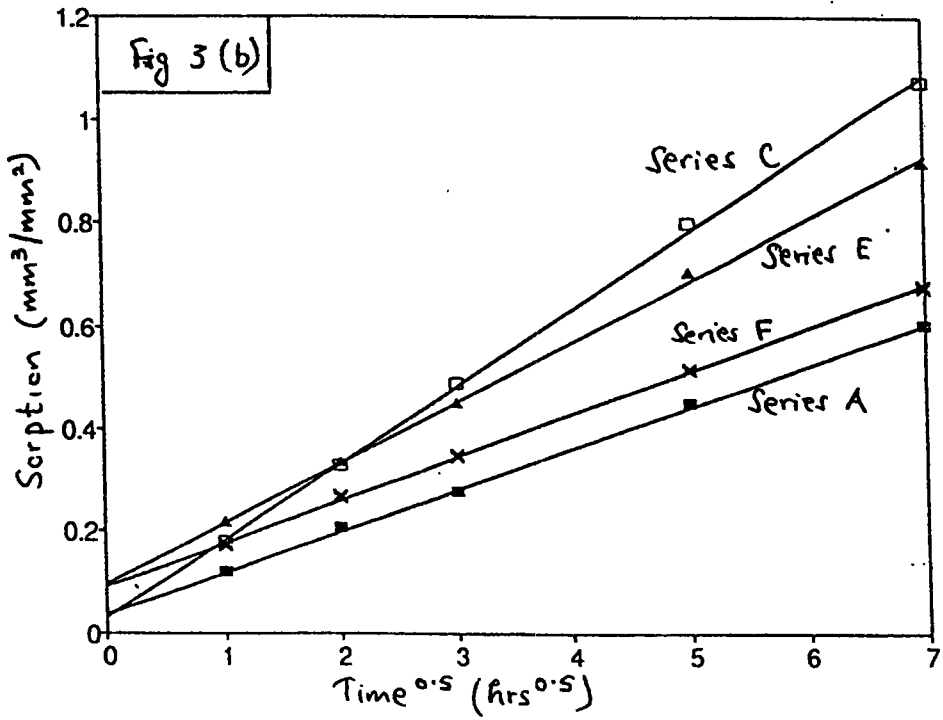
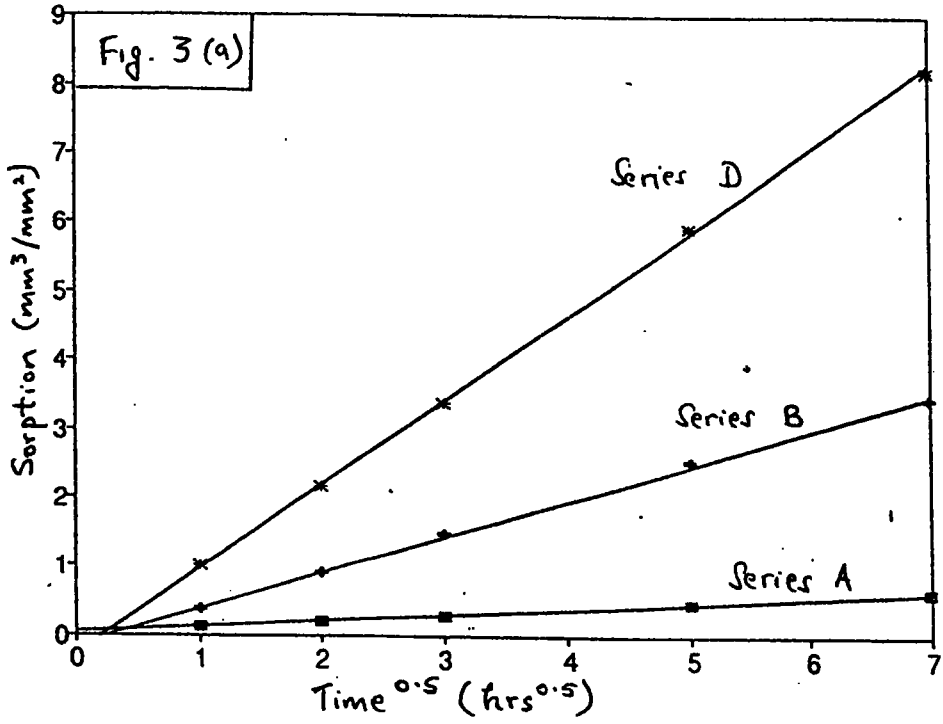


Figure 3: Sorptivity plots for concrete mixes.

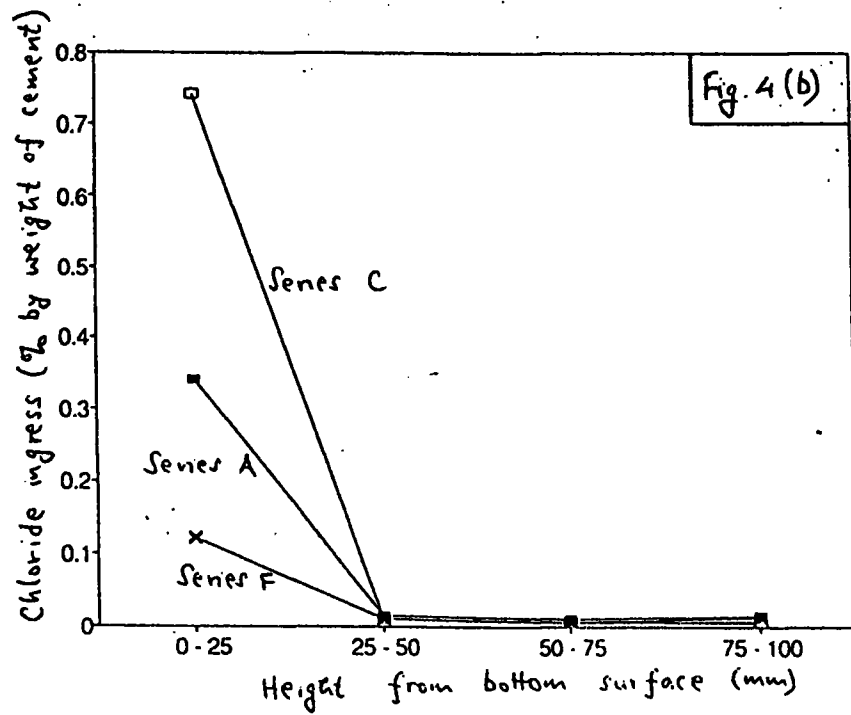
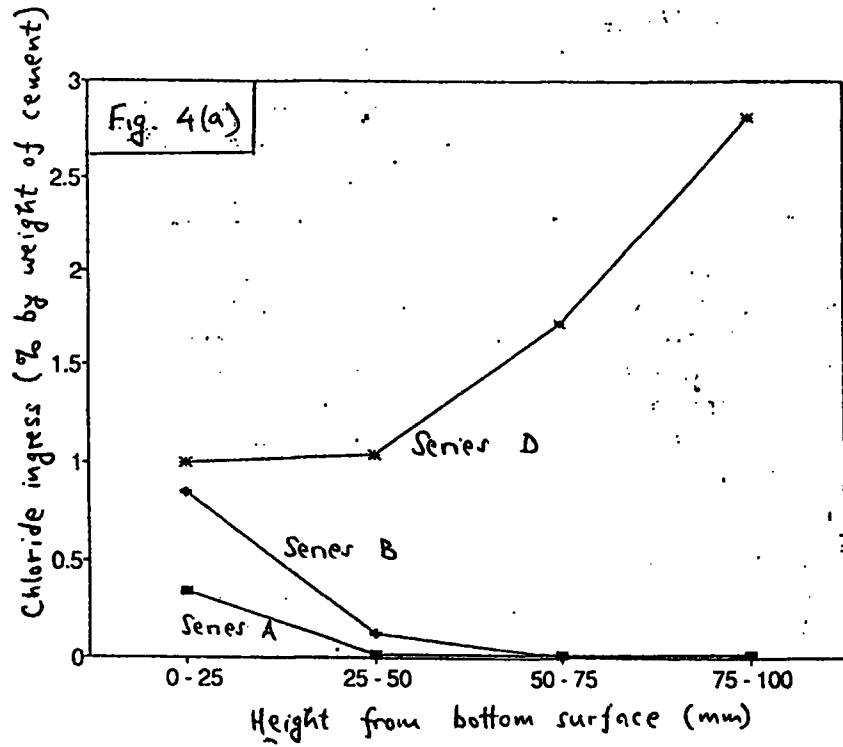


Figure 4: Chloride ingress results after 16 weeks of wick action.

Table 2 : Moisture Transport Phenomena

Series	Remarks	Weight Loss in 2 weeks (g)	Weight Loss at stability (g)	Sorptivity (mm/hr ^{0.5})
A	ct=400 kg/m ³ , w/c=0.4	20.02	40.38	0.081
B	w/c = 0.6	40.18	69.85	0.515
C	ct = 600 kg/m ³	25.09	57.07	0.150
D	w/c = 0.8	52.57	83.52	1.213
E	0.6% fibre	20.89	41.97	0.118
F	quarry dust	18.02	36.16	0.084

When considering the performance of the concrete mixes, it is clear that increasing the water/cement ratio from 0.4 through 0.6 to 0.8 (Mixes A,B,D) adversely influences all the durability indicators (weight loss, sorptivity and chloride ingress) in a very significant way. Furthermore, the increase of cement content to 600 kg/m³ (Mix C) is also adversely reflected in the durability indicators, though not to the same extent as when increasing the water/cement ratio. The inclusion of 0.6% (by volume) of coir fibre (Mix E) increased sorptivity slightly, but did not affect the weight loss figures, when compared to the control mix A; the chloride ingress profiles were not properly obtained for Mix E. The incorporation of fine quarry dust (Mix F) improved the weight loss and chloride ingress indicators when compared with the control mix A.

It may be concluded that a water/cement ratio of 0.4 and a cement content of 400 kg/m³ should be maintained for producing durable concrete in the marine environment. The addition of 0.6 % (by volume) of short, chopped coir fibre will not impair durability significantly, while the addition of gneissic ultrafine particles will improve it slightly.

E. Impact resistance of concrete armour units

The armour unit chosen for impact testing was essentially a cube having three interpenetrating cylindrical voids. In addition, the vertical edges were chamfered as well. Figure 5 shows the geometry of the specimens while Table 3 gives the dimensions. The dimensions of Series C specimens were identical to those of Series A; the former however had 0.6% (by volume) of short chopped fibre incorporated in the mix. The sizes of the units were such that manual placing could be envisaged.

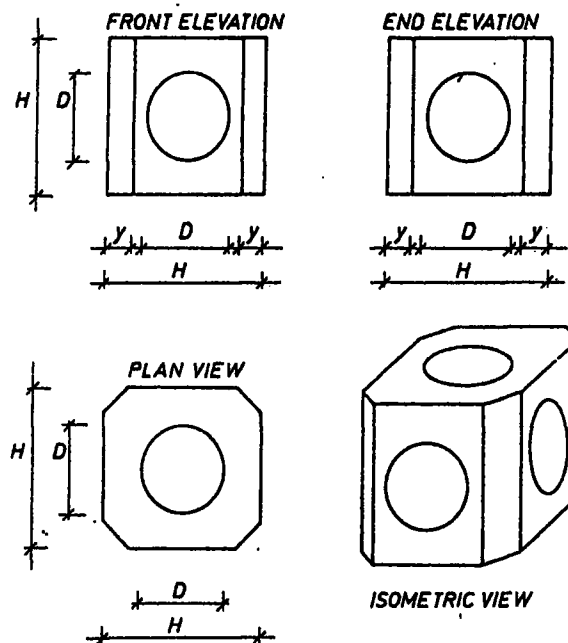


Figure 5: Geometry of hollow block units.

Table 3 : Dimensions of Hollow Block Units (see Figure 5 For Geometry)

Series	A,C	B	D
Height, H (cm)	45	45	40
Diameter, D (cm)	25	30	22
Chamfer, y (cm)	7	5	6
Volume (cm ³)	42544	31632	30562
Void Ratio (internal)	48.5	62.8	47.7
(total)	53.3	65.3	52.2
D/H	0.556	0.667	0.550

The impact resistance of the units was characterised by repeated dripping of units from varying heights onto a specially prepared rigid test bed, using a quick release mechanism developed at Moratuwa University (Dias 1993b). The number of drops required from each height for first cracking and disintegration were recorded. This resulted in plots such as Figures 6 and 7.

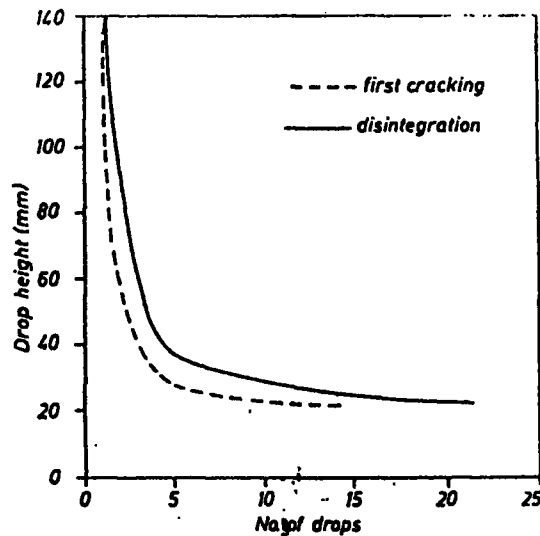


Figure 6: Impact test results for series A

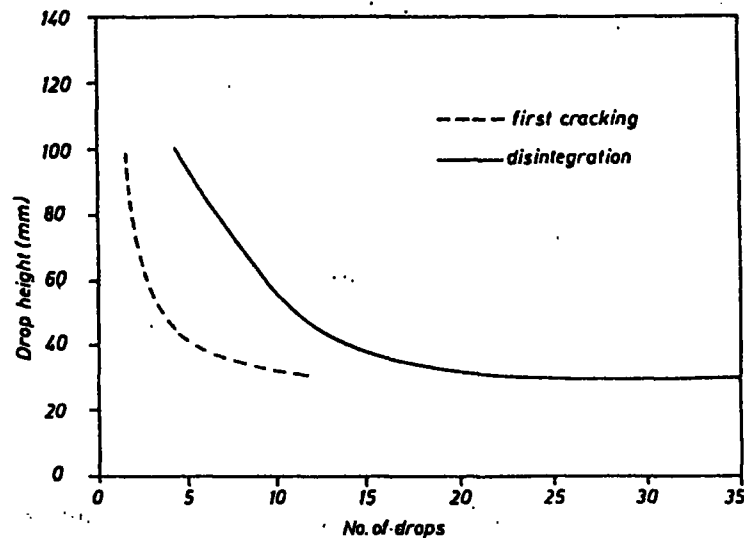


Figure 7: Impact test results for series C (with 0.6% coir fibre)

A comparison of figures 6 and 7 indicates that the first cracking behaviour and the disintegration behaviour (in particular) are improved by the inclusion of 6% (by volume) of coir fibre in the concrete mix. In addition, the region between the first cracking and disintegration lines is also increased in Figure 7, with the coir fibre adding a measure of "plasticity" to the otherwise unreinforced concrete. Evidence from the literature suggests that increases in fibre volume beyond 1% yield only marginal improvements in impact resistance (Franco *et al.* 1990).

The differing behaviours of Series A, B and D (see Figure 8 for example) are due to the differing weights and geometries of the units. These behaviours have been unified using a simple theory of impact loading and stress waves (Dias 1993b).

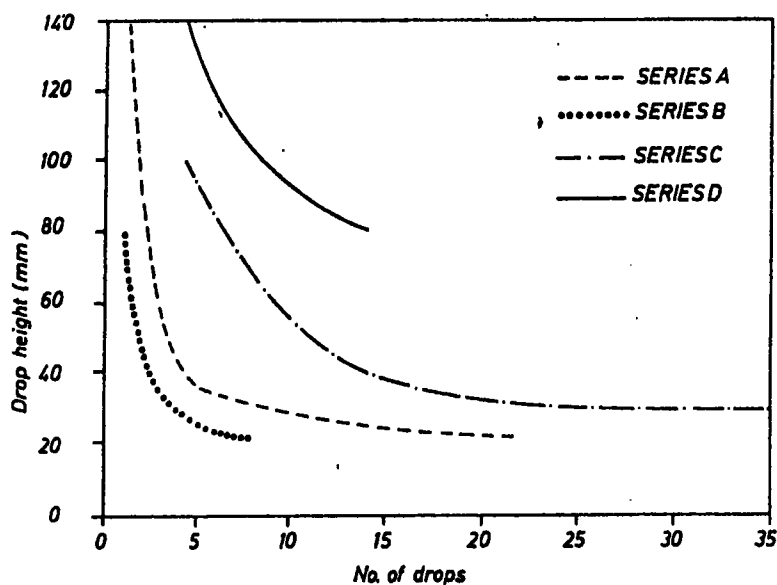


Figure 8: Comparison of impact test results (disintegration) for series A to D.

F. Conclusions

1. From detailed hydraulic model investigations, it was evident that single layer hollow block armour units offer a hydraulically efficient, structurally stable, cost effective solution in the construction of coastal structures and breakwaters. The overall porosity of the order of 60% for individual units offers attractive cost competitiveness. A high level of hydraulic and structural efficiency will no doubt produce very favourable long term effects.
2. A water/cement ratio of 0.4 and a cement content of 400 kg/m^3 should be maintained for producing durable concrete in the marine environment. The addition of 0.6% (by volume) of short (50 mm), chopped coir fibre will not impair durability significantly, while the addition of gneissic ultrafine particles will improve it slightly.
3. Both the first cracking behaviour and disintegration behaviour of hollow block concrete armour units (especially the latter) are improved by the inclusion of 0.6% (by volume) of short, chopped coir fibre.

G. Acknowledgements

This investigation was carried out at the Civil Engineering Department of the University of Moratuwa and at Imperial College, London. The chloride content determination was performed at the Ceylon Institute for Scientific and Industrial Research (CISIR). The research was funded by the Natural Resources, Energy and Science Authority of Sri Lanka (NARESA), on grant RG/89/E/2, "Investigations on the performance of

coastal structures armoured with natural rock and concrete armour units". Tests at Imperial College, London were carried out by Dr S. Hettiarachchi during his visits on the academic link sponsored by the British Council. The assistance of Professor Holmes of Imperial College, London and British Council is acknowledged. The contributions of Technical Assistants A.D.R. Sasanka and P.S.N. de Silva towards this work was indispensable and is gratefully acknowledged.

H. References

Burdall, A.C. and Sharp, J.V. (1986). Some aspects of the revision to the U.K. guidance notes for offshore structures. Int. conf. on concrete in the marine environment, Concrete Society, London, 37-48.

This work was an investigation of the hydraulic performance and structural integrity of coastal structures constructed with rock armour and artificial concrete units.

Although natural rock is available at a reasonable price in Sri Lanka, there are instances where the hydraulic performance could be improved greatly by the use of concrete armour units. Attention was focused on single layer hollow block armour units, a concept of more recent origin which provides a cost effective solution with respect to the volume of concrete required for a given area to be protected. Results have wide applicability in island states of the developing world having no access to rock armour.

In the design of rubble mound structures, it is important to understand the functions of the principal elements as well as the close inter-relationships among them. This study identified some of the important design aspects pertaining to the armour layer and the core with specific reference to structures armoured with single layer hollow block armour units and rock armour.

Results from extensive test programmes conducted on different types of hollow block armour units provided information of fundamental importance on the mechanics of wave action on coastal structures armoured with such units with particular reference to wave forces. These results have contributed to the development of design criteria for such structures. From the investigation, it was evident that single layer hollow block armour units offer a hydraulically efficient, cost effective solution in the construction of coastal structures and breakwaters. The overall porosity of the order of 60% for individual units offered attractive cost competitiveness. The high level of hydraulic efficiency will contribute to very favourable long term effects. With reference to rock armoured structures, a review has been made of the recent developments with respect to the hydraulic design.

The armour unit chosen for this investigation was of essentially cubic shape having three mutually perpendicular intersecting cylindrical voids and chamfered vertical edges. Various mixes were tried for optimising concrete durability under impact loading. The main durability indicators employed were sorptivity and chloride ingress. The study recommended the use of 400 kg/m³ of cement and a water/cement ratio of 0.4. The combination of gneissic ultrafines (under 0.15 mm in size) and river sand fine aggregate in the ratio 1:5 was also found to be beneficial with respect to some durability indicators. The addition of 0.6% (v/v) chopped dispersed colr fibre to the mix caused a slight reduction in the durability indicators but caused a significant improvement in the impact resistance of the units.

This impact resistance was tested by repeated dropping of units from varying heights onto a specially prepared rigid test platform, using a simple but effective quick release mechanism. The impact resistance was found to depend on both unit size and void ratio. A simple theory of impact loading and stress waves was used to explain the differing resistance of three different geometries that were tested. The units that were reinforced with dispersed colr fibre gave a markedly improved performance with respect to both initial cracking and final disintegration.

This work has produced several papers published in journals and presented at conferences, at both national and international level.

A PHARMACODYNAMIC EVALUATION OF MOMORDICA CHARANTIA AND M. DIOICA

**Dr B.M.R. Fernandopulle
Prof. W.D. Ratnasooriya
Dr J. Welihinda
University of Colombo.**

This study was designed to evaluate the antiulcerogenic and ulcer healing, antidiabetic, and abortifacient potential of gam karawila (*M. charantia*) and thumba karawila (*M. dioica*) which are commonly consumed vegetables in Sri Lanka.

The results demonstrate that the fruit extract of thumba karawila possess potent antiulcerogenic and ulcer healing effects on peptic ulcers in rats. The fruit extract of gam karawila was less potent with respect to these two activities. The active component is a triterpenoid. The antiulcer activity was independent of gastric acid inhibition and was mainly mediated via cytoprotective mechanisms.

With respect to antidiabetic activity, the fruit extract of thumba karawila exhibited marked hypoglycaemic effects in the rat, which was evident only in the presence of glycaemia.

On parenteral administration to pregnant rats the fruit extract of gam karawila demonstrated significant abortifacient effects. On oral administration it significantly retarded foetal growth without inducing abortion. Both fruit extracts were devoid of significant toxicity on long term administration.

This study has demonstrated, that thumba karawila is an orally active innocuous fruit which can be used to develop a potent cytoprotective drug, devoid of gastric acid inhibition for the treatment of peptic ulcer disease. The majority of the currently available antiulcer drugs are gastric acid inhibitors, and both long term acid inhibition and ulcer relapse following cessation of treatment is of great medical concern. Thus thumba could be a useful alternative or supplement for long term management. Thumba karawila would also have valuable synergistic effects with the currently available drugs in diabetes. Furthermore, since gam karawila is popular as a galactagogue this study also indicates that it may be prudent to avoid consuming large quantities of the fruit during pregnancy.

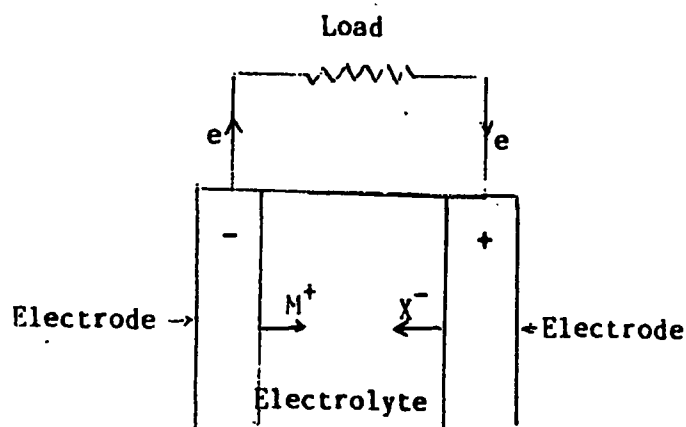
STUDY OF SOLID ELECTROLYTES AND CATHODE MATERIALS FOR SOLID STATE ELECTROCHEMICAL CELLS

Dr H.M.N. Bandara
Dr M.A.K.L. Dissanayake
Dr J.S.H.Q. Perera
University of Peradeniya.

Solid electrolytes are solid materials with considerable ionic conductivity. Although quite a number of materials are known to conduct well at elevated temperatures (eg. Li_2SO_2 , ZrO_2 etc.) only a handful of *solids* have acceptable levels of conductivity at room temperature. They are used in a multitude of modern electrochemical devices such as solid state cells, gas sensors, thermal sensors and electrochromic devices such as 'smart' windows. The search for solid electrolytes with improved performance is still in progress.

Electrochemical cells

An electrochemical cell is an ingenious device for the controlled conversion of chemical energy into electrical energy. Mass transfer (transport) within the cell is controlled by the charge transfer (electrons) in the outside circuit.



In this study we have investigated some new solid electrolytes and cathode materials.

(a) Solid electrolytes

(1) Cuprous sulphate:

This is a Cu^{++} ion conducting solid electrolyte with a room temperature (27°C) conductivity of $5.6 \times 10^{-4} \text{ cm}^{-1}$. Arrhenius plot of $\ln(\sigma)$ vs. $1/T$ gives a good linear relationship with an activation energy of 3.1 eV. It can be prepared by reacting Cu_2O with dimethylsulphate at $\sim 100^\circ\text{C}$.

(11) Clay electrolytes:

Clay materials are usually recognized as insulators. However, it has been possible to synthesise a clay material based on Aluminium and Magnesium hydroxides with an electrolyte incorporated into the clay. The material has a high ionic conductivity at elevated temperatures (conductivity at $300^\circ\text{C} = 1.2 \times 10^{-2} \text{ cm}^{-1}$) while retaining its mechanical rigidity.

(b) Cathode materials

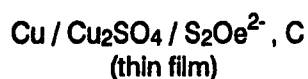
Feasibility of using persulphates as the cathode material was studied.



has a high redox potential and the half reaction does not involve the formation of gaseous products. However, since it has no conductivity, it has to be mixed with carbon powder.

Electrochemical cells

Out of the several electrochemical cells, studied during this project, the following configuration was found to be quite satisfactory.



The electrolyte is a thin film of Cu_2SO_4 on the Cu electrode.

The cell has a $V_{o,c}$ of 1.50 V and $I_{m,c}$ of 1.9 mA with a capacity of ~ 8 mA·h quite comparable with cells of similar size.

MANAGEMENT STRATEGIES FOR THE RESERVOIR FISHERIES OF SRI LANKA

U.S. Amarasinghe
Department of Zoology, University of Kelaniya.

Introduction

The extant reservoirs in Sri Lanka consists of ancient reservoirs that have been restored or rehabilitated and new reservoirs. The total surface area of different types of reservoirs is about 175,000 ha which gives a value of about 2.7 ha of water surface for every km² of Sri Lanka. With the proposals for the construction of new reservoirs, the total area of reservoirs will be over 250,000 ha giving 4 ha per km² of standing water for the country as a whole.

These reservoirs are productive biological systems and they support profitable fisheries. The total fish production in Sri Lankan reservoirs is about 30,000 metric tons which works out to over 300 kg per ha per year when compared to the average annual fish yield of 80 kg per ha in lake and reservoir fisheries in lowland areas of tropical developing countries (Oglesby, 1985), the mean production in the Sri Lankan reservoir fishery is very high.

In Sri Lanka, there are no natural lakes. As such, fish species in the indigenous fish fauna of Sri Lanka are not completely adapted to lacustrine conditions. Hence the indigenous fish species alone are said to be unable to produce high yields (Fernando and Holcik, 1982). The inland fishery of Sri Lanka which is almost entirely dependent on the magnitude of reservoir systems, is a relatively recent development after the introduction of an exotic cichlid species, *Oreochromis mossambicus* to Sri Lankan freshwaters in 1952. Fish yields in reservoirs in Sri Lanka have dramatically increased after this introduction. This trend is best exemplified in the case of the fishery of Parakrama Samudra (Fig. 1). Presently percentage contribution of *O. mossambicus* to the reservoir fishery is between 56% and 99% of the total catch (De Silva, 1988).

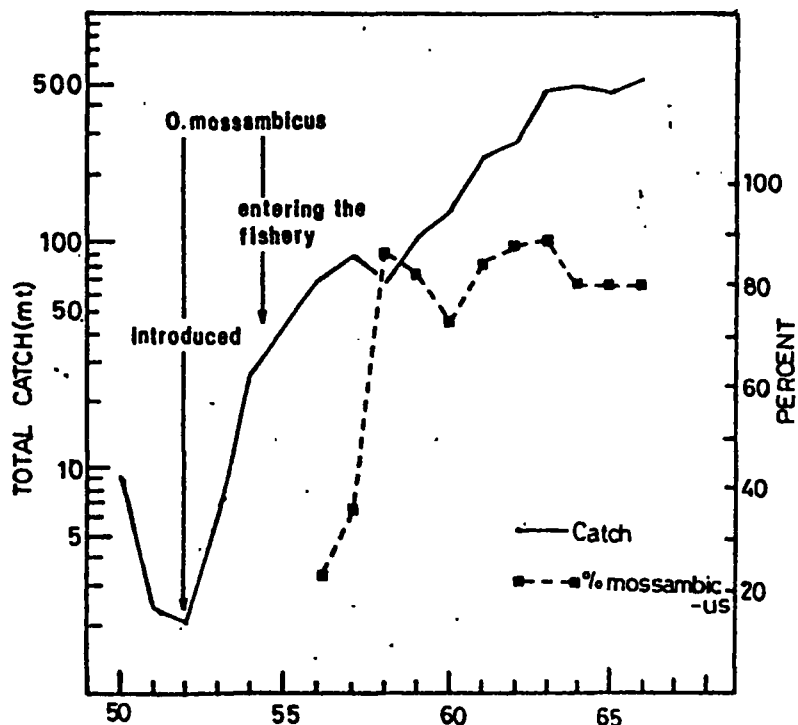


Figure 1: Development of the fishery of Parakrama Samudra (De Silva, 1988)

In the fisheries of most major perennial reservoirs, there had been nearly a three-fold increase in fishing effort within a period of six years. The overall mean effort per unit area (i.e., fishing intensity) in the reservoir fishery has increased from 0.019 crafts ha⁻¹ in 1978 to 0.050 crafts ha⁻¹ in 1984 (Fig.2: De Silva, 1988). This increase in fishing effort was mainly due to the supply of fibre glass crafts and fishing nets under a subsidy scheme.

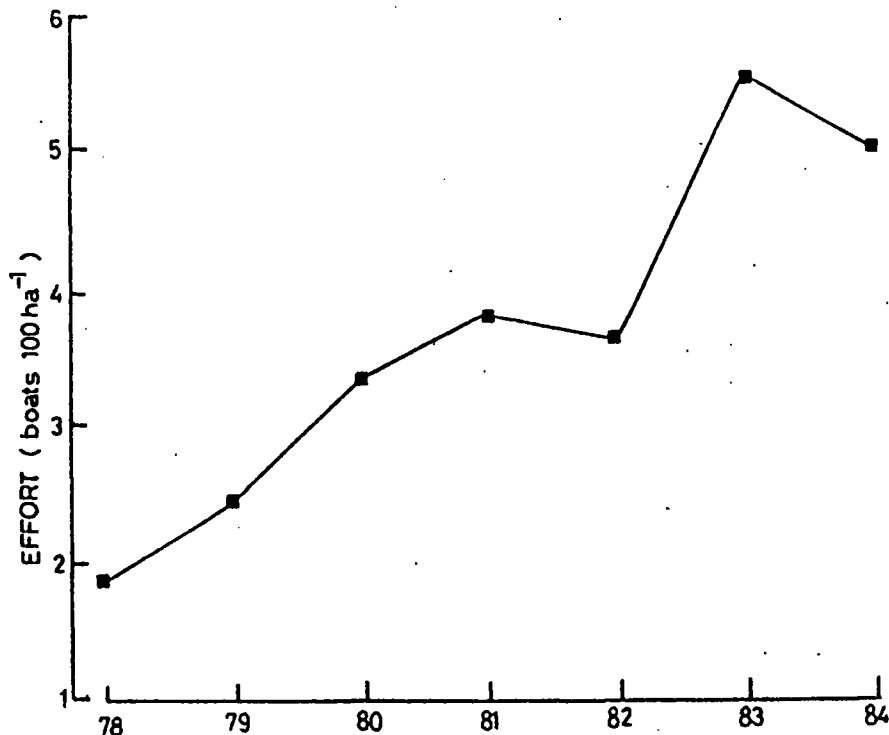


Figure 2: Changes in the mean number of boats operating in the reservoir fishery of Sri Lanka between 1978 and 1984 (De Silva, 1988).

The reservoir fishery of Sri Lanka is not managed scientifically. There is some evidence that the fish stocks in some reservoirs are over-exploited (De Silva and Fernando, 1980; Amarasinghe, 1988a). The mean landing sizes of the dominant fish species, *O. mossambicus* have declined in some reservoirs such as Parakrama Samudra (Table 1) indicating that over-exploitation takes place in the fishery.

Table 1: Declining trends in the mean landing size of *O. mossambicus* in Parakrama Samudra (Amarasinghe, 1992b). SL - Standard Length; TL - Total Length.

Year	Mean length (cm)
1957	34.2 (SL)
1964	28.4 (SL)
1966	27.2 (SL) Gillnet catches 23.2 (SL) Beach seine catches
1978	21.8 (SL)
1985-86	21.0 (TL)

Fish yields in Sri Lankan perennial reservoirs can be increased through effective management strategies. As such, the fisheries in selected perennial reservoirs were investigated with a view to developing management strategies for optimizing yields. This paper summarises the major findings of the study.

Catch and effort statistics

Number of crafts to be allocated in major reservoirs of Sri Lanka is determined by the Ministry of Fisheries depending on the official fish production figures. However the official fishery statistics in Sri Lanka seem to be unrealistic (Amarasinghe, 1992a). The average annual fish yield estimates which are based upon field studies of catch and effort for the majority of crafts actually fishing and data from the Ministry of Fisheries sources in some reservoirs (Table 2) indicate that the official data are probably over-estimates.

Table 2: Official and survey data on fish yields (kg ha⁻¹, yr⁻¹) in four Sri Lankan reservoirs. K - Kaudulla (2713 ha); M - Minneriya (2551 ha); PS - Parakrama Samudra (2262 ha); P - Pimburettewa (830 ha); * - Source: Ministry of Fisheries, Sri Lanka; a - Amarasinghe and Pitcher (1986); b - Amarasinghe and Samarakoon (1988); c - Amarasinghe (1987); d - Amarasinghe and De Silva (in press).

Year	K	M	PS	P
Official data*				
1980	287.9	197.7	507.3	618.5
1981	127.9	124.2	371.4	594.1
1982	130.8	257.5	185.9	315.9
1983	162.1	255.5	280.8	717.7
1984	415.5	258.7	171.2	884.6
1985	546.9	425.5	120.2	671.0
1986	590.3	461.0	129.0	391.7
1987	266.5	479.3	114.7	434.0
Survey data				
1982 - 83	-	-	120.0 ^a	-
1985	-	-	46.0 ^b	441.0 ^c
1986 - 89	192.0 ^d	130.0 ^d	-	-

Also in five reservoirs in southern Sri Lanka, fish production figures of the Ministry of Fisheries were 2.7 times higher than the actual fish production (Chandrasiri, 1986). As such, the inaccurate fishery statistics in the Sri Lankan reservoir fishery which are probably over-estimates, would lead to over-exploitation through the increased fishing effort above the optimal level, which result in lowering catch per unit effort and overall discouragement of true fishers who depend on the fishery for a livelihood. As such, there is a need for an effective procedure to collect more accurate fishery statistics in the reservoir fishery of the country. Accurate fishery statistical returns are useful not only for stock assessment but also for investment planning and economic analysis, and for social and nutritional studies (Caddy and Bazigos, 1985).

Collection of fishery statistics in scattered Sri Lankan reservoirs, situated in the rural areas, is rather difficult. Active involvement of fishers themselves in the submission of accurate statistics, either individually or through the co-operative societies with which they are affiliated is useful to overcome this problem (De Silva, 1988; Amarasinghe, 1992a).

In most reservoirs of Sri Lanka, fishers beat the water with wooden poles or weighted ropes to drive towards gillnets. The efficiency of this "water beating technique" is significantly higher than that of normal gillnetting (Amarasinghe and Pitcher, 1986). As such, in catch and effort surveys in reservoirs of Sri Lanka, stratification of data according to fishing methods is shown to be necessary to estimate the fish production more precisely (Amarasinghe and Pitcher, 1986; Amarasinghe and De Silva, 1992a).

Management of the capture fishery in perennial reservoirs

The present regulations for the capture fishery management in reservoirs of Sri Lanka are not scientifically determined. According to existing fishery regulations, mechanization of crafts is not allowed and seine nets cannot be operated in reservoirs. The minimum permissible mesh size for the gillnet fishery is 7.5 cm. These regulations however, are useful to an extent, to limit the fishing effort in the reservoir fishery of Sri Lanka.

Empirical models are useful for setting limits to the size of the fishery in reservoirs of Sri Lanka which are scattered throughout the dry zone of the country. Wijeyaratne and Amarasinghe (1987) have found that the Morpho-Edaphic Index (MEI or ratio of Electrical Conductivity to Mean Depth) is significantly correlated with the Maximum Sustainable Yield (MSY) in Sri Lankan reservoirs which is described by the following equation.

$$\ln \text{MSY} = 0.9005 \ln \text{MEI} + 1.922$$

Using this relationship, MSY values for several reservoirs were estimated and the actual fish yields in these reservoirs were found to be lower than MSY (Table 3).

Table 3: Maximum Sustainable Fish Yields (MSY) and actual yields in some reservoirs of Sri Lanka. Of - over fished; opt - optimally exploited. (a - Amarasinghe *et al.*, 1983; b - Wijeyaratne and Amarasinghe, 1987; c - Amarasinghe and De Silva, 1992; d - Amarasinghe and Pitcher, 1986).

Reservoir	MSY (kg, ha ⁻¹ , yr ⁻¹)	Actual Yield (kg, ha ⁻¹ , yr ⁻¹)	Remarks	Source
Badagiriya	584	362	<i>of</i>	b
Hurulu wewa	280	69	<i>of</i>	a
Kala wewa	399	187	<i>of</i>	a
Mahakanadarawa	850	102	<i>of</i>	a
Mahawilachchiya	625	588	<i>opt</i>	a
Minneriya	212	130	<i>of</i>	b,c
Muruthawela	91	16	<i>of</i>	b
Nachchaduwa	618	293	<i>of</i>	a
Nuwara wewa	546	151	<i>of</i>	a
Parakrama Samudra	228	120	<i>of</i>	b,d
Rajanganaya	404	422	<i>opt</i>	a
Tissa	896	374	<i>of</i>	b
Udukiriwela	416	36	<i>of</i>	b

Based on an analysis of catch and effort data of the fisheries of Sri Lankan reservoirs (De Silva *et al.*, 1991a), the maximum sustainable yield (MSY) is deduced to be 256 kg, ha⁻¹, yr⁻¹ and optimal fishing effort per unit area (i.e., optimal fishing intensity) is 3.2 boats, km⁻² (fig.3). The estimated MSY is lower than the present average yield of 283 - 307 kg, ha⁻¹, yr⁻¹ of the reservoir fishery of the country where the average effort per unit area (i.e., fishing intensity) is about 3.1 boats, km⁻². When the individual reservoirs are considered separately, the fisheries of most reservoirs appeared to be exploited at a sub optimal level (Fig. 4). However, when all the reservoirs are considered as a single unit on an yearly basis, rather than each reservoir as separate entity, the fishery seems to have a tendency to be over-exploited (Fig. 3).

In some reservoirs fishers practise beach seining which is illegal, sporadically. Using a multiple regression technique, an approach similar to the method employed by Marten (1979) to investigate the inshore fishery of Lake Victoria (East Africa), it has been shown that beach seining would lead to diminished returns through depletion of fish stocks (Amarasinghe and De Silva, 1992a).

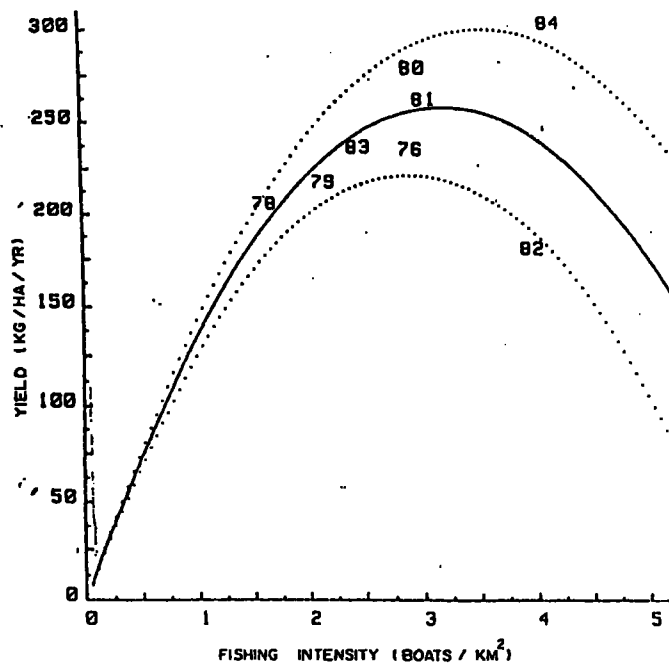


Figure 3: The relationship of the mean annual yield ($\text{kg, ha}^{-1}, \text{year}^{-1}$) to fishing effort per unit area (boats, km^{-2}) in the Sri Lankan reservoir fishery. Adopted from De Silva *et al.* (1991a).

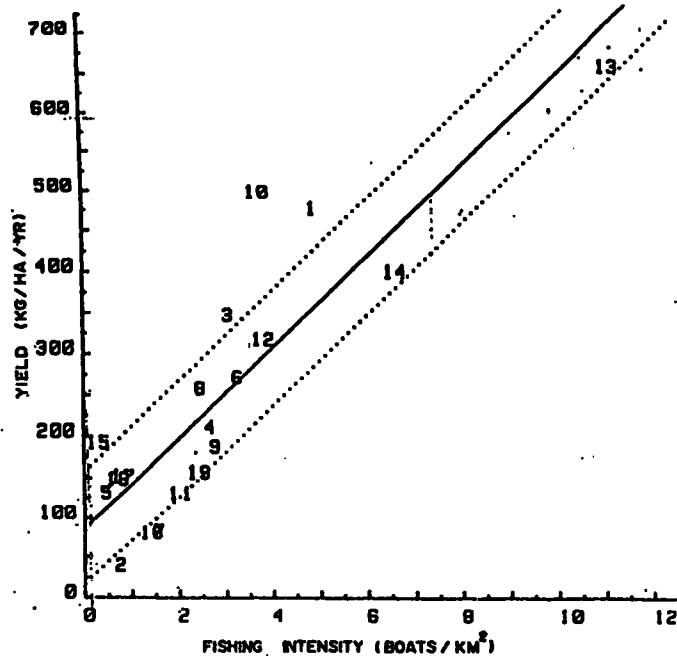


Figure 4: Relationship of the yield ($\text{kg, ha}^{-1}, \text{year}^{-1}$) to fishing effort per unit area (boats, km^{-2}) for the different reservoirs in Sri Lanka. 1 - Badagiriya; 2 - Huruluwewa; 3 - Kalawewa; 4 - Kaudulla; 5 - Lunugamwehera; 6 - Maduraoya; 7 - Mahakanadarawa; 8 - Mahawillachchiya; 9 - Minneriya; 10 - Pimburettewa; 14 - Rajanganaya; 15 - Ridiyagama; 16 - Senanayake Samudra; 17 - Udawalawe; 18 - Weerawila; 19 - Yodawewa. Adopted from De Silva *et al.* (1991a).

Stocking of perennial reservoirs to enhance the natural recruitment is another management option for the reservoir fishery in the country. In Sri Lankan major reservoirs, attempts have been made to use Chinese and Indian major carps to increase reservoir production by regular stocking during the last three decades. However, as shown in Table 4, the percentage recovery rates of Chinese and Indian carps in Sri Lankan reservoirs are very low.

Table 4: Recovery of the stocked carps in selected reservoirs of Sri Lanka. The weight of an average fish harvested has been assumed to be 3 kg. (Amarasinghe, 1992a).

Reservoir	Species	Total stocked 1983-87	Total catch (tons) 1984-88	No. of fish recovered	% recovery
Giritale (308 ha)	Bighead	365,000	89.3	29,800	8.2
	Common carp	11,000	0.5	1,700	15.5
	Mrigal	56,000	12.9	4,300	7.7
	Rohu	148,000	38.5	12,900	8.7
	Silver carp	25,000	-	-	-
Kaudulla (2713 ha)	Catla	4,000	-	-	-
	Common carp	4,000	-	-	-
	Rohu	10,000	-	-	-
Madura Oya (6280 ha)	Bighead	131,000	3.5	1,200	0.9
	Common carp	24,000	-	-	-
	Rohu	60,000	-	-	-
Minneriya (2551 ha)	Bighead	90,000	72.6	24,200	26.9
	Mrigal	34,000	10.6	3,500	10.3
	Rohu	135,000	58.2	19,400	14.4
Parakrama Samudra (2262 ha)	Bighead	64,000	-	-	-
	Catla	10,000	7.4	2,500	25.0
	Common carp	92,000	-	-	-
	Rohu	304,000	61.4	20,500	6.7
Pimburettewa (830 ha)	Bighead	6,000	-	-	-
	Catla	2,000	2.2	730	36.5
	Common carp	72,000	1.0	300	0.4
	Mrigal	128,000	2.9	1,000	6.2
	Rohu	34,000	13.5	4,500	13.2
	Silver carp	86,000	36.6	12,200	14.1

Stocking-recapture fisheries are successfully practised in some countries such as China. The stocking size of carp fingerlings in Chinese reservoirs range between 10 and 13 cm. Sophisticated methods are used for prevention of escape of fish through sluices and intake and the fishing techniques for harvesting fish are very efficient (De Silva *et al.*, 1991b). However, in Sri Lankan perennial reservoirs, the initial size of stocking is about 5 cm. Due to the limited pond space in fish breeding stations which are presently owned by the private sector, raising them upto 10 cm is practically difficult. The stocking densities of major carps in Sri Lankan major reservoirs are very low. Also, heavy natural mortality rates due to predation by carnivorous fish species in reservoirs and piscivorous birds may reduce the population sizes of carps stocked in reservoirs. However, as indicated in Table 4, in medium-sized (< 1000 ha) where higher stocking densities could be used than in larger reservoirs, fish production could perhaps be increased through stocking.

All strategies adopted to increase yield in the inland fishery should aim at providing animal protein at the lowest possible price and not providing a variety of table fish. As such establishing a stocking-recapture

fishery is not necessary in major perennial reservoirs of Sri Lanka where there is a profitable fishery based on exotic cichlids. One can suggest that yield from the stocking-recapture fishery, based on major carps could be increased by employing highly efficient fishing methods. However, such highly efficient fishing methods, as practised in Chinese reservoirs would lead to over exploitation of the cichlid fish stocks.

Recently developed length-based stock assessment methodologies (Pauly and Morgan, 1987; Sparre and Venema, 1992) have made possible to select appropriate techniques to assess exploited fish stocks in reservoirs. Consequently, dynamic pool models (Beverton and Holt, 1957, 1966) have successfully been employed to assess the exploited stocks in several reservoirs (Amarasinghe, 1987; Amarasinghe *et al.*, 1989; Amarasinghe and De Silva, 1992b). The relative yield-per-recruit values as functions of exploitation rates for different sizes at first capture for two cichlid species in Kaudulla and Minneriya reservoirs are shown in Fig. 5.

According to the yield-per-recruit analyses, the biologically optimum size of first capture of *O. mossambicus*, the dominant fish species in the country's reservoir fishery accounting for over 70% of the landings, is found to be about 20 cm total length (Amarasinghe *et al.*, 1989; Amarasinghe and De Silva, 1992b). Also, mean size of *O. mossambicus* and *O. niloticus* which is acceptable to consumer is about 24 cm total length (Amarasinghe, 1987, 1990a). The gillnet selectivity studies in Sri Lankan reservoirs (Amarasinghe, 1988b; Amarasinghe and De Silva, in press) indicate that the mesh size corresponding to the mean size of *O. mossambicus* which is acceptable to consumer (about 24 cm), is about 10 cm (Fig. 6).

Development of a subsidiary fishery for minor cyprinids

Minor cyprinids especially *Amblypharyngodon melettinus*, *Barbus dorsalis*, *B. chola* and *B. filamentous* are abundant in reservoirs of Sri Lanka (Amarasinghe, 1985). They remain unexploited as they are not caught in the gillnets of the existing fishery in which the minimum mesh size is about 7.5 cm. Also, the use of fishing gear other than gillnet is virtually impossible due to the presence of submerged tree stumps in most reservoirs. Experimental fishing trials conducted in a number of reservoirs of Sri Lanka indicated that four species of minor cyprinids which are abundant in reservoir fish fauna viz. *Amblypharyngodon melettinus*, *Barbus dorsalis*, *B. chola*, and *B. filamentous* could be exploited using 15 mm to 52 mm mesh gillnets without affecting the existing *O. mossambicus* fishery (Amarasinghe, 1985; De Silva and Sirisena, 1987). The annual potential yield of minor cyprinids in Parakrama Samudra is about 632 kg ha⁻¹ (Amarasinghe, 1990b) and in some reservoirs in southern Sri Lanka is about 900 kg ha⁻¹ (de Silva and Sirisena, 1989; see Table 5). Also small-scale fisheries for minor cyprinids are practised in some reservoirs. They have a commercial value as dried fish so that this resource is a potential supplementary source of income for fishers (Amarasinghe 1990b). However, these estimated potential yields of minor cyprinids would not perhaps be sustained once the fish populations come into equilibrium with the exploitation (Amarasinghe 1990b; Amarasinghe and De Silva, 1992c). Nevertheless fish yields in reservoirs could undoubtedly be increased by introducing a small-mesh gillnet fishery for minor cyprinids.

Table 5: Fishery potential of minor cyprinids in some reservoirs of Sri Lanka

Reservoir (ha)	Fishery Potential (kg, ha ⁻¹ , yr ⁻¹)	Authority
Badagiriya (482)	2191	De Silva and Sirisena (1989)
Lunugamwehera (3023)	635	- do -
Muruthawela (516)	35	- do -
Ridiyagama (888)	1234	- do -
Tissa wewa (234)	679	- do -
Yoda wewa (488)	688	- do -
Parakrama Samudra (2262)	632	Amarasinghe (1990b)

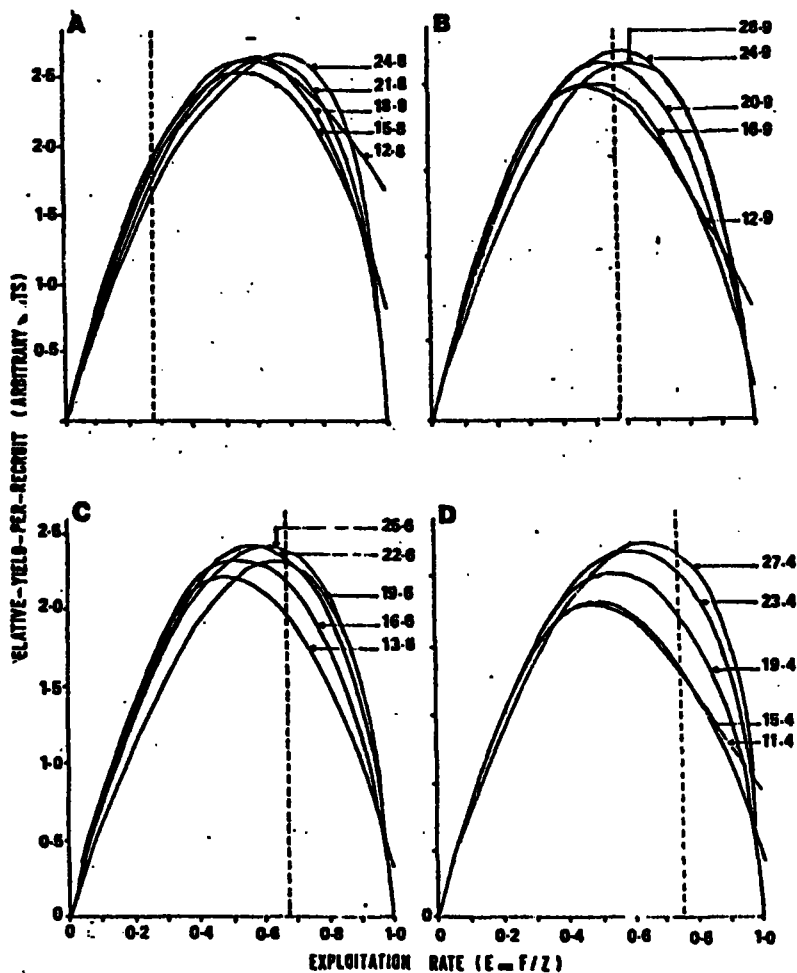


Figure 5: Relative yield-per-recruit values as functions of exploitation rates for different sizes of first capture (in cm) for two cichlid species in two Sri Lankan reservoirs. A - *O. mossambicus* in Kaudulla; B - *O. niloticus* in Kaudulla; C - *O. mossambicus* in Minneriya; D - *O. niloticus* in Minneriya (Amarasinghe and De Silva, 1992b).

Implementation of management strategies

The inland fishers could be divided into two categories, "organized" and "unorganized" and the income of "unorganized" sector is lower than that of "organized" fishers. The fishery regulations could be effectively imposed in the reservoir capture fisheries through well-organized cooperative societies of fishers (Amarasinghe, 1988c).

Present status of the inland fishery

In 1990, state patronage for the development of the inland fishery was discontinued. Under the present government policy however, no restrictions were imposed for the private sector and NGOs to develop the inland fisheries in Sri Lanka. Furthermore the Ministry of Fisheries and Aquatic Resources still continues extension work pertaining to the capture fisheries in reservoirs such as imposing fishery regulations, organizing fisheries cooperative societies, welfare activities etc. Also, research on inland fisheries and aquaculture is still carried out by the public sector.

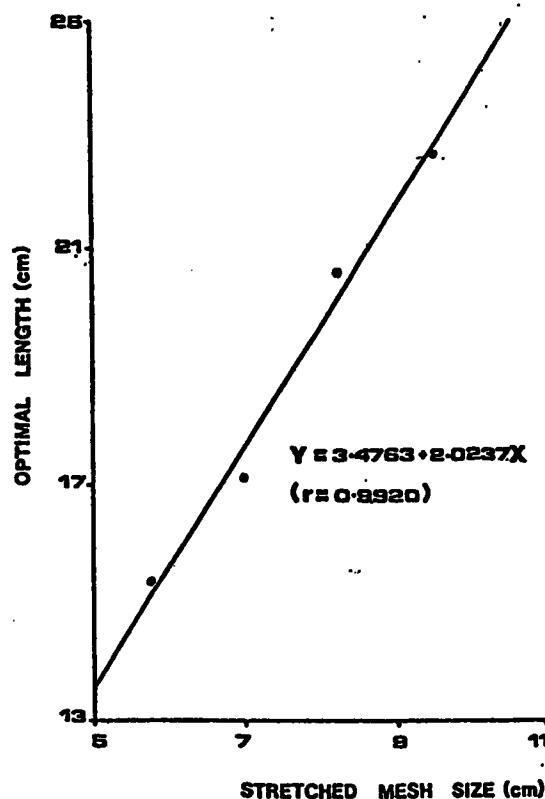


Figure 6: Relationship between the optimal length of *O. mossambicus* and the mesh size of gillnet in Parakrama Samudra (Amarasinghe, 1988b).

Despite the absence of state patronage for the development of the inland fisheries in Sri Lanka, the inland fishers in the dry zone are exclusively engaged in fishing in major reservoirs. This is due to the vital importance of the reservoir fishery as a cheap animal protein source for rural communities.

As indicated above, stocking of fingerlings of non-tropical carps cannot be considered as an effective management strategy when the reservoir fishery of the country is considered as a whole. However, Chandrasoma (1992) indicated that *Labeo rohita* stocked in three perennial reservoirs of Sri Lanka gave high financial rates of return. Also fish stocks in most reservoirs are over-exploited or sub-optimally exploited so that any increase in fishing effort might be detrimental to the fishery. Under the present government policy, stocking of fish fingerlings and providing crafts and nets under subsidy schemes have been discontinued. Since stocking of fish fingerlings and increasing fishing effort are not effective management options for the reservoir fishery of Sri Lanka, it is unlikely that the present government policy would have a negative impact on the fishery.

On the other hand, the present government policy has adversely affected the development of aquaculture in seasonal tanks. However there is a potential that aquaculture in seasonal tanks could be developed through private sector by adopting an approach where private enterprises and farmers can enter into an agreement to raise fish under a buy-back scheme (Amarasinghe, 1992a). Such a system is in operation in agricultural sector in which farmers cultivate crops for export and raise poultry where farmers are provided with the inputs and technical advice and then produce is purchased by entrepreneurs at the end of the growing period.

Management strategy

In the dry zone of Sri Lanka, the life styles of the rural communities are significantly dependent on the reservoirs. As such, strategies for the reservoir fishery development in the country should be viewed from the context of rural development. The management plans for inland capture and culture fisheries could be implemented effectively only when the aspirations of the rural communities are identified through socio-economic studies (Amarasinghe, 1988c, 1990a). As such, the research on the development of inland fisheries in Sri Lanka should be deviated from the conventional resource-oriented approaches to the integrated approaches which consider resource component as well as the social component which makes use of the resource. On the basis of the findings of the study, an effective management strategy for the reservoir fishery of Sri Lanka can be presented in the form of a flow-diagram (Fig. 7). This approach for the management of the fishery of Minneriya reservoir is presently being implemented by the Central Environmental Authority, Sri Lanka under a wetland conservation project.

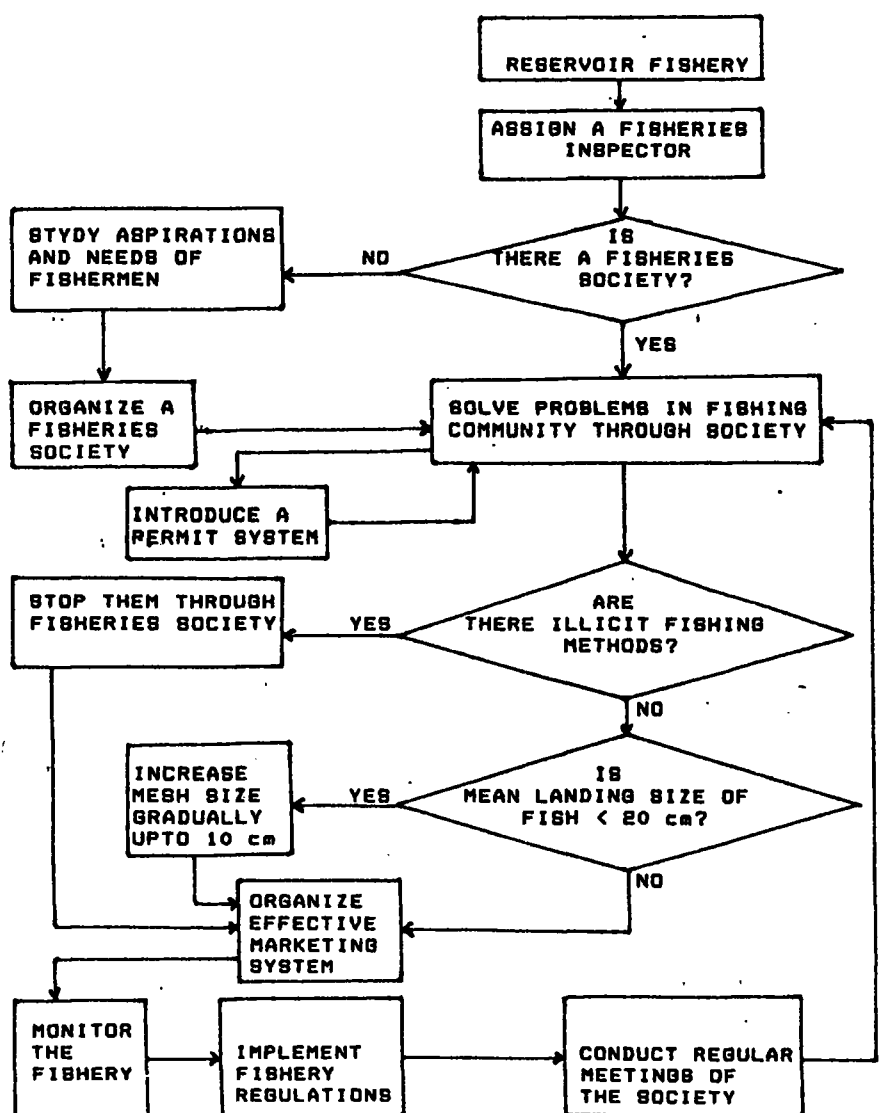


Figure 7: Diagrammatic representation of the management strategy for the reservoir fishery of Sri Lanka.

COASTAL ENVIRONMENTAL RESEARCH PROGRAMME - AN OVERVIEW

Pauline Dayaratne
National Aquatic Resources Agency (NARA).

Introduction

The coastal environmental research programme was designed to address the issues related to the coastal environment through several research projects carried out along the coast of Sri Lanka. In addition to providing the science and technology related to exploration and exploitation of the coastal resources, this programme also aims to get a deeper understanding of the nature and the functioning of the coastal ecosystem. As the increase in human activities in the coastal areas are contributing to the degradation of the very resources that has attracted the migration of people to these areas, the socio-economic component in some of these projects will give a deeper understanding of the socio-economic status of the communities that depend on these resources for their living. The critical habitats such as coral reefs are destroyed at an alarming rate due to mining, use of destructive fishing gear, collection of organisms especially due to the developing ornamental fish trade, due to water pollution including sedimentation etc. The other critical habitats such as mangroves, seagrass beds, salt marshes and mud flats are also destroyed at a significant rate due to human as well as developmental activities. The estuaries and lagoons are the key habitat for a number of marine organisms. All these habitats are extremely productive ecosystems forming internal links between land and sea and if correctly managed are of great value for the coastal population. The projects under this programme are all oriented towards coastal and estuarine research and aim to describe and quantify the interrelationships between important coastal ecosystems and the quality and productivity of the coastal zone. Through the research projects under this programme it is intended to get the appropriate knowledge necessary for the management of these systems.

This programme is funded by the Swedish Agency for Research Cooperation with Developing Countries (SAREC) and is implemented through the Natural Resources, Energy & Science Authority (NARESA) of Sri Lanka. The projects are carried out by the Sri Lankan Institutions with the fullest participation of the Sri Lankan Scientists. The projects are also designed around the training needs of the country so as to use as much as possible the identified training areas and available expertise keeping always in mind the goal of strengthening the scientific capability of the country.

Organization and execution of the programme

There are 6 research projects (Table 1) under the programme which are executed by the following government agencies.

1. National Aquatic Resources Research & Development Agency (NARA)
2. Department of Zoology, University of Sri Jayewardenapura
3. Department of Fisheries Biology, University of Ruhuna

The organization of the programme is given in the flow chart (Fig.1). The research and the Advisory Committee consisting of the following members, closely monitor and coordinate the activities of the programme on the Sri Lanka side.

1. Director General (NARESA) (Chairman)
2. Director General (NARA) (Alternate Chairman)
3. NARESA representative (Secretary)
4. Team Leaders of the respective projects
5. One representative from the Coast Conservation Department

Table 1 : List of projects under the coastal environment research cooperation programme

No. Project Title	Institute	Principal Researcher
1. Study of the Puttalam/Mundal estuarine system and associated coastal and estuarine water.	NARA	Dr P. Dayaratne
2. Survey of coral reefs of Sri Lanka.	NARA	Mr A. Rajasuriya
3. Study of two important river system in Sri Lanka with respect to pollutant transport into the coastal region.	NARA	Dr P. De Alwis
4. Recruitment and distribution of <i>Anguilla bicolor nebulosa</i> in Sri Lankan estuaries and river systems.	University of Ruhuna	Dr D.R.T. Kumaranatunga
5. Significance of estuaries for the recruitment of marine and fresh water prawns.	University of Sri Jayewardenapura	Dr J. Jinadasa
6. Biology of the clams in the Negombo lagoon.	University of Sri Jayewardenapura	Dr J. Jinadasa

There are paralled research projects carried out by the scientists of the Swedish Research Institutions mentioned in Figure 1.

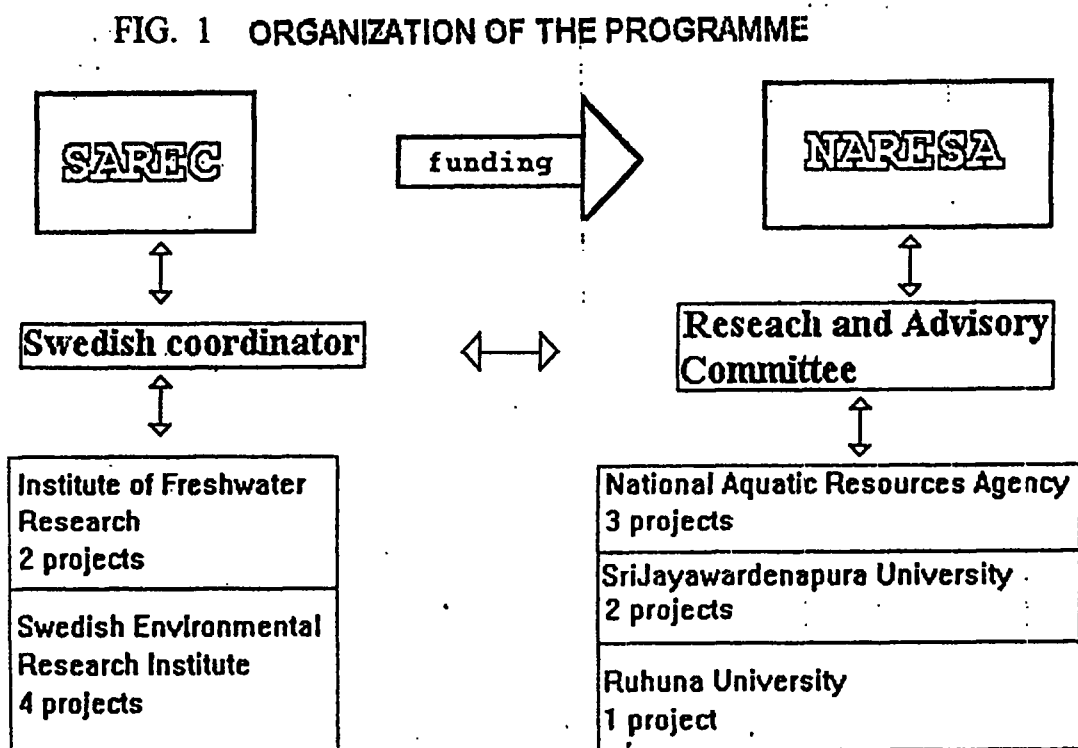


Figure 1: Organization of the programme

The coastal environmental research programme is a five year programme which was to commence in 1989. Due to unavoidable circumstances the programme got delayed for about one year and the research work of the projects under this programme commenced its activities in mid 1990. The first phase of the programme was completed after 2 years in July 1992 and the 2nd phase of the programme is ongoing. The programme is now scheduled to terminate by mid 1995.

Brief description of the projects carried out under this programme

Project No. SAREC/19/CE-01

Title: Study of the Puttalam/Mundal estuarine system and associated coastal and estuarine waters.

This is a multidisciplinary study carried out by several technical divisions of NARA covering inter-related fields such as capture fisheries, socio-economics, aquaculture, water quality and physical oceanography. The main objective of this study is to enhance the capabilities of NARA in conducting multidisciplinary research in the related fields and to prepare an integrated resources management plan for the study area.

Detailed research surveys were carried out under this project to collect the scientific information and to get the knowledge necessary to address the management issues in the area. Several research papers have already been published using the information collected under this project (Annex 1). This project provided opportunities for NARA officers to register for postgraduate degrees at the local as well as foreign universities. A total of 6 M.Phil degrees 3 in the field of Fisheries Biology, 1 in Fisheries Ecology and 2 in Physical Oceanography and two Ph.Ds in Physical Oceanography are expected as outputs of this project.

Training opportunities were provided to scientists of NARA in the fields of coastal resources management, physical oceanography and tropical fisheries data collection analysis. Opportunities were also provided to the scientists working for the project to present parts of the research studies at international conferences. The local scientists also got on the job training through the collaborative work carried out with the Swedish counterpart staff. The studies on plankton and productivity, physical oceanography and nutrient studies are among these.

Project No. SAREC/19/CE-02

Title: Survey of coastal reefs of Sri Lanka

The main objectives of this study were;

- * to inventorise all major reefs within the north-west, south-west and south coastal waters of Sri Lanka
- * to study the species distribution and composition
- * to study the ecology and state of health of some selected reefs
- * to determine the socio-economic links between the reef and the human communities depending on them
and
- * to determine the resources potential of the reef.

The research work carried out under this project has led to the declaration of a marine sanctuary at the Bar reef off Kandakuliya in April 1992. During this study five species of Hermatypic corals new to Sri Lanka, one of which is a new genus for Sri Lanka, were discovered.

A detailed study of the three adjacent reef systems in the north-west in Bar reef, Kandakuliya reef and the reef at Thalawila was carried out. The socio-economic study component of the project SAREC/19/CE-01 also covered the coral reef fishing communities. At present these reefs are threatened by the ornamental fish collectors who use destructive methods in collecting ornamental fish and other invertebrates and are also destroyed by the Crown of Thorn star fish *Acanthaster planci*. Research papers published so far under this project is given in Annex 11.

Project No. SAREC/19/CE-03

Title: Study of two important river systems in Sri Lanka with respect to pollutant transport into coastal region.

The two rivers Kelani Ganga and Kalu Ganga have been selected for the riverine input into coastal zones. Kelani Ganga is heavily polluted by industrial waste from the 'Free Trade Zone' where a large number of Petro-chemical, chemical, textile, mechanical and leather industries are located. Municipal sewage from Colombo is also released into this river. Kalu Ganga on the other hand is considered relatively unpolluted. However the pesticides and fertilizers from the agricultural land upstreams of both these rivers can affect the water quality. This was a three year project which commenced about 1 year later than the two previous projects and the collection of data on the water quality at Kalu Ganga and Kelani Ganga has now been completed.

Several Physico-chemical parameters such as oxygen, salinity, BOD, phosphate, nitrate, nutrients etc. have been studied to ascertain the nutrient levels and nature of organic pollutants. Fish samples have been collected to study the levels of pesticide in fish.

Project No. SAREC/19/CE-04

Title: Recruitment and distribution of *Anguilla bicolor* and *Anguilla nebulosa* in Sri Lanka estuaries and river systems.

The area selected for this study was the Malala river system covering the Mahagala wewa, Pahala Andara wewa, Ranmudu wewa, Kudabagiri wewa, Badagiri wewa and Mahala lagoon of the Hambantota district and the Garaduwa lagoon system covering the Ganduwa lagoon and Thalaramba stream in the Matara District.

Detailed biological studies on *A. bicolor* and *A. nebulosa* such as length/weight relationship, morphometric characters, gonadosomatic index and otolith studies have been carried out so far. Histological studies and chemical analysis with liver and thyroid have been carried out to analyse protein and lipid contents.

Three research papers and one M.Phil thesis is under preparation.

Project No. SAREC/19/CE-05

Title: Significance of estuaries for the recruitment of Freshwater and Marine Prawns.

The major study area selected for this project was the Bolgoda lagoon and Negombo lagoon. Samples have been collected from other localities such as Weligama, Rekawa and Kirinda for comparison. Traps were used to collect the fish samples. Electrophoresis studies have been carried out for the stock identification of prawns. These studies have revealed that prawn species collected from the mouth, middle and head end of the Bolgoda lagoon belong to one population. The mark-recapture data and the other marking techniques used to study the migration of penaeid prawns *Metapenaeus ensis* in the Bolgoda lagoon was not successful. 4 species of *Penaeus* spp and one *Metapenaeus* spp. were identified from the Negombo lagoon and Bolgoda lagoon and 3 spp. of *Metapenaeus* spp. and *Macrobrachium rosenburgii* were identified from the feeding canals of the Bolgoda lagoon.

Project No. SAREC/19/CE-06

Title: Distribution and Biology of clams in Negombo lagoon

The main objective of this project was to study the distribution of the clam species according to habitat in the Negombo lagoon and to study the population dynamics of the major clam species.

Sampling was carried out twice a month at Kurana, Liyanagemulla, Kapungoda, Dungalpitiya and Thaladuwa. 1 sq.m. quadrates were used to do the sampling. Parameter studies were dissolved oxygen, temperature, salinity and the length/weight of the clams. Four species of clams were identified upto a depth of 12 cm. They are:

Meretrix casta (20-35) with a wide distribute living in sandy soil. 75% of the shell used for limestone.

Metrix lusora - Found only at the mouth of the lagoon when the salinity is high.

Gelonia coxhas (35 - 100 mm) - Abundant only in mud soil.

Gaffrarium tumidum (44 - 75 mm) - Found at the mouth of the lagoon with high salinity.

Acknowledgement

The author wishes to thank NARESA for giving this opportunity to present an overview of the coastal environmental programme and for providing the information about the research projects. The assistance given by the team leaders of the respective projects under this programme during the preparation of this document is highly appreciated.

Remarks

The author as the leader of the project SAREC/19/CE-01 had all the information on this project. The information on all the other projects were provided by NARESA to prepare this overview.

Annex 1 - List of the research papers published under SAREC/19/CE-01

1. **Alwis, M.M.** Study of fisheries, fishery resources and plankton of Puttalam estuary, Sri Lanka. (Abstract) NARA/NARESA/SAREC Workshop on coastal eco-system study programme 8th and 9th Sept. 1992.
2. **Gunaratne, A.B.A.K.** Present status of finfish fishery of Mundel Lake, Sri Lanka. (Abstract) NARA/NARESA/SAREC Workshop on coastal eco-system study programme 8th and 9th Sept. 1992.
3. **Corea, A.S.L.E.** Environmental impact of shrimp farming on the water quality of Dutch Canal, Sri Lanka. (Abstract) NARA/NARESA/SAREC Workshop on coastal eco-system study programme 8th and 9th Sept. 1992.
4. **De Alwis, P. and Abesirigunawardena U.** Studies on nutrient aspects of the Puttalam Lagoon, Sri Lanka. (Abstract) NARA/NARESA/SAREC Workshop on coastal eco-system study programme 8th and 9th Sept. 1992.
5. **Arulanathan, K.** Some studies on tidal water volume exchange in the Puttalam estuarine system, Sri Lanka. (Abstract) NARA/NARESA/SAREC Workshop on coastal eco-system study programme 8th and 9th Sept. 1992.

6. **Selladurai, M.** Studies on the fluctuation of flushing time and salinity in the Negombo lagoon, Sri Lanka. (Abstract) NARA/NARESA/SAREC Workshop on coastal eco-system study programme 8th and 9th Sept. 1992. Ed. P. Dayaratne and N.P. Wijayananda.
7. **Wijeratne, E.M.S.** Studies on tidal oscillation and volume flux in the Puttalam lagoon, Sri Lanka. (Abstract) NARA/NARESA/SAREC Workshop on coastal eco-system study programme 8th and 9th Sept. 1992. Ed. P. Dayaratne and N.P. Wijayananda.
8. **Wijeratne, E.M.S., Arulanathan, K. and Wijayananda, N.P.** Sea level fluctuations in the Kalpitiya lagoon. (Abstract) Sri Lanka Association for the Advancement of Science 48th Annual Session 7th - 11th December, 1992.
9. **Alwis, M.M. and Dayaratne P.** (1992). Finfish and shellfish resources utilization of Puttalam estuary, in the North Western province of Sri Lanka. Paper presented at the 3rd Asian Fisheries Forum held in Singapore from Oct. 26 - 30.
10. **Jayawardena, P.A.A.T. and Dayaratne P.** (1992). Present status of the trawler fishery around Kalpitiya in the North Western provinces of Sri Lanka. Paper presented at the 4th Asian Fisheries Forum held in Singapore from Oct. 26 - 30.
11. **Gunaratne, A.B.A.K.** Present Status of Mundel Lake Fishery in Sri Lanka. (Abstract) NARA/NARESA/SAREC Workshop on Coastal Eco-system study programme 8th and 9th Sept. 1992. Ed. P. Dayaratne and N.P. Wijayananda.

Annex II - List of research papers published under SAREC/19/CE-02

Present status of coral reefs in Sri Lanka (Conference on the protection of sensitive sea areas, held in Malmo Sweden in 1991). Published in the proceedings.

Status of Coral Reefs in the Northwestern, Western and Southern Coastal areas of Sri Lanka (Presented at the Colloquium on Global Aspects of coral Reefs, held in Miami 1993). (Proceedings will be published later).

Distribution of Butterfly fish (Family : Chaetodontidae) on Reefs in the west coast of Sri Lanka (Annual Scientific Sessions of NARA, 1993, to be published later).

Human disturbances on coral reefs in Sri Lanka, A case study. (Published in AMBIO Nov. 1993).

THE SAREC/NARESA BUFFALO RESEARCH PROGRAMME

Dr S.S.E. Ranawana
Veterinary Research Institute, Gannoruwa, Peradeniya

Summary

Although water buffaloes have played an important role in the rural economy of Asian villages from ancient times, until recently, they have received little scientific attention. In Sri Lanka, early research was supported mainly by the IAEA through its regional programmes. Organized and planned research on water buffaloes in Sri Lanka really began with a Workshop held in 1980 in Peradeniya. At this Workshop information available up to that time was presented by the scientists who had gathered for the meeting who then proceeded to identify the research needs. This Workshop and the Research programme that followed were sponsored by the Swedish Agency for Research Cooperation with Developing Countries (SAREC). This programme which attracted scientists from many disciplines went on to a second and third phase which were also funded by SAREC.

The research has been conducted at three levels which correspond roughly to the three funding stages. In the first, baseline information was generated on the present systems of buffalo rearing in the country including information on aspects such as breeding and reproduction, utilization, disease prevalence and feeding. At the next level, research was carried out on biological processes and the pathology of disease processes which provided the basic information for the next stage, that of manipulating the animals and the systems for maximum production. The third stage, which is being carried out now hopes to incorporate research findings into more productive, alternate systems based on current situations.

The studies have shown that buffaloes are still important for farm power chiefly for paddy cultivation and that they are increasingly being used for milk production. The major constraints to buffalo farming have also been identified and, in some cases, solutions were found. The challenge today is to establish systems of buffalo farming which whilst being more productive in terms of milk, work (and meat), must also be sustainable in the more intensive systems of land use found in most parts of the country and in particular the Dry Zone. The project has generated the data needed to meet this challenge and such systems are in fact being tested today.

Apart from generating data, the programme has also supported the training of a considerable number of researchers at both Masters and Doctoral levels. Through a short-term Fellowship scheme of training, new techniques and technologies have been introduced. SAREC has also helped to build-up infrastructure including the establishment of research farms and modern laboratory facilities all of which will have a lasting influence on Veterinary and Animal Science Research in Sri Lanka.

The Buffalo Research Programme, an overview

Buffaloes were first domesticated in Asia more than 5000 years ago and even today, over 90% are found in this region. In Sri Lanka, fossil records indicate their presence from prehistoric times. The ancient chronicles carry detailed references to their use for a variety of purposes. They remain part of the rural landscape in Sri Lanka together with the tank and the Dagoba.

In Sri Lanka and its Asian neighbours, buffaloes have been used primarily for activities connected with the cultivation of the Asian staple, rice. Their popularity for this purpose stems, no doubt from their strength and stamina, suitability for working in deep mud, an ability more than cattle to subsist on very poor grazing land and a relative freedom from disease. Despite their importance to the rural economy on small farms in Asia, or possibly because they are largely confined to Asia, till very recently little research attention was paid to them. It is only in the last 15 years or so that major research projects to study buffaloes have been launched in Asian countries.

In Sri Lanka, serious research on the water buffalo dates back about 12 years. The Swedish Agency for Research Corporation with Developing Countries, SAREC (to use their Swedish acronym), have supported research on buffaloes for much of this time. Initial contacts with SAREC were made by Dr. Oswin Perera, now with the IAEA in Vienna, who was given a grant by SAREC to carry out a survey on conditions prevailing on small buffalo farms in Sri Lanka with special emphasis on reproduction which was Dr. Perera's primary interest. He and Dr LNA de Silva, presently in the Faculty of Veterinary Medicine, studied more than 11,000 animals in paddy farms over several years in many parts of the Island. They published their findings in a document that remains today the basic reference on the management of indigenous buffaloes on these small farms. Due, no doubt to the excellence of their work, SAREC indicated their willingness to support a major research programme on water buffaloes.

As a first step, it was decided to hold a workshop with the following objectives:

- review the information available on the water buffalo in Sri Lanka
- discuss these findings
- prepare a list of research priorities

Accordingly, all those who had information on buffaloes were invited to present papers at the workshop which was held from 24-28 November, 1980. In addition, others in the country who were involved or interested in buffalo development activities were invited to participate in the discussions. As a result, we had a wide range of papers from studies on management and utilization to those on draught power, nutrition, physiology, reproduction, disease and even a paper on the behaviour of wild buffaloes in the Ruhuna National Park. Each paper was followed by a lively discussion. The last two days were spent in preparing a list of priority areas for research. The papers, discussions and recommendations for research were published by SAREC as Sarec Report 3, in 1982 and included a list of recommended research priorities. This publication, being one of the first from the region on buffaloes, has been widely read and quoted and has also brought International attention to the research work being carried out on buffaloes in Sri Lanka.

The research programme got underway in 1983 with funds from SAREC within the administrative and financial control of NARESA. The projects were evaluated and monitored by a research and Advisory Committee appointed by NARESA, which consisted entirely of working scientists. SAREC provided the guidance, funds and was receptive to any other requests that we made. In this connection, at our request, they set up common funds to deal with some of the constraints peculiar to research workers in Sri Lanka. These were,

- an urgent spare parts fund
- a reprint service
- an international contacts fund
- training in specialized techniques

Aside from this, SAREC adopted a healthy attitude of allowing us "to get on with the job" with minimum interference, an attitude which no doubt contributed to the success of the project.

In addition, when the need was pointed out, SAREC, agreed to support the development of two research farms. The need for these arose from the fact that at that time there were no farms with indigenous buffaloes and that the project envisaged doing research mainly on Lanka animals. A small farm with 40 animals was developed, accordingly, at Mawala on a University property. This farm was meant for more intensive work with fewer animals. It took longer to find a suitable site for the large farm. Eventually what has now turned out to be an ideal site was found on a property belonging to the National Livestock Development Board at Kullyapitiya. With the help of SAREC and using local resources to some extent, this farm has now been developed into an excellent field station for research on indigenous buffaloes. Whilst thanking the NLDB for their enthusiastic cooperation in this project, I hope that in these more commercial days, they will continue to realize the importance of this station.

Nineteen individual research projects in the following areas were initially approved:

- physiology and nutrition(4)
- reproduction(2)
- management, draught and genetics(4)
- diseases and their control(9)

The research work was commenced in 1983. A few of the original projects dropped out mainly due to the scientists concerned leaving the country. At the same time several others joined the programme. We were particularly gratified to have two projects on socioeconomic aspects of buffalo production the inclusion of which made the programme a well-balanced, multidisciplinary programme. Several interim Review Seminars were held during the first five years, at which the scientists presented and discussed the results generated by their experimentation.

As the first phase of the project neared completion and before the next phase was commenced, it seemed an appropriate time to review the work done. Accordingly, A Symposium was organized which had as its objectives, to:

- present results of research on the water buffalo since 1980
- invite selected scientists from the region to present papers on buffalo research
- involve research workers, invited scientists and others associated with buffalo development in a discussion
- to review this phase of the programme- to publish the proceedings

Accordingly, we invited to the meeting, which was held on 7-10th March, 1989, all those who could contribute and those that could have benefited from the papers and discussions. The first session in fact, was set aside to a description of the buffalo development activities of the three main state agencies, DAPH, MASL & NLDB, involved. We believed that this session set the stage for the research papers that followed so that the discussions bore a relationship to actual buffalo development activities and not taken in isolation.

Before I go on to a brief description of the next phases of the buffalo research programme, it would be appropriate to describe the present situation with respect to water buffaloes in Sri Lanka. Buffaloes in Sri Lanka have traditionally been managed very simply with minimum inputs of time or money by farmers. In the dry zone they are allowed to graze free in communal herds on natural pastures and are normally not supplemented. Once or twice a year, they are rounded up and used for work. After paddy is cultivated, they may even be driven off into the jungle in some areas. This situation is now changing rapidly in many areas of the dry zone with the advent of several large-scale irrigation and settlement schemes. No longer are the wide tracts of natural pasture available since land use under these schemes is much more intensive. Farmers are being asked to keep fewer animals and to rear them more intensively. Farmers will then have to spend more time and money on their animals and we cannot expect them to do so unless they get an additional return from them. The very survival of buffaloes in these areas, therefore, appears to be under threat. Continued use of buffaloes under these changing conditions will depend on the successful development of intensive systems of management which will be economically viable.

Such intensive systems with cross bred buffaloes that produce more milk than the indigenous variety could be viable particularly if the milk is converted to value-added products such as curd. Complete management, feeding, breeding and disease control packages needed to be developed and tested. The information generated by the first phase of the programme was generally adequate to set up such units in a scientific manner. Several other challenges were posed by these proposed systems. Management of buffaloes will need, for example, to take into account their different environmental physiology. Feeding will have to be based on agroindustrial by-products available in the area. Breeding will pose a major challenge and may have to be by Artificial Insemination. A total package of disease prevention based on the research done will have to be formulated.

When allocating funds and identifying individual projects for the next phases of the Buffalo Research Programme, these changing needs of buffalo farming in country had to be taken into account. The main thrust had to be the setting up and monitoring of intensive systems while each research projects should serve to fill gaps in our present knowledge and to further improve and refine them.

From a large number of applications received, a total of 33 individual research projects were approved for the 2nd phase of the programme. These include projects on:

- Development of intensive systems(2)
- Reproduction(6)
- Breeding(4)
- Curd Technology(2)
- Physiology & Nutrition(6)
- Diseases(7)
- Miscellaneous including socioeconomic(6)

The inclusion of projects on socioeconomic studies, on the technology of curd making and others made this next phase a well- balanced, multidisciplinary programme. The major area not represented was the study of draught although the current project in this area was expected to continue. A proportion of the Phase II projects were continued from the first stage whilst some were new. In addition to funds for individual projects, the farms and the ancillary support, SAREC also provided in this stage some common facilities, namely, computers and vehicles as these had been identified as constraints. It must also be stated that the unprecedented disturbances that prevailed in Sri Lanka for several years affected, like everything else, the research work under the BRP.

Funds under the 3rd Phase of the Buffalo Research Programme was given out for 25 individual projects which included 2 on Breeding and Reproduction, 6 on health, 7 on Management and Utilization and 10 on Physiology and Nutrition. As in Phase 2 the most funds were given to a project that hopes to develop an intensive system for dual- purpose buffaloes using information generated by scientists in different fields.

Overall, the Buffalo Research Programme has funded 74 individual projects although some of them have been continuations of earlier ones. A breakdown by category and discipline is shown in the Table below:

Table: A summary of research projects carried out under the SAREC Buffalo Research programme - by discipline.

Category	Discipline	Number	Total
Breeding & Reproduction	Breeding	3	
	Reproduction	10	13
Physiology & Nutrition	Physiology	11	
	Nutrition	7	18
Health	Bacteriology	5	
	Parasitology	6	
	Virology	3	
	Pharmacology	2	
	Toxicology	1	
	Pathology	4	21
Management & Utilization	Management	7	
	Socio-economic	6	
	Utilization	9	22
	Total	74	

The research has been conducted at three levels which correspond roughly to the three funding stages. In the first, baseline information was generated on the present systems of buffalo rearing in the country including information on aspects such as breeding and reproduction, utilization, disease prevalence and feeding. At the next level, research was carried out on biological processes and the pathology of disease processes which provided the basic information for the next stage, that of manipulating the animals and the systems for maximum production. The third stage, which is being carried out now hopes to incorporate research findings into more productive, alternate systems based on current situations.

The studies have shown that buffaloes are still important for farm power chiefly for paddy cultivation and that they are increasingly being used for milk production. The major constraints to buffalo farming have also been identified and, in some cases, solutions were found. The challenge today is to establish systems of buffalo farming which whilst being more productive in terms of milk, work (and meat), must also be sustainable in the more intensive systems of land use found in most parts of the country and in particular the Dry Zone. The project has generated the data needed to meet this challenge and such systems are in fact being tested today.

At this stage, it is necessary to ask, were the original objectives achieved? The answer, as always, is in some ways yes and in some ways no. It is pertinent to examine the reasons why all the objectives could not be achieved. Firstly, a lack of suitably qualified personnel in all the fields identified; examples are areas such as Genetics and Draught. Secondly, due to many of the scientists concerned leaving the country. Thirdly, due to the generally disturbed conditions in the country at large which certainly affected some of the field projects. It must also be remembered that each scientist has a particular area of expertise or experience in which he or she usually likes to work. This may not be identical to those identified as research priorities at the Workshop in 1980. Finally, one has also to consider what is practically possible under the conditions in a country such as Sri Lanka where the research infrastructure and support is much less developed than in the West.

Nevertheless, much has been achieved. The research work that has been carried out will be or has been published. Although some of the projects are as yet incomplete, interim results have been written up as papers, presentations at meetings both here and abroad and as theses. Apart from the publications in the scientific press, a monograph embodying the results of research on the Water Buffalo in Sri Lanka was published as part of a NARESA Series. This booklet was aimed at students and teachers at high school level as well as extension workers and the interested public. In addition, several research students have been trained both at Masters and Doctorate levels, this being a major objective of the programme. Research infrastructure has been built-up both by way of farm facilities as well as laboratory equipment. The short-term Fellowship programme has resulted in the introduction and establishment of new technologies and several new techniques both of which have enhanced the research-related services such as diagnostic, clinical and advisory services. It could be argued that in the field of scientific research in Sri Lanka, this programme has been unique in several ways. It has brought together scientists from different disciplines to carry out both basic and applied research directed towards an area of immediate importance to the rural economy and to rural agriculture.

We hope that by the end of the current phase of the programme, that intensive buffalo systems suitable for farmers will have been developed so that farmers will begin to benefit from the research work. This should lead to increased productivity from buffaloes in Sri Lanka in terms of work, milk and even meat, such increased production being the ultimate objective of any agricultural research programme.

Acknowledgement

This presentation would not be complete if I did not mention the quiet but crucial support provided by two individuals without whom even what was achieved would not have been possible. These are Dr Carl Thornstrom of SAREC who visited every year and showed a personal interest in the Programme and Mr MAT de Silva of NARESA who was associated with the project from its inception.