NATIONAL SURVEY OF RESEARCH AND DEVELOPMENT IN SRI LANKA 1996

Compiled by
Ms C. M. Fernando, M.Sc.
Mr W. Amaradasa, M.Sc.

Natural Resources Energy and Science Authority
47/5, Maitland Place
Colombo 07

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PREFACE

This report was compiled for the Natural Resources Energy and Science Authority of Sri Lanka on the direction of Prof. Priyani Soysa, Director General, NARESA.

The report is based on the data gathered in a questionnaire-based national survey of all organizations in the state, university and private sectors, engaged in Scientific and Technological activities (STA), which was conducted in 1996/97 by the S&T policy unit of NARESA.

This is the third in a series of surveys initiated by NARESA (formerly NSC) to fulfill it's mandate to collect data on Research and Development (R&D) Expenditure and Scientific and Technical Personnel (STP) and to advise the Minister of Science & Technology on the current status of STA in Sri Lanka. The data presented in this report highlights trends in the flow of R&D expenditure and the utilization of scientific and technical personnel, which could be a crucial input to formulation and implementation of a national science policy.

The definitions and methods used conformed to internationally accepted OECD and UNESCO guidelines to facilitate national and international comparability. Since the two previous national surveys were based on the classifications recommended by UNESCO in 1978, the latest sectoral classification system adopted in the revised Frascati Manual (1993) was not utilized in this survey in order to maintain comparability over time.

We wish to thank the heads and staff members of all the respondent organizations - universities, research institutions, government departments and private sector firms including banks for their invaluable co-operation, which is an essential pre-requisite for the successful completion of a national study of this nature.

We are indebted to Ms. H.Priyadarshani, Ms. A. Kanthi, Ms. D. Suriyaarachchi, and Ms. D. Fernando for their untiring efforts in data entry and word processing. We are also grateful to Mr. Kevin Hall and Mr. Thikshana for their co-operation.

Finally, we wish to record our deep appreciation of the encouragement and advice given by Prof. Priyani Soysa, Director General, NARESA during this assignment.

Ms C.M.Fernando
Mr R.M.W. Amaradasa

March 1998

FOREWORD

This survey was undertaken by NARESA to fulfil a requirement of this institution to provide data for Science and Technology Policy reviews.

There was better compliance on this occasion from the organizations involved in Research & Development than before. Perhaps there may have been some gaps in the private sector although a tremendous effort was expended to obtain information from that sector. NARESA was fortunate to get the compliance that was achieved.

In Sri Lanka, due to lack of a critical mass of scientists, it is observed that scientists have to play many roles, namely; education, service and research. This recognition is essential in evaluating the research outcome among the academic scientists.

However, there are many research institutes where the main function is that of research. In some of these institutions, there may be an over-assessment of expenditure on research if institutional expenses have not been disaggregated. In certain sectors, as in NARESA, funding resources have expanded because of the recognition of performance evaluation. The treasury allocations are historical, namely; based on the previous year's performance and expenditure of allocated funds.

The new Ministry of Science and Technology worked hard to plead for better understanding of the need of Research for National Development. It is still far too low as this study reveals. It is well understood that there are financial constraints due to the North-East conflict that is hampering the allocation of funds for Science and Technology Development. The sooner this problem is solved the better for National Development.

Until then, it is our greatest endeavor to make a strong plea for release of cash flows to facilitate research which must have an even flow of finance for research workers and for upgrading scientific equipment in this era of international revolution of Science.

It is expected that Science Indicators are reviewed annually.

NARESA is grateful to Ms. Clodagh Fernando who accelerated and helped Mr. Wasantha Amaradasa in this effort and Mr. Amaradasa himself who was mainly responsible for the data collection .

Priyani E. Soysa

Prof Priyani E.Soysa
Director-General,
NARESA

List of Abbreviations

ACCMT	-	Authur C. Clarke Centre for Modern Technologies
AEA	-	Atomic Energy Agency
AgENT	-	Agricultural Enterprise Development Project (USAID)
AFAR	-	Association for Fisheries and Aquatic Resources
AMC	-	Anti - Malaria Campaign
API	-	Agricultural Productivity Index
BMARI	-	Bandaranaike Memorial Ayurvedic Research Institute
BOI	-	Board of Investment
CARP	-	Council for Agricultural Research Policy
CEA	-	Central Environment Authority
CEB	-	Ceylon Electricity Board
CISIR	-	Ceylon Institute for Scientific & Industrial Research
CRI	-	Coconut Research Institute
DEA	-	Department of Export Agriculture
DNM	-	Department of National Museums
DOA	-	Department of Agriculture
DOF	-	Department of Forest Conservation
DOH	-	Department of Health
DOM	-	Department of Meteorology
EDB	-	Export Development Board
FAO	-	Food and Agriculture Organization
FDI	-	Foreign Direct Investment
FTE	-	Full Time Equivalent
GATT	-	General Agreement on Tariff and Trade
GDP	-	Gross Domestic Product
GERD	-	Gross Domestic Expenditure on Research and Development
GNP	-	Gross National Product
GOSL	-	Government of Sri Lanka
GSMB	-	Geological Survey & Mines Bureau
HDI	-	Human Development Index
HEB	-	Health Education Bureau
HORDI	-	Horticulture Research & Development Institute (DOA)
IAEA	-	International Atomic Energy Agency

Ichem	-	Institute of Chemistry
ICT	-	Institute of Computer Technology
ICTAD	-	Institute for Construction Training and Development
IDB	-	Industrial Development Board
IE	-	Institute of Engineers
IFS	-	Institute of Fundamental Studies
IIMI	-	International Irrigation Management Institute
ILO	-	International Labour Organization
IPS	-	Institute of Policy Studies
IRED	-	Innovations et Reseaüx pour le Developpement
IUCN	-	International Union for the Conservation of Nature
LWMRC	-	Land & Water Management Research Centre (DOA)
MBBS	-	Bachelor of Medicine and Bachelor of Surgery
MD	-	Doctor of Medicine
MNC	-	Multinational Corporation
MOST	-	Ministry of Science & Technology
MRI	-	Medical Research Institute
NAB	-	National Apprenticeship Board (Now NAITA)
NAITA	-	National Apprenticeship and Industrial Training Authority
NARA	-	National Aquatic Resources, Research & Development Agency
NARESA	-	Natural Resources Energy & Science Authority
NASSL	-	National Agricultural Society of Sri Lanka
NBRO	-	National Building Research Organization
NDT	-	National Diploma in Technology
NERD	-	National Engineering Research & Development Centre
NGO	-	Non Governmental Organization
NIBM	-	National Institute of Business Management
NIHS	-	National Institute of Health Services
NLDB	-	National Livestock Development Board
NORAD	-	Norwegian Agency for Research & Development
NSC	-	National Science Council (now NARESA)
NWSDB	-	National Water Supply and Drainage Board
NYSC	-	National Youth Services Council
OECD	-	Organization for Economic Cooperation and Development
OU	-	The Open University
PGIA	-	Post Graduate Institute of Agriculture

PGIM	-	Post Graduate Institute of Medicine
PGRC	-	Plant Genetic Resources Centre (DOA)
Ph. D.	-	Doctor of Philosophy
PIM	-	Post Graduate Institute of Management
R&D	-	Research and Development
RPRDC	-	Rice Processing , Research & Development Centre
RRI	-	Rubber Research Institute
SAREC	-	Swedish Agency for Research Co-operation
SCI	-	Science Citation Index
SEC	-	State Engineering Corporation
SLAAS	-	Sri Lanka Association for the Advancement of Science
SLISTIC	-	Sri Lanka Scientific & Technical Information Centre.
SLVA	-	Sri Lanka Veterinary Association
SRI	-	Sugarcane Research Institute
STA		Scientific and Technological Activities
STET	-	Scientific and Technological Education and Training
STP	-	Scientific and Technological Personnel
STS	-	Scientific and Technological Services
TRI	-	Tea Research Institute
TRIPS	-	Trade Related Intellectual Property Rights
TVEC	-	Tertiary and Vocational Education Commission
UGC	-	University Grants Commission
UNDP	-	United Nations Development Programme
UNESCO	-	United Nations Education Scientific and Cultural Organisation
UOC	-	University of Colombo
UOJ	-	University of Jaffna
UOK	-	University of Kelaniya
UOM	-	University of Moratuwa
UOP	-	University of Peradeniya
UOR	-	University of Ruhuna
UOSJ	-	University of Sri Jayewardanapura
VRI	-	Veterinary Research Institute
WHO	-	World Health Organization
WNPS	-	Wildlife and Nature Protection Society-
WTO	-	World Trade Organization

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Preamble

DEVELOPMENT OF ORGANIZATIONAL FRAMEWORK FOR SCIENCE AND TECHNOLOGY POLICY PLANNING AND IMPLEMENTATION IN SRI LANKA

The organizational framework for planning and implementation of Science and Technology policy plays a pivotal role in the promotion and development of S&T activities in a country.

The historical evolution of the organizational structure for S&T in Sri Lanka can be traced under four broad interactive segments which have developed in parallel during the past century, particularly in the past fifty years, namely:

1. **Institutional Policy Framework** set up to promote development of Science and Technology and to involve the scientific community directly in the policy planning and implementation process, through representative multi-disciplinary associations.

2. **Research Institutes** established to carry out research and experimental development activities and provide scientific services in key areas of the economy and government departments with research functions.

3. **Professional Societies** in various disciplines and sub-disciplines and apex bodies.

4. **Tertiary Education Network** including universities, advanced technical and vocational training institutes and postgraduate training and research institutions.

Institutional Policy Framework

The establishment of the Chemical Society in1940 was a landmark in the institutional set up and was soon followed by recognition of the scientific community when in 1942 the British Governor appointed a scientific advisory committee for the first time.

The Chemical Society spearheaded the formation of the Ceylon Association for the Advancement of Science (now re-named SLAAS) in 1944 embracing scientists of all disciplines in one multi-disciplinary apex organization, which was a pioneering achievement.

This association agitated from the outset for the creation of a national body charged with responsibility for the formulation and implementation of a National Science Policy and the initiation and promotion of scientific Research and Development in the country. The Sri Lankan scientists were no doubt inspired by the historic Science Policy statement enunciated by the Indian Prime Minister, Jawaharlal Nehru in the Indian Parliament in 1947 and the political patronage afforded to the promotion of Science in India.

Although the CAAS (now SLAAS) proposals were presented in 1948 and accepted in principle by the government, it took twenty years to implement them by establishing the National Science Council (NSC) in 1968. Meanwhile the scientific community took the initiative to fill the void, in part, by establishing within the CAAS a General Research Committee (GRC) to stimulate and coordinate scientific research in the country.

Under Parliamentary Act No. 9 of 1968 (and the revised Act No. 36 of 1975) the National Science Council was given statutory responsibility, inter alia, to initiate, sponsor and support scientific and technological research directed towards development and to advise the Minister on the allocation of funds for such research and on the formulation and implementation of a national science policy.

The Natural Resources, Energy and Science Authority (NARESA) was established by Act No. 78 of 1981, superseding the NSC, and given a wider mandate covering the development of science and technology, natural resources and energy resources for the benefit of the people in a manner consonant with the national interest. NARESA was entrusted with the responsibility of advising the Minister of Science and Technology on the formulation and implementation of a national science policy and technology policy, allocation of funds for research, collection and dissemination of information relating to scientific and technical matters, reporting on effective utilization of available scientific personnel, among other related functions.

The first Science Policy statement was made by the President of Sri Lanka at the annual sessions of the SLAAS in 1978. Other highlights in the consultative process were the formulation of a comprehensive Science Policy document outlining strategies for implementation in the form of a sessional paper in 1986 and the appointment of a Presidential Task Force on Science and Technology Development to advise the incumbent Presidents in 1991 and again in 1994.

According to universally accepted UNESCO guidelines, scientific and technological activities (STA) comprise three broad interactive categories, namely:

a) Research and experimental development activities (R&D)
b) Science and technological education and training at the tertiary level (STET)
c) Science and technological services (STS)

The major focus of this study is the analysis of R&D funding in Sri Lanka in relation to economic development and the growth and deployment of scientific and technological personnel (STP) across the different sectors and scientific disciplines. Whenever relevant the other two areas are covered to highlight their impact on the national S&T effort.

Chapters one and two describe historical perspectives and the objectives and methodology of the study, basic science indicators - their uses and limitations.

Chapter three discusses the financial resources for R&D, sources of funding and distribution of funds between sectors of performance and disciplines and nature of research.

Chapter four describes the status of scientific and technical manpower resources, their utilization and deployment among sectors and disciplines, research intensities and technical support indices.

Chapter five reviews the university system and summarizes the growth and expansion of the tertiary education system in relation to strategic needs for development.

Chapter six focuses on the agriculture sector in relation to GDP and some indicators of research output from the major research institutes.

Chapter seven deals with the role of Science and Technology in economic development in relation to structural changes taking place in the economy and the challenges of globalization.

Chapter 1

INTRODUCTION

1.1 Overview

The latter half of the twentieth century has witnessed a phenomenal growth of scientific and technological research and associated development activities in the industrialized countries. A strong positive correlation and symbiotic relationship has been established in these countries between their Science and Technology (S&T) capability and Research and Development (R&D) Expenditure on the one hand and the pace of economic development on the other.

In the developing countries of the third world, R&D expenditure has been given low priority for economic reasons and S&T capability has not developed or impacted to the same extent due to cultural factors and their colonial past. As a result their economies are lagging behind in the global scenario of rapid technology-driven economic growth, which has been variously characterized as the 'Technology Revolution' or 'Research Revolution'.

Nevertheless, a gene pool of qualified scientists, technologists, technocrats and technicians exists in most developing countries, constituting a powerful indigenous resource base which has the potential to play a pivotal role in fashioning and triggering a socially acceptable and culturally relevant technology-driven development process.

In the context of the growing tendency towards globalization of trade and economic liberalization in the Third World it is imperative for Sri Lanka to harness the existing S&T capacity under a unified coordinated strategy and to identify gaps, imbalances and weaknesses which have to be addressed in order to achieve competitiveness in the global economy.

From this perspective NARESA is mandated to perform an important task in assembling, collating and analyzing reliable and up-to date statistical information on the present status and emerging trends in S&T activities in Sri Lanka which will enable identification of constraints to R&D growth and utilization of S&T personnel.

This would give a broad picture of the national S&T rubric and provide a sound basis for the development of a National Science and Technology policy incorporating strategies and structures that will enable promotion of S&T activities in consonance with economic and social development goals of the country at all levels and interfaces - sectoral, intersectoral, national and global.

The Indian model of S&T development geared to fulfill the needs and aspirations of society, which was enunciated in the historic Scientific Policy resolutions of 1958 and followed up by several key government initiatives led to an enormous growth of scientific and technical capability in all sectors including industrial, nuclear and space sciences. The Indian experience has particular salience for other developing countries with similar socio-cultural backgrounds and colonial histories like Sri Lanka who are now at the threshold of entry into the global economic scenario.

On the other hand transposing Western development models may not be totally relevant to third world countries whose development objectives must be underpinned by concerns of equity and social justice to overcome wide income disparities which have led in the past to social unrest and instability.

1.2 Conceptualization & Definitions

The main focus of this study is to estimate the total expenditure on Research and Development (R&D) and to explore the scientific and technological manpower resource potential (STP) in Sri Lanka with a view to understanding the present status of S&T capability, the level of efficiency in its usage and emerging trends in its application.

Data on S&T activities have to be collected and interpreted within a conceptual framework in order to provide valid and reliable information to policy makers and decision makers and to enable meaningful comparisons with national and international data bases.

For this purpose the following UNESCO definition has been widely accepted.

"For statistical purposes Scientific & Technical (S&T) Activities can be defined as all systematic activities which are closely concerned with the generation, advancement, dissemination and application of S&T knowledge in all fields of science & technology, i.e. the natural sciences, engineering and technology, the medical and agricultural sciences as well as the social sciences and humanities.

S&T activities (STA) covered by this definition extend over a broad spectrum with no clear cut demarcations or boundaries but for purposes of measurement STA have been broadly categorized into 3 areas viz.

a) Research and Experimental Development activities (R&D) -

Activities involving systematic creative work to increase scientific and technological knowledge and to devise new practical applications.

b) Scientific and Technological Services (STS) -

Activities contributing to generation, dissemination and application of scientific and technical knowledge.

c) Science and Technology Education and Training (STET) -

Specialised non-university, university, post-graduate and further training activities in the field of S&T.

It must be emphasized that these three categories are not separate or hierarchical, but parts of an interactive system which feed and support each other.

1.3 S&T Indicators

A major constraint to the assessment of S&T capability is the lack of yardsticks which are internationally valid, nationally relevant and lend themselves easily to quantitative measurement.

UNESCO and OECD have outlined standardized terminology and methodologies to define and obtain some quantitative measures or Indicators of the different aspects of the system, which are internationally comparable. In addition there has been a great deal of individual research into the development and refinement of indicators and the methodology is still in an evolutionary stage.

However there is an intricate nexus of intangible sociological and environmental parameters and complex inter-relationships which are country-specific and difficult to quantify and lack comparability in a globally applicable logical framework.

Two types of indicators have been developed. The first type are Input indicators which measure resources which are required as inputs for the pursuit of S&T activities, mainly funds and personnel. The other type are Output indicators which attempt to measure the direct products of S&T activities. Input indicators are more commonly used because they are easier to measure, data is more readily available and their interpretation is simpler in the national and international context.

a) Input Indicators

Two key macro indicators for measurement of R&D expenditure and scientific manpower resources (STP) which are internationally applied and recognized and for which UNESCO have standardized definitions are given below.

1. Total Expenditure on Research & Development (R&D) measured by GERD (Gross Domestic Expenditure on Research & Development)

This measure includes R&D domestically performed with foreign funds, but excludes R&D funds paid abroad. GERD is a national aggregate useful for policy makers but has limited significance for international comparisons because it is affected by price levels, exchange rate fluctuations and variations in Gross Domestic Product (GDP) which exists among nations.

The ratio of GERD to GDP or **R&D Coefficient** is a dimension-less indicator which is unaffected by price variations and differences in GDP and is a more useful indicator for international comparisons as well as for analysis of trends over time within a country.

Indicators disaggregating Total Expenditure on R&D by sector, discipline, type of research activity and by nature of research are used for further analysis.

2. Total stock of economically active Personnel engaged in Scientific and Technological activities (STP) in aggregate terms.

This is an absolute value which is useful for policy making and manpower planning but is not internationally comparable between countries of different population size. A more useful indicator for comparative studies is the number of scientific personnel per million population.

The distribution of the total aggregate STP by relevant parameters such as age, sex, discipline, sector etc. and rate of growth over time are other useful indicators which are generally used in STP studies.

b) <u>Output Indicators</u>

The need for output indicators is clear and well recognised but they have to be used with great circumspection as they are more difficult to measure than input indicators and even more difficult to standardize for cross national comparisons. Some commonly used output measures are:

1. **Bibliometric analysis** which includes

- No. of publications (books, journals and articles) by local scientists within and outside the country cross analysed by discipline.
- Citation counts within and outside the country.
- Number of publishing authors.
- Rate of growth of publications of local scientists in learned journals.

2. **Patents**

Patent data are readily available in developed countries but have serious shortcomings in developing countries where very few patents are registered and reliance on imported technology is relatively high. Moreover, due to their lack of organisation and resources the developing countries are severely handicapped under the global patent regime of the World Trade Organisation (WTO), which enables multinationals with their vast resources to exploit the storehouse of traditional knowledge and genetic biodiversity in the developing countries and apply for international patents.

1.4 Uses and Limitations of Indicators

a) Uses

1. S&T indicators provide insight into the performance and dynamics of the S&T system highlighting new developments, sectoral variations and emerging trends within a country.

2. They give validity to international comparisons.

3. They enable building time series models which guide policy makers in planning and forecasting.

4. They provide a shared language for scientists and policy makers to communicate and negotiate and serve to build awareness of scientific issues among administrators.

5. The ratio of GERD to GDP is generally taken as a valid measure of the commitment of the government to integrate S&T in the economic development of he country. Scientists in developing countries apprehend the government when there are signals indicating a decline in GERD/GDP and agitate for an increase up to the level of the industrialized countries. The government on the other hand, finds it difficult to allocate public funds for R&D where the immediate turnover is not visible and therefore difficult to justify.

b) Limitations

While indicators represent a potentially powerful analytical tool their limitations must be recognized and they have to be constantly improved and refined to ensure reliability and validity. S&T indicators have several limitations as indicated below.

1. While the level of GERD/GDP ratio is regarded as a basic requirement, recent studies show that new indicators which are complementary to GERD/GDP ratio should also be developed. Many countries have conducted surveys to look into incremental process/ product innovations at the micro-level. Such incremental innovations which may be part -time or discontinuous are not labeled as R&D but have been shown to be significant precursors to R&D specially in small and medium enterprises.

2. In estimating capital expenditure on equipment, buildings etc., depreciation is not always taken into account .

3. Input indicators measure quantity but not quality. Output indicators attempt to measure quality but have not reached a stage of precision required for meaningful analysis relative to input indicators. More-over they cannot take into account intangible effects which are not directly measurable but can have a real impact on scientific and technical capability, especially in developing countries which have infrastructural limitations leading to implementational shortcomings.

4. The Input model ignores the very interactive nature of research and development and pre-occupation with quantitative measures could preclude adequate consideration of relevant non-quantifiable features.

5. Since S&T Activities do not take place in isolation but are subsumed in economic activities at all levels as represented schematically in **Chart 1** (page 10), differentiation of expenditure on R&D becomes a major problem, specially in developing countries where accounting procedures are not as advanced or sophisticated.

6. The total number of scientists engaged in R&D or Head Count Index is an inflated measure since the majority of scientists do not work full time on R&D. Hence a suitable deflator has to be employed based on the percentage of time devoted to R&D in order to compute a full time equivalent (FTE). R&D recurrent expenditure on salaries has to be calculated on the basis of FTE.

1.5 Historical Perspective

a) Global Scene

Earliest measurement of Research and Development activities were confined to Universities and learned societies which attempted to monitor and evaluate their own efforts. Grants for research were sporadic and small, being based on prestige rather than on performance ratings. Rapid technological growth in the latter half of the 19th century in the western countries led to the establishment of research units by industrial organizations to collect statistics on R&D expenditure as a measure of comparison with competitors.

First official government sponsored surveys of STA are reported to have commenced in the Soviet Union in the 1930s and in the USA in the 1940s. With the establishment of the National Science Foundation in USA in 1950, regular surveys of R&D were conducted in USA and considered to be an important input into policy-making by the Federal government.

In the 1950s and 1960s the other industrialized countries belonging to the Organisation for Economic Co-operation and Development (OECD) began collecting systematic data on R&D. The need for standardization of definitions and methodologies was recognized and a Committee of experts appointed by OECD produced a draft document which was discussed and adopted in 1963 at a conference of OECD members held in Frascati, Italy. This document known as the Frascati Manual provided guidelines for definition and measurement of S&T activities and has been revised several times in 1930, 1976 and 1981 based on the experience gained.

UNESCO launched its first international study on R&D expenditure using mainly the methodologies and definitions laid down in the first Frascati Manual. Following OECD, UNESCO published its own Statistical Year Book annually beginning in 1968. In 1980 UNESCO, published its own Manual of standardized definitions and procedures in measurement of R&D, STP and STS which was more broad based than the Frascati manual and had greater relevance to the developing countries. These two manuals are used in tandem by all countries as guidelines for conducting surveys of STA.

b) National Initiatives

1. R&D Expenditure

The first study on Research and Developing Expenditure in Sri Lanka was carried out in 1970 by the Ceylon Institute of Scientific and Industrial Research and covered the period 1955 to 1966. This study covered 38 major scientific institutions in the country and estimated the R&D expenditure for the period 1950 to 1966 (Cooray, N. 1970). It should be noted that this study obtained data mainly from government estimates and annual reports which do not always reflect actual expenditure on R&D. There was no attempt to differentiate R&D expenditure from related activities resulting in over estimation of GERD. According to this study the ratio of GERD/GDP reached a peak in 1958/59 (0.34) and declined thereafter.

Although UNESCO definitions for the measurement of R&D expenditure were used, the report highlights various constraints to identification of the actual quantum of expenditure for R&D in the research institutions. In many of the research institutions expenditure on R&D forms only a part of the total expenditure. A major part of their activities involve technical services such as routine testing and analytical work, training of scientific personnel and advisory work. These are scientific activities which are related to but not a direct input to the research functions of the institution.

The second and third surveys carried out in 1978 and 1986 by the National Science Council (now NARESA) also used the same definitions and methodologies for the measurement of R&D expenditure. The two reports from these surveys indicate that GERD/GDP continued to decline to 0.21 per cent in 1975 and 0.18 per cent in 1984 (Liyanage, S. et al 1977 & De Silva and Liyanage 1987). An unpublished study undertaken in 1993 revealed that the R&D coefficient had further declined to 0.13 per cent in 1992. The present study indicates a reversal in the trend with the ratio increasing marginally to the 1984 value of 0.18 per cent.

2. STP Surveys

The earliest survey of S&T manpower was undertaken by the Sri Lanka Association for the Advancement of Science (SLAAS) in 1972. This study had limited value because it was restricted in scope to the membership of SLAAS (Pattiarachchi 1972).

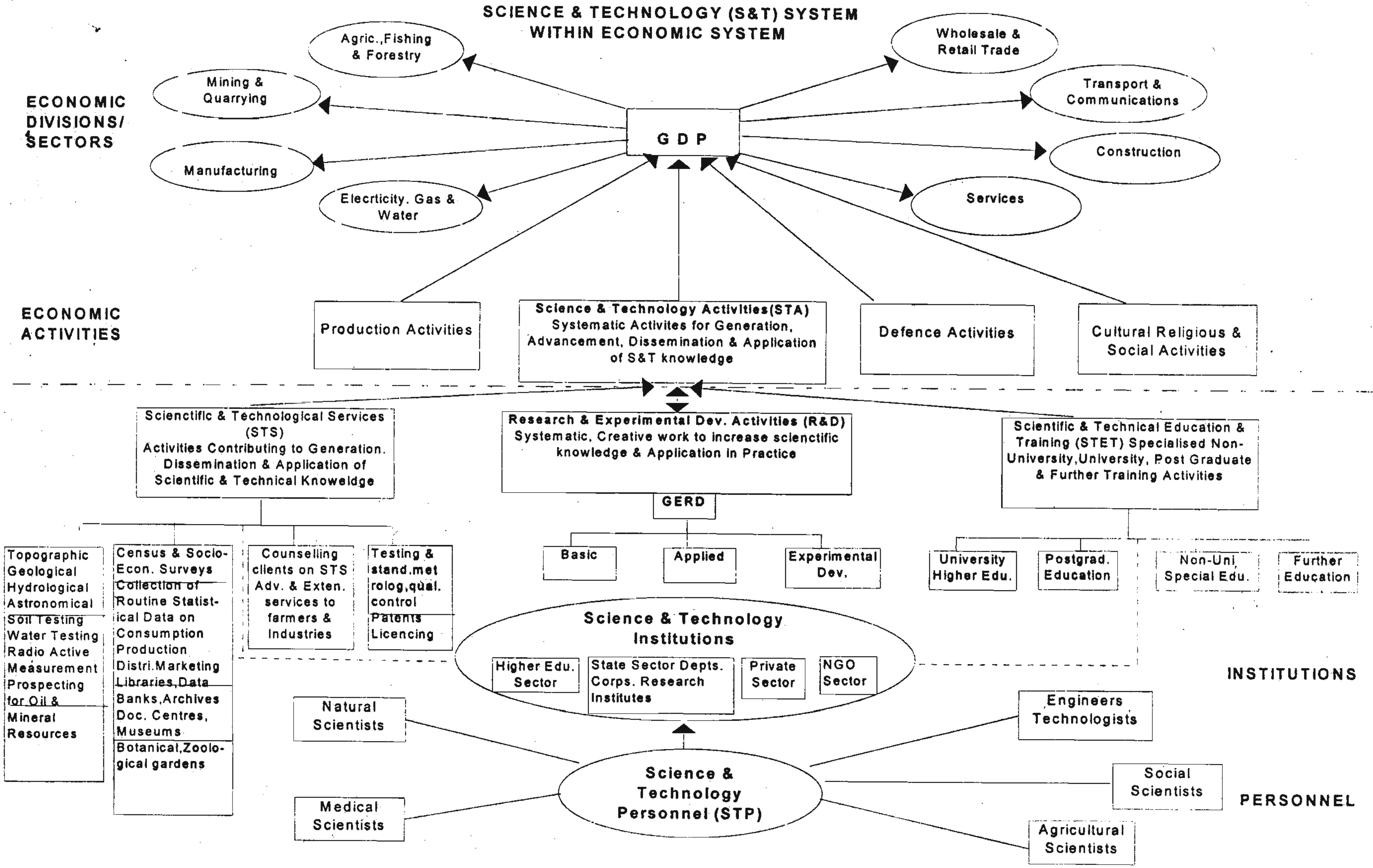
A more comprehensive and systematic study of S&T manpower was undertaken by the National Science Council in 1972/73. This survey was based on methodology recommended by UNESCO and involved two stages. In the first phase a questionnaire was addressed to all government departments requesting a list of S&T personnel employed by them. A fairly satisfactory response rate of 80 per cent was obtained in this phase. In the next phase a questionnaire which sought to obtain detailed personal data was sent to all individual scientists included in these lists. The response rate in the second phase was very unsatisfactory being only 35 per cent. Nevertheless, the total stock of economically active manpower was estimated from the data obtained in the first phase from the institution lists to be 6,845 (NSC 1973).

Benefitting from the previous experience the National Science Council refined its methodologies and data collection procedures and conducted a second major study in 1977/78 which combined (a) a survey of R&D expenditure during 1956-1965 and (b) a survey of the stock of S&T personnel in 1977.

This survey which had an overall response rate of 60 per cent estimated that rates of GERD/GDP had increased marginally from 0.17 per cent in 1966 to 0.21 per cent in 1975 while total stock of STP had declined considerably from 6,845 in 1973 to 4,569 in 1977 (De Silva, M. 1979).

The third study in the series conducted by NSC was undertaken in 1984/85 and indicated a reverse trend with ratio of GERD/GDP declining marginally from 0.21 percent in 1975 to 0.18 per cent in 1983 while the total stock of STP increased substantially from 4,569 in 1977 to 8,253 in 1985. In this survey social scientists (1,949) medical scientists (372) and technicians (3,908) were included for the first time and taking them into reckoning the total stock of STP increased to 10,599 scientists and engineers supported by 3,908 technicians.

Chart 1


SCIENCE & TECHNOLOGY (S&T) SYSTEM
WITHIN ECONOMIC SYSTEM
ECONOMIC DIVISIONS/ SECTORS
Agric.,Fishing & Forestry
Mining & Quarrying
Manufacturing
Elecrticity, Gas & Water
G D P
Wholesale & Retail Trade
Transport & Communications
Construction
Services
ECONOMIC ACTIVITIES
Production Activities
Science & Technology Activities(STA) Systematic Activites for Generation, Advancement, Dissemination & Application of S&T knowledge
Defence Activities
Cultural Religious & Social Activities
Scienctific & Technological Services (STS) Activities Contributing to Generation. Dissemination & Application of Scientific & Technical Knoweldge
Research & Experimental Dev. Activities (R&D) Systematic, Creative work to increase sclenctific knowledge & Application in Practice
GERD
Scientific & Technical Education & Training (STET) Specialised Non-University,University, Post Graduate & Further Training Activities
Topographic Geological Hydrological Astronomical
Soil Testing Water Testing Radio Active Measurement Prospecting for Oil &
Mineral Resources
Census & Socio-Econ. Surveys
Collection of Routine Statistical Data on Consumption Production Distri.Marketing
Libraries,Data Banks,Archives Doc. Centres, Museums
Botanical,Zoological gardens
Counselling clients on STS Adv. & Exten. services to farmers & Industries
Testing & stand.met rolog,qual. control
Patents Licencing
Basic
Applied
Experimental Dev.
University Higher Edu.
Postgrad. Education
Non-Uni Special Edu.
Further Education
Science & Technology Institutions
Higher Edu. Sector
State Sector Depts. Corps. Research Institutes
Private Sector
NGO Sector
INSTITUTIONS
Natural Scientists
Medical Scientists
Science & Technology Personnel (STP)
Engineers Technologists
Social Scientists
Agricultural Scientists
PERSONNEL

Chapter 2

PRESENT STUDY - OBJECTIVES & METHODOLOGY

2.1 Objectives

The main purpose of this study was to construct strategic indicators of STA activities in Sri Lanka in relation to economic performance. The primary objective is to provide a sound basic data base to assist government policy planners in framing a National Science & Technology Policy.

2.2 Methodology

This study follows UNESCO guidelines on definitions and methodologies as in the previous studies to ensure comparability and validity. It concentrates primarily on the following input indicators:

a) R&D expenditure

1. Growth of R&D Expenditure in Sri Lanka (1966 - 1996)
2. Ratio of GERD/GDP (R&D Coefficient)
3. National Expenditure on R&D (GERD) by source of funding
4. National Expenditure on R&D (GERD) by nature of activity
5. National Expenditure on R&D (GERD) by sector of performance
6. National Expenditure on R&D (GERD) by scientific discipline
7. National Expenditure on R&D (GERD) by type of funding

b) Manpower Resources (STP)

1. Stock of economically active STP by sector of performance
2. Stock of economically active STP by discipline
3. Stock of economically active STP by sex
4. Educational Attainment of STP
5. Technical Support Index - Ratio of technicians to scientists

c) Manpower Resources in R&D

1. Stock of economically active STP engaged in R&D (Head Count Index) by sector and by discipline
2. Stock of economically active STP engaged in R&D - Full time equivalent (FTE) by discipline and sex
3. Stock of R&D personnel by educational attainment
4. Research Intensity by discipline and sex

2.3 Survey Design

A two stage survey design was adopted in accordance with international practice. In the first stage all institutions where S&T activities were likely to be carried out in accordance with the UNESCO definitions were identified. OECD source materials were used for further clarification and amplification of definitions in order to determine elements to be included or excluded from the survey.

All identified organizations and institutions in the state, private and NGO sector were listed and categorized according to sector of performance. This list constitutes the main sampling frame for the survey.

A structured two-part questionnaire was sent to all institutions on this list seeking information on

a) R&D expenditure classified under capital, recurrent and other

b) List of all S&T personnel employed by the institution.

A copy of relevant UNESCO definitions was sent to each institution to help in identifying individuals who qualified for inclusion in the list. Detailed information on age, sex, academic and professional qualifications, subject specialities and extent of engagement in R&D activities was sought in respect of each individual scientist..

Responses to these two questionnaires were analyzed to determine the target population and construct the structural input indicators listed above.

2.4 Sources of Error

The following potential sources of error were identified.

a) Coverage

In identification of S&T institutions we have to ensure maximum coverage as any major omission can lead to errors in analysis. Historically organized systematic research activities commenced in Sri Lanka under government sponsorship during the colonial era to serve the British economic and trade interests. Even today the major R&D effort is concentrated in 16 state sector research institutions and several government departments.

More than 100 public sector institutions were surveyed. All 16 major research institutions and 58 others where S&T activities were carried out have responded. Those which did not respond were followed up and found to be non S&T institutions. The list of respondent institutions is given in **Annex 1**.

A list of private sector institutions which were likely to be engaged in R&D was compiled with the help of the Directory of Exporters prepared by the Export Development Board, Ferguson's Directory and newspaper reports. However, except for the banking sector there was a very poor response attributable primarily to several reasons - lack of understanding of the concepts and definitions used, lack of appreciation of the purposes of the survey, low prioritization, confidentiality of information on R&D, etc. This gives rise to a deficiency in the survey data, since there has been a surge in non-traditional exports and a corresponding increase in R&D activity in private firms concomitant with the government policy of encouraging the private sector as the main engine of economic growth.

There is evidence in many countries (Holland, Canada, India) that conventional institutional survey techniques based on the Frascati definition exclude incremental micro-level innovations which are part-time and discontinuous and hence could fail to capture the emergence of innovative firms in the industrial arena.

It may be necessary to undertake the preparation of a new industrial data base compiled from non-traditional sources to highlight firms which are technologically innovative and serve as gene markers for potential R&D activity.

A list of non-governmental organizations (NGOs) was prepared from the Directory of NGOs published by IRED (Innovations et Reseaux pour le Developpement) and they were included in the survey but the response was minimal.

b) Identification of Target Population

In identifying the target population for the STP survey boundary problems can arise leading to type I and type II errors. Type I error results from rejecting a scientist who should be included (false negatives) and type II error is committed it we accept an individual who should be rejected (False positives). In the earliest surveys there were substantial type I errors, e.g. many medical scientists and social scientists were excluded.

In order to avoid type I and II errors in this survey a detailed list of disciplines and specialities under each discipline prepared according to the UNESCO guidelines (**Annex 2**) was sent to each institution surveyed along with the questionnaire. Respondents were encouraged to clarify any doubts with the NARESA staff before finalising the responses to the questionnaires.

In the case of R&D expenditure research done by individuals and state sponsored special projects could not be covered giving rise to some degree of type I error.

c) Sampling Error

There is no sampling error as all identified institutions were covered.

d) Non-sampling Error

Two common types of non-sampling error which occur in this type of survey are error due to non-response and measurement errors.

1. Non-response

Non-response is a major problem which had to be tackled both at institutional level and individual level. Every effort was made to reduce unit non-response by sending several follow up letters and telephone reminders and scheduling personal interviews.

Item non-response, where certain variables like age, sex, speciality were omitted in the responses, was another source of error which could lead to distortion of the disaggregated analyses.

2. Measurement error

Measurement errors can arise in computing R&D expenditure since most institutions do not maintain separate accounts for R&D work only. In some of the earlier surveys the total expenditure incurred by the main research institutions was taken as R&D leading to a degree of over-estimation. In the present survey an attempt was made to identify the actual level of R&D activities in each institution and apportion total expenditure on R&D and other related activities. The computation was undertaken in close consultation with the management and accounting personnel of the institution. This differentiation has to be reckoned with in comparisons with previous surveys.

The INFORM database maintained by the Centre for Agricultural Research Policy - CARP was used to cross-check R&D expenditure in the Agricultural sector. Major drawbacks of the CARP data base are the absence of data on capital expenditure and recurrent expenditure is based on estimates rather than actuals.

University Grants Commission (UGC) reports were used to calculate the percentage of time allocated to research by different levels of academic staff in the various faculties of the Universities. Further details are given in the analysis.

2.5 Analysis of Data

In the next three chapters, data from the present study is analyzed against the backdrop of previous studies but in comparing trends it must be borne in mind that survey procedures have been continuously refined and earlier data may not have the same degree of precision. The analysis will attempt to examine the survey data from the perspective of deployment of S&T activities in key areas of the national economic infrastructure and to identify significant changes and trends which could impact on future growth.

Chart 2

SUMMARY OF R&D EXPENDITURE - 1984 & 1996

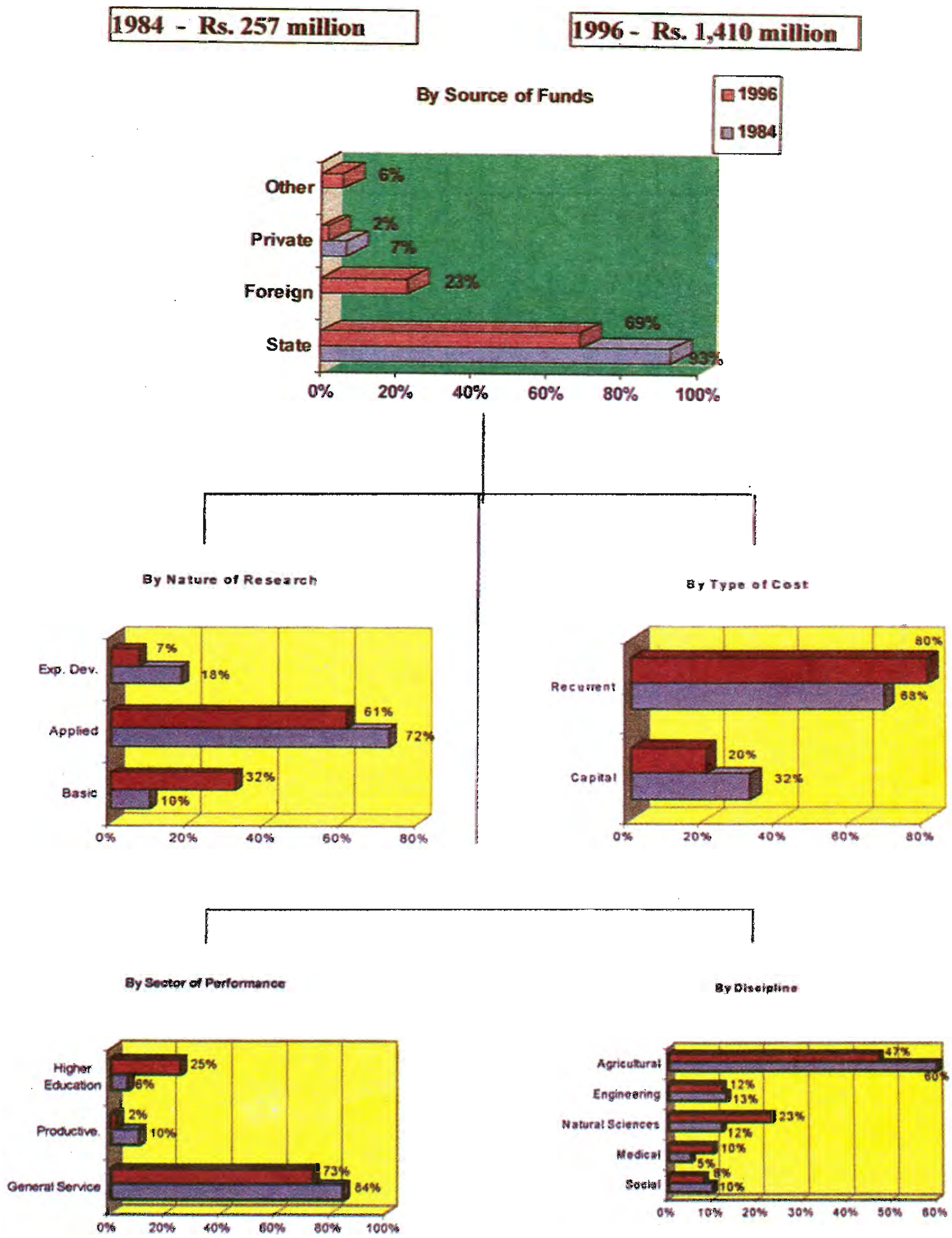


Chart 3

GERD, GDP, GERD/GDP RATIOS, R&D PERSONNEL, TOTAL POPULATION AND R&D PERSONNEL PER THOUSAND POPULATION FOR DIFFERENT AREAS IN THE WORLD (1992).

	GERD	GDP	GERD/GDP (%)	R&D scientists and engineers ('000s).	Population (millions)	R&D scientists per thousand population
European Union	117.67	6079	1.9	740.9	369.0	2.0
European Free Trade Association	5.47	233	2.3	32.6	11.9	2.7
Central and Eastern European Countries	2.89	188	1.5	285.5	131.0	2.2
Israel	1.24	64	1.9	20.1	5.4	3.8
Commonwealth of Independent States	4.13	496	0.9	452.8	283.0	1.6
USA	167.01	5953	2.8	949.3	257.5	3.7
Canada	8.13	537	1.5	64.6	27.8	2.3
Latin America	3.93	1063	0.4	158.5	464.6	0.3
North Africa	0.72	160	0.4	81.6	219.7	0.4
Middle and Near East	3.11	598	0.5	117.4	465.9	0.3
Sub-Saharan Africa	1.09	245	0.4	176.8	482.6	0.4
Japan	68.31	2437	2.8	511.4	124.8	4.1
NICs	10.73	824	1.3	136.7	92.5	1.5
China	22.24	3155	0.7	391.1	1205.0	0.3
India	7.10	940	0.8	106.0	887.7	0.1
Other countries in Far East	0.69	982	0.1	60.3	513.5	0.1
Australia and New Zealand	4.12	341	1.2	48.5	21.2	2.3
World total	**428.58**	**24295**	**1.8**	**4334.1**	**5563.1**	**0.8**

Source : *World Science Report (1996) - UNESCO*

Chapter 3

FINANCIAL RESOURCES FOR RESEARCH AND DEVELOPMENT (R&D)

3.1 Growth of R&D Expenditure

Table 3.1 gives a summary of GERD, GDP and population statistics during the 30 year period covered by the R&D surveys undertaken in Sri Lanka.

Table 3.1 R & D Expenditure (GERD)

Year	GDP Current Prices (Rs. m)	GERD Rs.m (US$)	GERD at Constant Prices (Rs.m) (1975=1)	GERD as per cent of GDP	Total Population (millions)	GERD Per million population
1966	7,529	19.8		0.3	11.5	1.7
1975	11,100	45.1 (6.4)	45.1	0.2	13.5	3.3
1984	142,700	257.0 (9.7)	75.5	0.18	15.6	16.5
1993	499,800	649.0 (13.1)	85.1	0.13 (est.)	17.6	36.8
1996	769,900	1,410 (23)	139.1	0.18	18.3	77

Source: Central Bank Annual Reports & Department of Census & Statistics

The Gross National Expenditure on Research (GERD) in absolute terms has increased sharply and reached an all time high of Rs. 1410 million in 1996. The average annual growth rate has increased substantially from 15 per cent for the period 1966-75 to 21 per cent for the period 1975-84 and declined to 15 per cent during the period 1985-96. It is evident that the escalation in GERD in absolute terms which has taken place in recent years is much less in real terms due to the effects of inflation.

The GNP price deflator employed by the Central Bank was used to calculate GERD at constant prices (1975) to eliminate inflationary effects. The growth rate is much less, but still indicates a steady rise in expenditure on R&D, reflecting an increasing commitment by the government to the promotion of R&D in spite of heavy demands from other sectors, such as defence, education and health.

3.2 GERD/GDP Ratio

The GERD/GDP ratio which shows a declining trend from 0.3 in 1996 to 0.18 in1984 and 0.13 in 1993 has improved marginally to 0.18 which is a healthy signal, but it is still well below internationally accepted standards (see **Chart 3**). The corresponding statistics for a few selected countries presented in Table 3.2 indicates a high variation within the region with Bangladesh (0.2) and Sri Lanka (0.18) at the bottom end of the scale.

While some countries in the Asian region have recorded impressive growth in GERD in the 1990s, notably Singapore (26.5 per cent) and Taiwan (16.5 per cent), Sri Lanka has experienced a modest growth rate of 5.2 per cent comparable to Malaysia (5.5 per cent) but much higher than some developed countries such as U.K. and USA.

Table 3.2 International Comparisons of GERD/GDP

Country	GERD/GDP	Year	Real Growth in GERD	Period
Australia	1.35	1990	n.a.	
Bangladesh	0.2	1993	n.a.	
China	0.5	1995	n.a.	
India	0.8	1995	n.a.	
Japan	2.72	1993	4.0	1989 - 93
Korea	2.10	1993	12.0	1989 - 93
Malaysia	0.34	1994	5.5	1992 - 94
Pakistan	0.5	1993	n.a	
Singapore	1.12	1994	26.0	1988 - 92
Sri Lanka	0.18	1996	5.2	1984 - 96
Taiwan	1.82	1994	16.5	1989 - 93
U.K.	2.3	1992	-2.3	1989 - 93
U.S.A	2.8	1992	0.3	1989 - 93

Source: National Survey of R&D-Malaysia (1994) **n.a. not available**

3.3 R&D Expenditure by Source of Funding

During the last decade it can be seen that there is a considerable variation in the distribution of sources of funding, with government funding declining from 93 per cent in 1984 to 70 per cent in 1996 (vide Table 3.3). However, the government continues to sponsor the major proportion of research in the country, while private sector investment in R&D (1.5 per cent) is meagre and needs to be stimulated. It is evident that the country receives nearly one fourth of funding for R&D from abroad.

Table 3.3. R&D Expenditure by Sources of Funding and Type

Year	1984 (Rs. m)			1996 (Rs. m)		
Source	Recurrent	Capital	Total	Recurrent	Capital	Total
State	161.5 (62.9%)	77.9 (30.3%)	239.4 (93.2%)	780.7 (55.4%)	200.3 (14.2%)	981.0 (69.6%)
Foreign				266.5 (18.9%)	58.0 (4.1%)	324.5 (23.0%)
Private	12.8 (5.0%)	4.6 (1.8%)	17.4 (6.8%)	3.0 (0.2%)	18.5 (1.3%)	21.5 (1.5%)
Other				79.3 (5.6%)	3.3 (0.3%)	82.6 (5.9%)
Total	174.3 (67.9%)	82.5 (32.1%)	256.8 (100.0%)	1129.5 (80.1%)	280.1 (19.9%)	1409.6 (100.0%)

Fig. 1 Sources of Funds

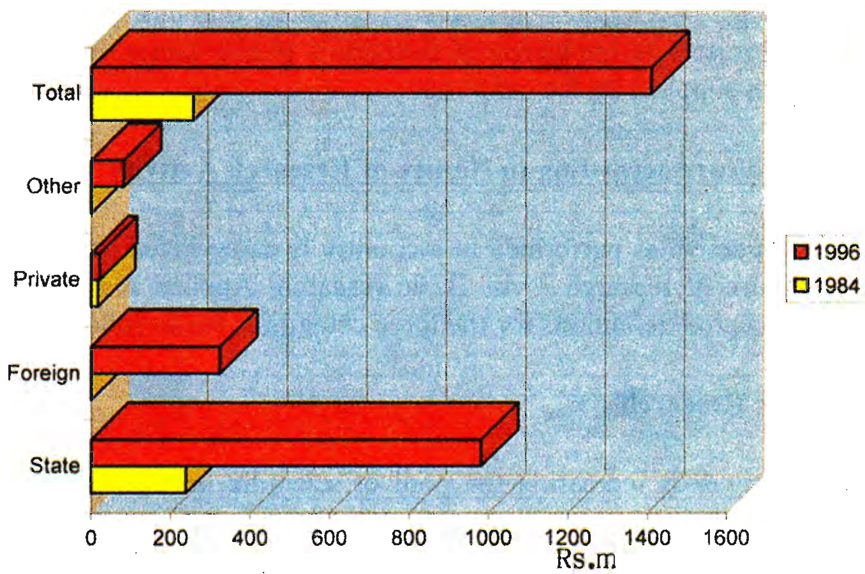
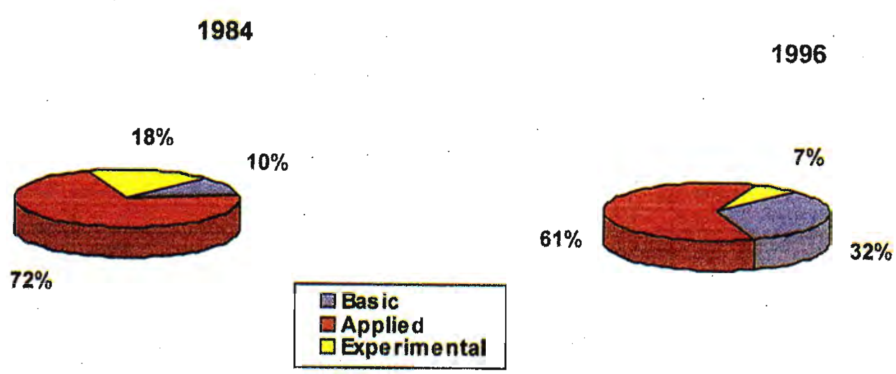


Fig. 2 R&D Expenditure by Nature of Research Activity



The data obtained from institutions indicates that UNDP, FAO, SAREC, NORAD, WHO and FORD Foundation are the major sources of foreign assistance. Further analysis of foreign funding reveals that more than 50 per cent of expenditure in the social sciences is funded by foreign sources and conducted mainly by non-government organizations. It is possible that some foreign grants made to individual scientists are not captured in the statistics supplied by institutions.

It should be noted that the differentiation and computation of R&D incorporated in some of the foreign-funded large scale development projects is extremely difficult. However, since the R&D component of these projects is implemented through a public sector institution it would be included in the statistics supplied by the institution.

3.4 R&D Expenditure according to Nature of Research Activity

The nature of research activities performed in a country is categorized generally into three areas depending on the nature of research - viz. Basic research, Applied research and Experimental Development. The accepted definitions for the three categories are as follows:

Basic /Strategic Basic Research

Any activity directed towards increasing the pool of scientific knowledge or discovery of new fields of investigation without any specific practical application in view. In developing countries basic research is often narrowed down to specific areas due to limitations of facilities, personnel and resources and to prioritization of social and political needs. This type of research is termed strategic basic research.

Applied Research

Any activity directed towards the increase of scientific knowledge but with a specific practical objective in view. Applied research is problem oriented.

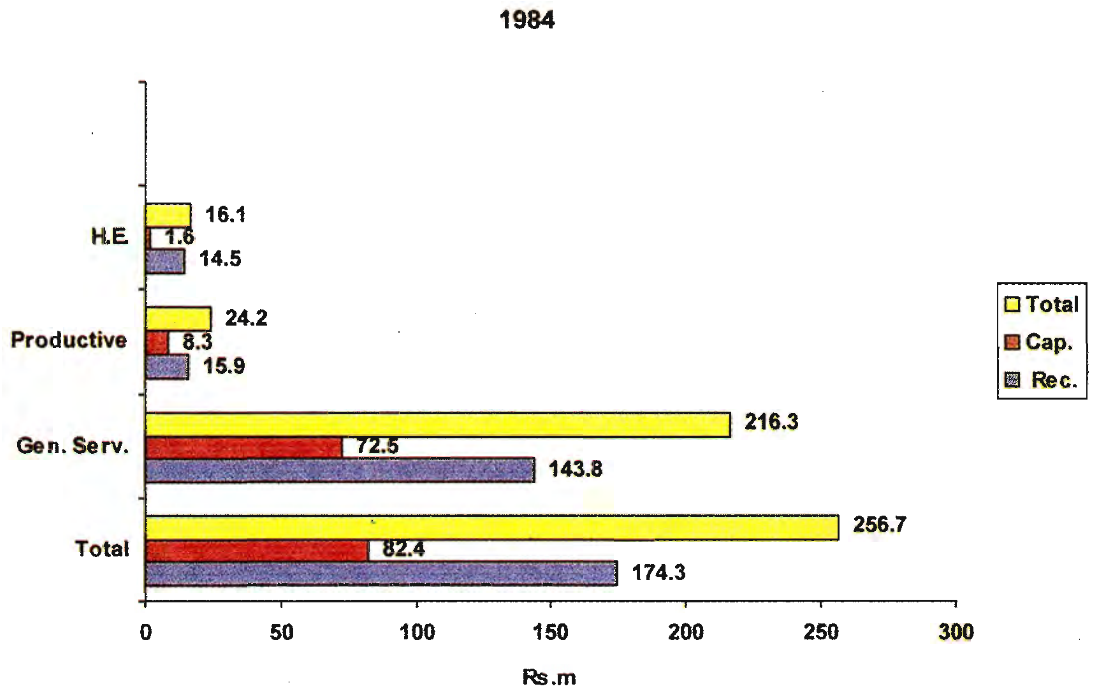
Experimental Development

Systematic activities undertaken to test the feasibility or put into practical use the knowledge generated by Basic and Applied research and the introduction of improved materials, products, devices and processes, including development of prototypes and pilot plants.

Table 3.4 Expenditure on R&D by Nature of Research Activity

Year	1975(Recurrent only)		1984		1996	
Nature of activity	Amount Rs. m	Per cent	Amount Rs. m	Per cent	Amount Rs. m	Per cent
Basic Research	1.23	4.0	24.75	10.0	446.3	32.0
Applied Research	25.32	77.0	185.16	72.0	867.3	61.0
Experimental Development	6.12	19.0	46.89	18.0	96.0	7.0
TOTAL	32.67	100.0	256.80	100.0	1,409.6	100.0

Fig 3. R&D Expenditure by Sector



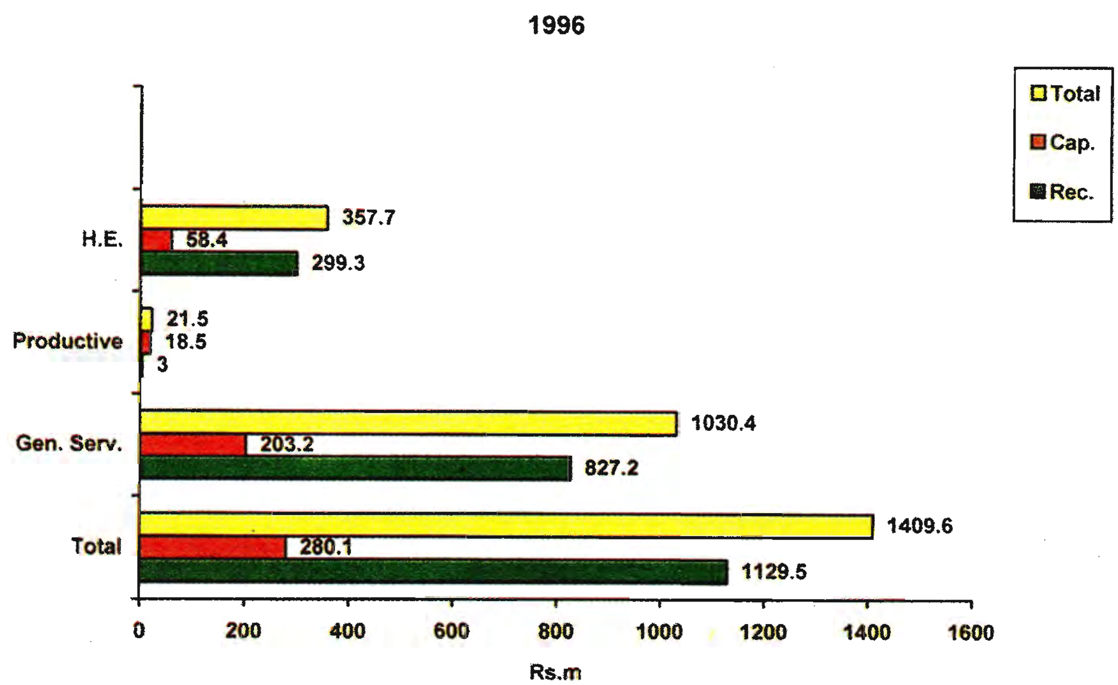


Table 3.4 gives the composition of R&D expenditure according to nature of research. The expenditure on basic research has maintained an increasing trend - more than doubling from 4 per cent in 1975 to 10 per cent in 1984 and trebling from 10 per cent to 32 per cent in 1996.

In developing countries the applied research component is as high as 70-80 per cent of R&D while basic research and experimental development are of low priority. Scientists in the third world realise the importance of basic research to establish a stable scientific base. However, according to national priorities most of the funds for research are directed towards problem oriented research at applied research institutions. Most basic research is conducted by university researchers.

Experimental Development Activities are undertaken mainly at the state sponsored institutions such as the Industrial Development Board (IDB), Ceylon Institute of Scientific and Industrial Research (CISIR), National Engineering Research and Development Centre (NERD) and National Building Research Organisation (NBRO). They service both public and private sector organisations in promoting commercialization and marketing of applied research findings. However, due to shortage of financial and human resources and the absence of a co-ordinated industrial development strategy their impact has been limited. Some of the large private sector firms and multinationals such as Unilevers undertake their own experimental development activities.

3.5 R&D Expenditure by Sector

Table 3.5 gives the distribution of R&D expenditure by sector of performance at current prices. The General services sector is the highest consumer of R&D expenditure (73 per cent) while the expenditure in the Productive Sector and Higher Education sector represents only 28 per cent of the total R&D expenditure. The sectoral distribution of expenditure shows a considerable deviation when compared to 1984.

Table 3.5 R&D Expenditure by Sector of Performance

Year	1984			1996		
Sector	Recurrent Rs. m	Capital Rs. m	Total Rs. m	Recurrent Rs. m	Capital Rs. m	Total Rs. m
General Services	143.8 (56.0 %)	72.5 (28.3 %)	216.3 (84.3 %)	827.2 (58.7 %)	203.2 (14.4 %)	1030.4 (73.1 %)
Productive	15.9 (6.2 %)	8.3 (3.2 %)	24.2 (9.4 %)	3.0 (0.2 %)	18.5 (1.3 %)	21.5 (1.5 %)
Higher Education	14.6 (5.7 %)	1.6 (0.6 %)	16.2 (6.3 %)	299.3 (21.2 %)	58.4 (4.2 %)	357.7 (25.4 %)
TOTAL	174.3 (67.9 %)	82.4 (32.1 %)	256.7 (100.0%)	1129.5 (80.1%)	280.1 (19.9%)	1409.6 (100.0%)

A salient feature is the substantial increase of R&D expenditure in the Higher Education sector. This increase could be attributed partly to the salary increases in the Higher Education sector compared to the other sectors and partly to an increase in research activities. This is evident from the fact that the proportion of recurrent expenditure in the Higher Education sector has nearly quadrupled from 5.6 per cent in 1984 to 21.2 per cent in 1996, while the proportion of capital expenditure in the Higher Education sector has increased seven fold from 0.6 per cent in 1984 to 4.2 per cent in 1996.

The percentage of time spent on research by the academic staff was used to calculate the proportion of salaries to be included in the recurrent R&D expenditure. The statistics published by the University Grants Commission on the basis of actual estimates given by Heads of Departments for each university and faculty were used for this purpose. It is significant that there are wide variations between faculties and universities depending on teaching loads, disciplines and facilities for research. In general high rates were reported by faculties of architecture, agriculture, science and medicine and low rates by faculties of management, education and cultural studies at the other end of the spectrum.

Since the technical staff and the non-academic staff provided supporting services to the academic staff in both teaching and research functions, it was felt that a proportion of their salaries should also be added to the recurrent R&D expenditure in the Higher Education sector.

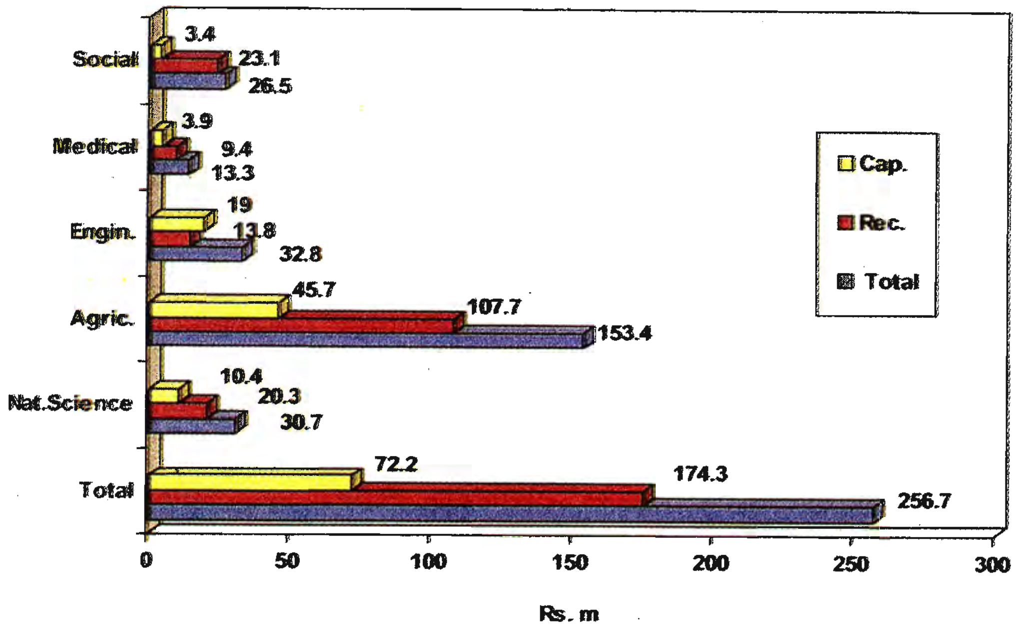
Due to non-availability of an accepted mechanism to estimate the contribution of the non-academic staff the relevant component was estimated at 10 per cent while for the technical staff and for all academic services it was decided to use an estimate of 15 per cent, which was approximately the average time spent on research by academics of all faculties and universities taken as a whole.

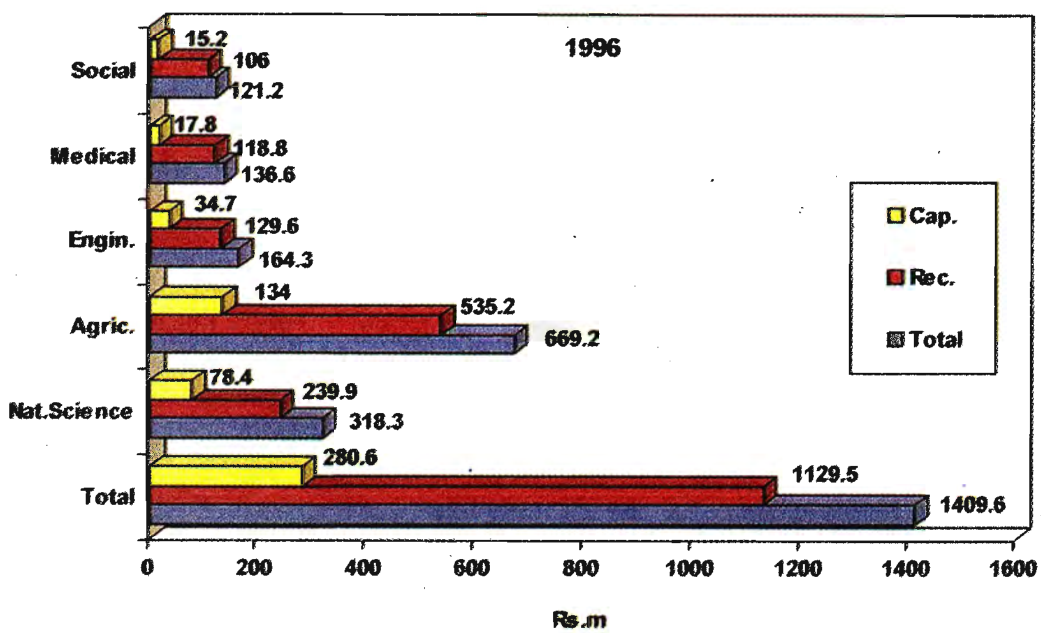
In addition, researchers use equipment which is usually categorized as laboratory and teaching equipment for both research and teaching purposes. Therefore, a part of that expenditure together with a part of the expenditure on new buildings should be added to the R&D capital expenditure in the H.E. Sector. Again, there is no valid formula to measure the share that should be included in the R&D expenditure and a conservative estimate of 10 per cent of the total capital expenditure was used.

With regard to the productive sector, inquiries revealed that many process/product development activities in private sector firms which are involved in export oriented marketing are not being captured in the estimate of R&D expenditure. The records at EDB, CISIR and AgEnt show that many process development activities are taking place. However, most of the entrepreneurs who were contacted are either not interested or not in a position to quantify such efforts. Therefore, the efforts made on the incremental process/product development activities are not included in this study but could be the subject of a special study later.

There are a limited number of large firms in the private sector which are export-oriented but they have links with multinationals and depend more on available technologies developed abroad which give quick returns. They have made only marginal efforts to develop their own R&D activities. As a result of this under-reporting and consequent under-estimation the relative share of the productive sector has decreased from 9.4 per cent in 1984 to 1.5 per cent in 1996.

Fig. 4 R&D Expenditure by Discipline





3.6 R&D Expenditure by Discipline

Table 3.6 gives the breakdown of R&D expenditure by discipline for 1996 with comparative figures 1984. The Agriculture sector (when classified according to the institutional basis) still dominates the country scenario with 47.4 per cent of total expenditure. Although, compared to 1984 the percentage share of the agricultural sector has dropped by 12 per cent, in absolute terms the total expenditure has increased over ten-fold from Rs. 153.4 million in 1984 to Rs. 669.2 million in 1996.

In contrast, the medical (9.7 per cent) and natural sciences (22.6 per cent) have increased its share of R&D expenditure indicating a significant shift of funding and research activity towards these two disciplines. It is significant that these two disciplines, in particular medical sciences, have attracted a substantial amount of foreign funding in recent years.

Table 3.6 R&D Expenditure by Discipline and Type

Year	1984			1996		
Discipline	Recurrent Rs. m	Capital Rs. m	Total Rs. m	Recurrent Rs. m	Capital Rs. m	Total Rs. m
Natural Sciences	20.3	10.4	30.7	239.9	78.4	318.3
	(7.9 %)	(4.1 %)	(12.0 %)	(17.1 %)	(5.5 %)	(22.6 %)
Agriculture	107.7	45.7	153.4	535.2	134.0	669.2
	(42.0 %)	(17.8 %)	(59.8 %)	(37.9 %)	(9.5 %)	(47.4 %)
Engineering	13.8	19.0	32.8	129.6	34.7	164.3
	(5.4 %)	(7.4 %)	(12.8 %)	(9.2 %)	(2.4 %)	(11.6 %)
Medical Sciences	9.4	3.9	13.3	118.8	17.8	136.6
	(3.7 %)	(1.5 %)	(5.2 %)	(8.4 %)	(1.2 %)	(9.7 %)
Social Sciences	23.1	3.4	26.5	106.0	15.2	121.2
	(9.0 %)	(1.2 %)	(10.2%)	(7.5 %)	(1.1 %)	(8.6 %)
TOTAL	174.3	82.4	256.7	1129.5	280.1	1409.6
	(67.9 %)	(32.1 %)	(100.0 %)	(80.1 %)	(19.9 %)	(100.0 %)

3.7 Type of Funding (Recurrent & Capital)

When comparing the type of funding by sector (vide Table 3.5) a differential pattern emerges across the sectors. In the General services sector the ratio of recurrent to capital expenditure has doubled from 2 : 1 in 1984 to 4 :1 in 1996, while in the University sector the ratio has almost halved from 9 : 1 in 1984 to 5 : 1 in 1996.

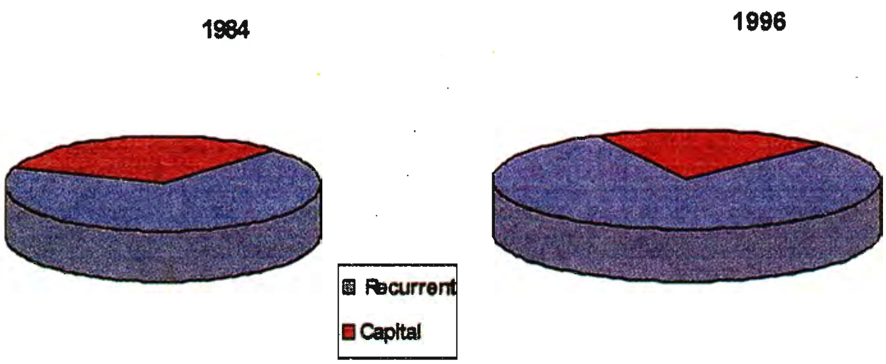
In the Productive sector a striking feature is the three-fold increase in capital expenditure and a significant reversal in the ratio of capital to recurrent from 1 : 2 in 1984 to 6 : 1 in1996. This could be attributed to increase in expenditure on buildings, machinery and equipment by the private sector to meet the challenges of modernization, rationalization and export orientation of the economy.

The breakdown of expenditure by type and discipline shows a more uniform trend, with recurrent expenditure being four times higher than capital expenditure across all disciplines This is a significant increase from 1984 when the recurrent to capital ratio was only 2 : 1 . A major reason for this general trend could be the increased level of salaries compared to the level of spending on equipment.

During the year under review it appears that no major buildings were constructed within the General Services sector and the Higher Education sector, which together account for 98.5 per cent of total R&D expenditure. The capital expenditure mainly represents the funds used for equipment. Hence it could be contended that the state sector R&D system is struggling to maintain its level of activities within existing facilities with no major approaches to use of new technologies.

Compared to 1984, the above trend to spend more on the recurrent component is reflected in foreign sources also.

Fig. 5 R&D Expenditure by Type



Chapter 4

SCIENTIFIC & TECHNOLOGICAL MANPOWER RESOURCES (STP)

4.1 General Definitions

The stock of economically active Scientific and Technological Personnel (STP) is a key indicator of scientific and technical capability in the country. The S&T personnel can be broadly categorized into three types, namely:

a) Scientists
b) Technicians
c) Auxiliary Personnel

The term 'scientist' includes any person engaged in S&T activities who has received scientific and technical training in any field of science (natural sciences, engineering, medical, agricultural and social sciences) in accordance with the UNESCO definition of 1985 (see **Annex 2**).

The term 'technician' includes any person engaged in S&T activities who has received special vocational or technical training in any branch of science and technology in accordance with the above mentioned UNESCO definition.

The term 'auxiliary personnel' covers those persons who are indirectly associated with the performance of S&T activities within the economic framework. This category, which includes administrative personnel, clerical and secretarial staff and semi-skilled workers, are subsumed in other economic activities and it is extremely difficult to identify and measure their contribution to S&T activities. Hence they have been excluded from this study and from previous studies undertaken in Sri Lanka.

However, two important sub-sets of auxiliary personnel who make an important contribution to S&T activities and to the development of S&T capability are i) medical officers of health with the first degree (MBBS) serving in the health sector and ii) secondary school graduate and certificated teachers of science and mathematics. They too have been excluded from the main STP analysis to maintain consistency, but some relevant statistics on these two categories are provided in the next chapter.

4.2 General Trends

The data gathered in this survey is analyzed on the basis of the above conceptual framework. The total number of economically active scientists has increased marginally to 13,286 in 1996 compared to 10,579 in 1984. On the other hand, the number of technicians has increased substantially from 3,908 in 1984 to 14,514 in 1996. Although part of this increase could be due to under-reporting in the earlier surveys, it is evident that there is still a significant increase in technicians in the work force.

The relatively slow growth rate of economically active scientists in the work force can be attributed mainly to the brain drain of scientists and professionals to the developed countries which offer more attractive remuneration, better working conditions and a more stable socio-economic environment.

According to a study conducted by a high level ministerial committee in 1974, during a 36 month period from May 1971 to June 1974, the number of professionals migrating abroad was 1,705, i.e. 18 per cent of the total STP manpower available in the country at the time. A more recent study conducted by the Marga Institute (an NGO) estimates the total professional migration during 1980 to 1985 to be 9,059.

Correspondingly, the high growth rate of economically active technicians in the work force suggests that there is an increasing demand for technicians to fill the hiatus created by migration of scientists. In the light of the highly competitive nature of the international demand for scientists it is most likely that the majority of scientists who migrated are in the top category with internationally recognized qualifications, marketable skills and considerable experience. Hence the combined effect of these two trends could lead to a weakening of S&T capability and efficiency within the country in the long run.

4.3 Deployment of S&T Personnel by Sector of Performance

There are three main sectors of performance. The General Services sector which includes a large number of state sector institutions servicing the entire community. The Productive sector which includes industrial and trading establishments which are engaged in the production, distribution and export of goods and services. The Higher Education sector which covers all educational establishments at the tertiary level and postgraduate research centres.

Table 4.1 Distribution of STP by Sector

Year	1984		1996	
Sector	STP		STP	
	No.	Per cent	No.	Per cent
General Services	8,620	59.5	18,645	67.1
Productive	3,603	24.9	5,165	18.6
Higher Education	2,264	15.6	3,990	14.3
TOTAL	14,487	100.0	27,800	100.0

It is seen from Table 4.1 that the majority of scientific personnel are employed in the General Services sector (67 per cent), which provides a wide range of S&T services such as quality control, testing, standardization and training in addition to research and development. The productive sector employs 19 per cent while the Higher Education sector employs only 14 per cent of total STP in the country.

The comparative statistics for 1984 shows a marginal shift to the General Services sector from 59.5 per cent to 67.1 per cent and a decline in the Productive sector from 24.9 per cent to 18.6 per cent and Higher Education sector from 15.6 per cent to 14.3 per cent. However, in absolute terms the number of scientific personnel employed in the private sector has increased by 43 per cent from 3,603 in 1984 to 5,165 in 1996, reflecting an increasing reliance on the application of science and technology in the private sector.

Fig. 6 STP by Sector

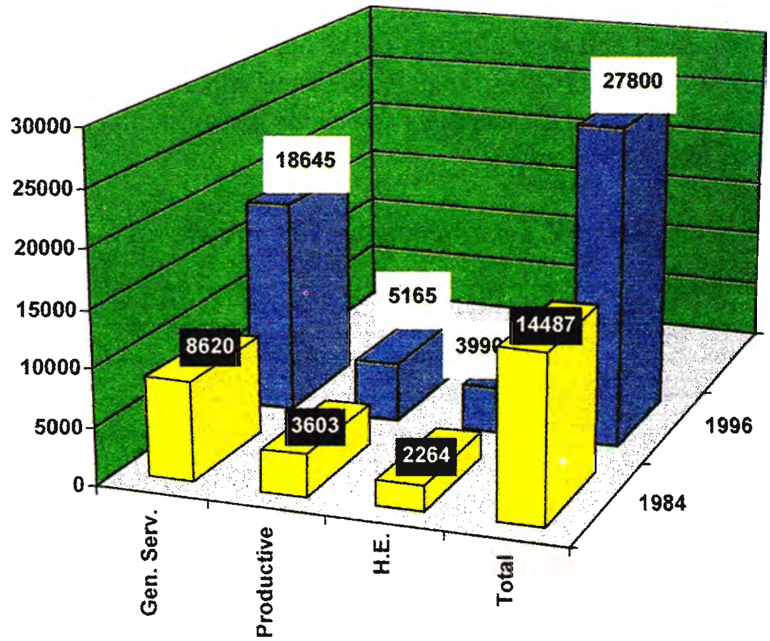
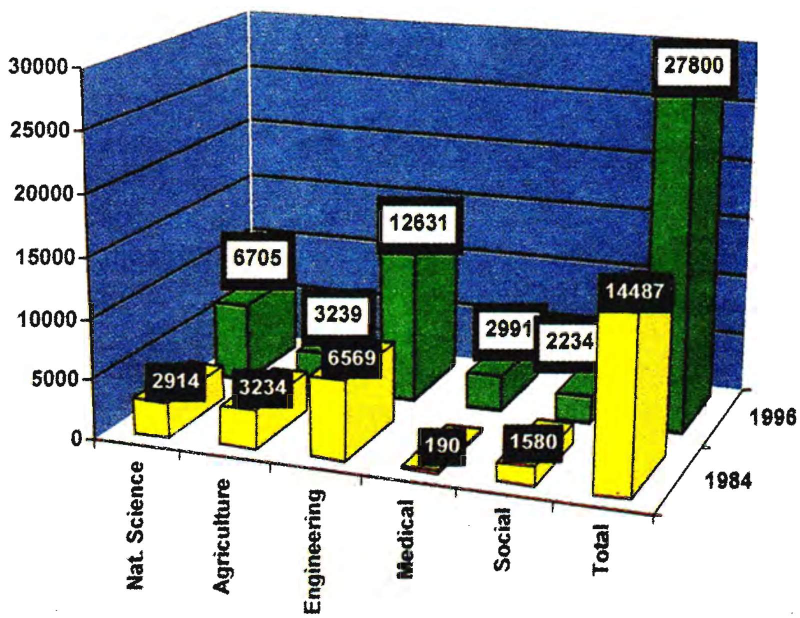


Fig. 7 STP by Discipline



4.4 Distribution of S&T Personnel by Discipline

The distribution of scientists and technicians by discipline is shown in Table 4.2. The highest percentage of scientists and technicians is in the engineering (45.4 per cent) discipline, followed by natural scientists (24.1 per cent) and agriculturists (11.7 per cent). The distribution pattern is somewhat different from the 1984 statistics, mainly because medical scientists were under-reported and a large number of natural scientists working in agricultural institutions were classified as natural scientists in the 1984 survey.

Table 4.2 Distribution of Scientists and Technicians by Discipline

Year	1984		1996	
Discipline	STP		STP	
	No.	Per cent	No.	Per cent
Natural sciences	2,914	20.1	6,705	24.1
Agriculture	3,234	22.3	3,239	11.7
Engineering	6,569	45.4	12,631	45.4
Medical sciences	190	1.3	2,991	10.8
Social sciences	1,580	10.9	2,234	8.0
TOTAL	14,487	100.0	27,800	100.0

4.5 Major Fields of Specialization of S&T Personnel

The fields of specialization of the scientific and technical personnel is a good indicator of the expertise available in the country, research priorities and the direction of research funding. Some of the major fields of specialization based on information supplied by institutions and individual scientists are listed below, but the list is not exhaustive.

Agriculture

Agricultural Economics	27
Agricultural Chemistry	10
Agricultural Engineering	16
Agricultural Biology	17
Agricultural Plantation	21
Agronomy	113
Animal Science	263
Food Science	11
Food Technology	19
Forestry	17
Genetics	09
Plant Breeding	39
Plant Pathology	23
Plant Physiology	22
Post Harvest Technology	15
Soil Chemistry	11
Soil Science	31
Horticulture	16

Engineering

Chemical Engineering	78
Civil Engineering	1736
Electrical Engineering	848
Electronics	35
Mechanical Engineering	450
Mining	11
Textile Technology	11
Town & Country Planning	46
Hydrogeology	17
Irrigation	12

Medical Sciences

Anaesthesiology	21
Anatomy	12
Community medicine	44
Epidemiology	09
Forensic Medicine	12
Medical Parasitology	10
Medicine	79
Microbiology	43
Obstetrics & Gynaecology	57
Ophthalmology	17
Pediatrics	51
Pathology	32
Pharmacology	15
Physiology	13
Psychiatry	17
Radiotherapy & Oncology	16
Surgery	78
Traditional Medicine	17
Virology	15

Natural sciences

Analytical Chemistry	11
Biochemistry	35
Botany	28
Chemistry	95
Histopathology	17
Entomology	48
Environmental Science	18
Organic Chemistry	18
Rubber Technology	15
Quality Control	16
Radiology	20
Geology	18
Physics	43
Mathematics	43
Mathematics & Statistics	21
Computer Science	33
Statistics & Computer Science	43
Statistics	15
Surveying	71

4.6 Educational Attainment of S&T Personnel

The breakdown of scientists by discipline and level of education is a key indicator of the depth and vitality of S&T capability in the country. Details are shown in Table 4.3 below. The number of scientists with doctoral degrees and those with master's degrees has doubled from 1984 to 1996 while the number with bachelor's degrees has declined marginally. The percentage of scientists with doctoral degrees in the work force has increased from 7 per cent in 1984 to 11 per cent in1996 and the percentage of scientists with master's degrees from 10 per cent in 1984 to 16 per cent in 1996.

Table 4.3 Educational qualifications of S&T scientists

Year	1984				1996		
Qualifications / Discipline	Bachelors	Post-grad. Diploma	Masters	Doctoral	Bachelors	Masters	Doctoral
Natural Sciences	1,919	100	488	336	1,704	607	489
Agriculture					440	240	125
Engineering	3,076	152	353	102	3,048	453	127
Medical Sciences	223	34	59	25	886	206	442*
Social Sciences	1,352	122	116	256	888	610	290
TOTAL	6,570	408	1,016	719	6,966	2,116	1,473
% of Scientists	62	4	10	7	52	16	11

*Includes MD

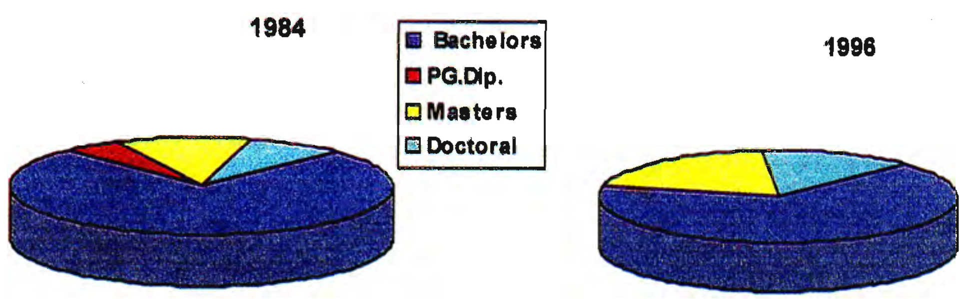
The major reasons for this trend can be identified as the increased availability of higher degree courses in national universities, the establishment of postgraduate research institutes affiliated to universities and the desire of young scientists to obtain postgraduate qualifications in order to enhance their job and promotion prospects. While this trend is very encouraging for the future and has contributed significantly to improving the quality and performance of the STP work force, the question remains as to what extent it has compensated for the brain drain of experienced middle and top level scientists with international exposure.

The comparable figures for India which are given below in Table 4.4 reveals the gap which exists between the R&D capability of the two countries - India has nearly 50 per cent postgraduates compared to only 27 per cent in Sri Lanka.

Table 4.4 Comparative Statistics on Educational Qualifications

Country	India		Sri Lanka	
Qualifications	No.	Per cent	No.	Per cent
Doctoral	15,243	18.2	1,473	11.1
Masters and other Postgraduate	26,004	31.0	2,116	15.9
Bachelors	25,469	30.3	6,966	52.4
Diploma/Other	17,176	20.5	2,731	20.6
TOTAL	83,892	100.0	12,544	100.0

Fig. 8 STP by Educational Qualifications



4.7 Distribution of S&T Personnel by Sex

The distribution of scientists by sex and discipline (based on a 50 per cent sample) is presented in Table 4.5. Technicians were excluded from this analysis as sufficient data was not available.

Table 4.5 Distribution of Scientists by Sex and Discipline

Year	1996			
Sex / Discipline	Male	Female	Total	Per cent Female
Natural Sciences	1,801	1,064	2,865	37.1
Agriculture	614	274	888	30.9
Engineering	4,402	714	5,116	14.0
Medical Sciences	1,278	905	2,183	41.5
Social Sciences	1,612	622	2,234	27.8
TOTAL **1996**	9,707	3,579	13,286	**26.9**
TOTAL **1984**	8,916	1,663	10,529	**15.8**

An encouraging trend is the increasing number of females entering the STP work force. Female scientists constitute 27 per cent of the work force in 1996 compared to 16 per cent in 1984. The highest percentage of female employment is in the medical sciences (42 per cent), closely followed by natural sciences (37 per cent) and agriculture (31 per cent). The lowest proportion of females are in engineering (14 per cent), but in this discipline too the proportion of females has doubled since 1984.

The distribution of scientists by sector and sex presented in Table 4.6 shows that the proportion of females is highest in the Higher education sector (38 per cent), while the General services sector has employed 29 per cent and the Productive sector only 15 per cent of females. The comparative figures for 1984 show a similar pattern, but the proportion of females has increased across all sectors.

Table 4.6 Distribution of Scientists by Sex and Sector

Year	1984				1996			
Sex / Sector	Male	Female	Total	% F	Male	Female	Total	% F
General Services	5,101	1,006	6,107	16.5	4,178	1,719	5,897	29.1
Productive	2,275	184	2,459	7.5	3,476	623	4,099	15.2
Higher Education	1,540	473	2,013	23.5	2,053	1,237	3,290	37.5
TOTAL	8,916	1.663	10,579	15.7	9,707	3,579	13,286	26.9

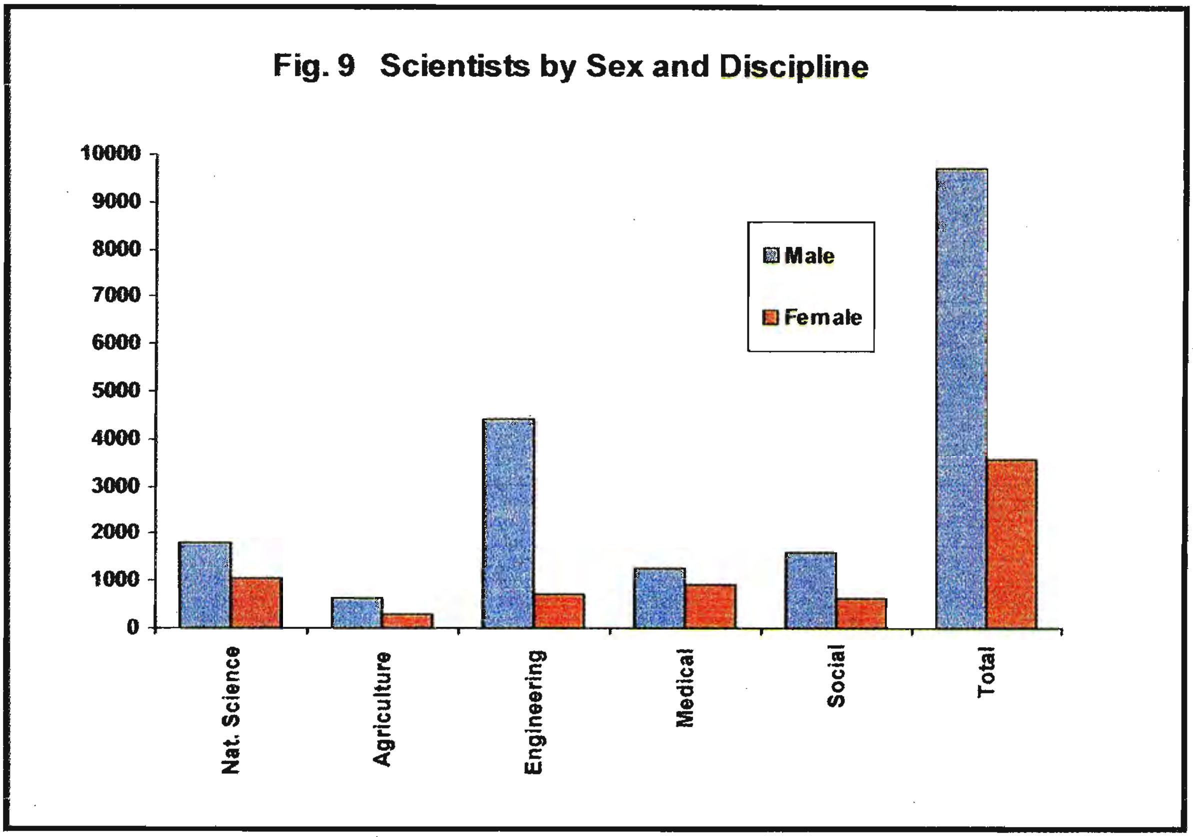


Fig. 9 Scientists by Sex and Discipline
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Male
Female
Nat. Science
Agriculture
Engineering
Medical
Social
Total

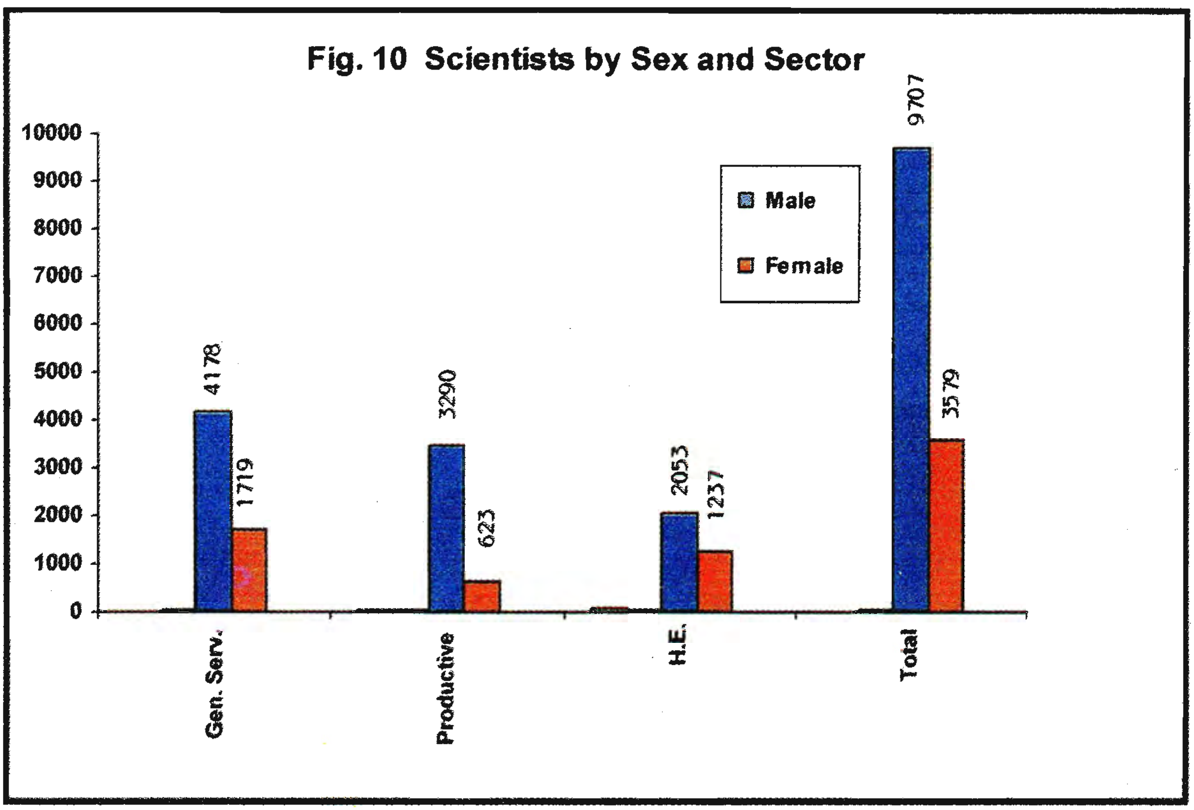


Fig. 10 Scientists by Sex and Sector
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Male
Female
4178
1719
3290
623
2053
1237
9707
3579
Gen. Serv.
Productive
H.E.
Total

4.8 Technical Support Index

The ratio of technicians to scientists is defined as the Technical Support Index and is an important indicator of the support extended to researchers. The technical support staff can carry out a great deal of the routine work associated with research and thereby extend research activity to a significant extent in countries like Sri Lanka where there is a shortage of top level researchers.

The breakdown of the Technical Support Index by sector is given in Table 4.7.

Table 4.7 Technical Support Index by Sector

Sector	Scientists	Technicians	Technical Support Index
General Services	5,897	12,748	2.17
Productive	4,099	1,076	0.26
Higher Education	3,290	700	0.21
TOTAL	13,286	14,514	1.09

The General Services sector has a high technical support index of 2.2 because of the large number of technicians employed by state sector institutions and departments which provide an island-wide network of infrastructural services, such as the Ceylon Electricity Board, Telecommunications Department and Irrigation Department. The Productive sector and the Higher Education sector have a very low technical support index.

It is seen from Table 4.8 that the technical support index is highest in the disciplines of agriculture and natural sciences (1.65) and lowest in medical sciences (0.37). However, it should be noted that in the field of medical sciences, the ratio would be much higher if auxiliary personnel serving in hospitals throughout the island such as medical doctors with first degree, nurses and para-medicals are included as support staff. In social sciences, field investigators are used for data collection and verification. Their services are used mostly in a temporary capacity on a project basis and no data on numbers is available.

Table 4.8 Technical Support Index by Discipline

Discipline	Scientists	Technicians	Technical Support Index
Natural Sciences and Agriculture	3,753	6,191	1.65
Engineering	5,116	7,515	1.47
Medical Sciences	2,183	808	0.37
Social Sciences	2,234	-	
TOTAL	13,286	14,514	1.09

4.9 Auxiliary Personnel in Medical Sciences

The Ministry of Health of GOSL has the primary responsibility for the protection and promotion of people's health predicated on the main premise of providing free and accessible health care in the public sector to all citizens. It's key functions include setting policy guidelines; conducting medical and para-medical education; management of teaching and specialized institutions and hospitals; and bulk purchase and distribution of medical supplies.

The Ministry of Health has an island-wide administrative set-up under eight Regional Directors of Health Services assisted by 23 Deputies. Each Deputy Director's area is sub-divided into several Divisional Director of Health Services areas, congruent with the Divisional Secretariats which are the main administrative units in the country. The Divisional Directors are responsible for preventive, promotive and curative services in the D.S. Division.

Community health services which include disease prevention, health and nutrition promotion and family welfare services are provided by field level health personnel such as public health inspectors and midwives. Patient care services are provided on a three tier basis by a network of curative institutions ranging from central dispensaries providing out-patient care, maternity homes, rural hospitals, peripheral and district hospitals providing primary health care; base and provincial hospitals which provide secondary health care and teaching hospitals and special hospitals which provide tertiary health care.

This extensive network of free health services and a consistent policy of successive governments prioritizing investments in the field of health have given Sri Lanka a better health status than most of the developing countries and health indices such as Human Development Index (HDI) of 0.704, life expectancy (74 years), maternal mortality rate (4.2 per 10,000 live births) and infant mortality rate (18.2 per 1000 live births) which compare favourably with those of developed countries. The total government expenditure on health during 1996 was Rs. 10,533 million, an increase of 10 per cent over the previous year. The expenditure on health comprised 5.5 per cent of total government expenditure and 1.6 per cent of GDP.

The total health manpower in 1995 comprised 4,069 doctors excluding specialists (558), 421 dental surgeons, 1,376 registered/assistant medical practitioners, 13,403 staff nurses, 174 public health nursing sisters, 949 public health inspectors and 4,383 public health midwives. They are supported by 4, 690 para-medical personnel including 627 pharmacists, 617 dispensers, 620 medical laboratory technologists, 245 radiographers, 175 physiotherapists and 2,288 hospital midwives. The annual output of various categories of medical personnel in 1995 are given below:

Category	Institution	Output
Doctors	Universities	616
Dentists	"	125
Nurses	Nurses Training School	926
Pharmacists	Medical Faculty, Colombo	34
Physiotherapists	School of Physiotherapy	18
Radiographers	School of Radiography	21
Medical Lab. Technologists	MRI/NIHS	63

The Postgraduate Institute of Medicine provides postgraduate training locally and scholarships are granted for training at specialized institutions abroad. The National Institute of Health Services (NIHS) is the national focal point for health systems research. The NIHS provides basic training for all categories of public health staff, while in-service training and continuing education programmes are conducted for most categories.

4.10 Research & Development (R&D) Personnel

The proportion of S&T personnel engaged in R&D activities is a key indicator of intensity and quality of S&T activities in the country and their potential economic impact. The R&D component provides the new knowledge, innovations and solutions to problems which enhance S&T capability of the country and ensures that it is geared to national needs and priorities. For the purpose of classification under R&D, the OECD definitions of activities to be included and excluded were used as guidelines to maintain international comparability. A brief summary is given in **Annex 3.**

The proportion of R&D personnel in the STP work force is very small in developing countries compared to their strength in developed and highly industrialized countries and this contributes in some measure to the syndrome of under-development.

Table 4.9 . R&D resources in some South Asian Countries

Country	Total Population (1995) Millions	Adult Illiteracy Rates (1995)			R&D personnel per1,000 population (1988-95)	Tertiary Enrolment in Science per cent of Total Enrolment (1992)	Tertiary Students abroad per cent at home (1988-93)
		Male	Female	Total Adult			
Bangladesh	118.229	50.6	73.9	61.9	0.02	25	1.3
Bhutan	1.770	43.8	71.9	57.8			20.0
India	929.005	34.5	62.3	48.0	0.10	26	1.0
Nepal	21.457	59.1	86.0	72.5	0.04	14	3.2
Pakistan	136.257	50.0	75.6	62.2	0.10		3.9
Sri Lanka	17.928	6.6	12.8	9.8	0.20	34	10.0
Average least developed countries				52.0	0.30	33	
Average industrialized countries				1.0	3.30	30	

Source: World Science Report 1998

It is seen from Table 4.9 that the average R&D personnel per 10,000 population for industrialised countries (3.3) is over 10 times that of the least developed countries (0.3). The figures for all South Asian countries is even less than the average for least developed countries, with Sri Lanka having the highest ratio of 0.20. Despite a high literacy rate which is significantly above all the other countries in the region, Sri Lanka has an inexplicable shortage of technically qualified personnel.

The above indicator - i.e. number of R&D personnel per million population can be a useful measure for policy making where the targets can be set and achievements measured against the targets (e.g. to increase the stock of R&D scientists and engineers by two fold in five years time). By making such policy decisions and translating them into practice and at the same time targeting priority areas the R&D expenditure as a percentage of GDP will concomitantly increase to some desired level.

Furthermore, if the private sector industries are encouraged to involve in process/product changes targeting on value addition, by implementing policies such as tax benefits for R&D expenditure, the natural growth of S&T in the country can be promoted. Unfortunately, during the last twelve years there has been no visible attempt to increase the stock of R&D personnel by governmental policy decisions.

a) Computation of R&D Personnel

The identification and measurement of R&D personnel is beset with problems, since most R&D activities are carried out on a part-time basis by scientists and technicians attached to research institutions and research divisions of government departments and industrial firms, while a considerable proportion of their time is devoted to non-R&D activities such as testing, training and administration. This is more so in the case of developing countries where there is a shortage of trained personnel.

The actual number of personnel who are mainly or partly employed on R&D or Head Count data is measured initially. The conversion of the Head Count data into its Full-time Equivalent (FTE) in the case of part-time workers is done on the basis of actual working time devoted to R&D. The conversion factor will differ for various institutions and is difficult to evaluate.

In universities and institutions of higher education, research and teaching are inextricably linked as most academic staff perform both functions, and buildings, equipment and auxiliary services are used for both purposes. More-over, research results feed into teaching and teaching experience is inevitably an input into academic research. The actual time spent by academic researchers in each faculty of each university was obtained from statistics published by the UGC and verified by discussions with the respective Heads of Department. The Full-time Equivalent (FTE) for the Higher Education sector was computed on this basis.

b) R&D Personnel - Head Count

The total Head Count of scientists engaged in R&D in 1996 is estimated at 5,965 i.e. 47.6 per cent of the scientists in the STP work force, compared to 3,320 i.e. 31.4 per cent of the scientists in the STP work force in1984. The distribution of scientists and technicians engaged in R&D (Head Count) by sector are presented in Table 4.10.

Table 4.10 Distribution of R&D Scientists (Head Count) by Sector

Year	1984				1996			
Sector	Scientists No.	%	Technicians No.	%	Scientists No.	%	Technicians No.	%
General Services	1,344	48.2	462	66.7	1,916	32.2	533	53.4
Productive	204	7.3	43	6.2	56	0.9	64	6.4
Higher Education	1,242	44.5	188	27.1	3,993	66.9	402	40.2
TOTAL	2,790	100.0	693	100.0	5,965	100.0	999	100.0

There appears to be a major shift in the focus of research activity with the Higher Education sector increasing its participation from 45 per cent in 1984 to become the dominant sector in 1996 accounting for 67 per cent of R&D. The general sector which played the major role in 1984 with 48 per cent has declined to 32 per cent in 1996. The productive sector continues to play a very ineffective and dormant role, relying more on the other two sectors and imported technology to meet its requirements.

Two factors contributing to this trend could be the increase in postgraduate education facilities at the universities and postgraduate institutes and the increase in consultancy assignments to university personnel.

The distribution by discipline and sex is given in Table 4.11. It is seen that the highest percentage of R&D scientists are in natural sciences & agriculture (36 per cent) and social sciences (33 per cent) and the lowest percentage is in the field of engineering (7 per cent).

Table 4.11 Distribution of R&D Scientists (Head Count) by Discipline and Sex

Discipline	Head Count of R&D Scientists (1984)						Head Count of R&D Scientists (1996)					
	Male		Female		Total		Male		Female		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Natural Sciences	1,225	48	447	56	1,672	50	923	23	564	29	1,487	25
Agriculture*							547	14	119	6	666	11
Engineering	381	15	39	5	420	13	344	9	69	3	413	7
Medical Sciences	147	6	88	11	235	7	939	23	524	27	1,463	24
Social Sciences	775	31	218	28	993	30	1,251	31	685	35	1,936	33
TOTAL	2,528	100	792	100	3,320	100	4,004	100	1,961	100	5,965	100

* Included under Natural Sciences in 1984

c) **R&D Personnel - FTE & Research Intensity**

On conversion to the Full Time Equivalent (FTE), the total number engaged in full time R&D in 1996 works out to 3,448 (FTE) compared to 2,790 (FTE) in 1984. The Research Intensity measured as the ratio of FTE to total number of scientists in STP work force is 25.9 per cent which is a marginal decrease over 1984 (26.4 per cent). It is evident that while the number of scientists engaging in R&D activities has risen substantially in 1996, the percentage of time devoted by them to R&D is much less than in 1984. The Research Intensity by discipline and sex is given in Table 4.12

Table 4.12 Research Intensity by Sex

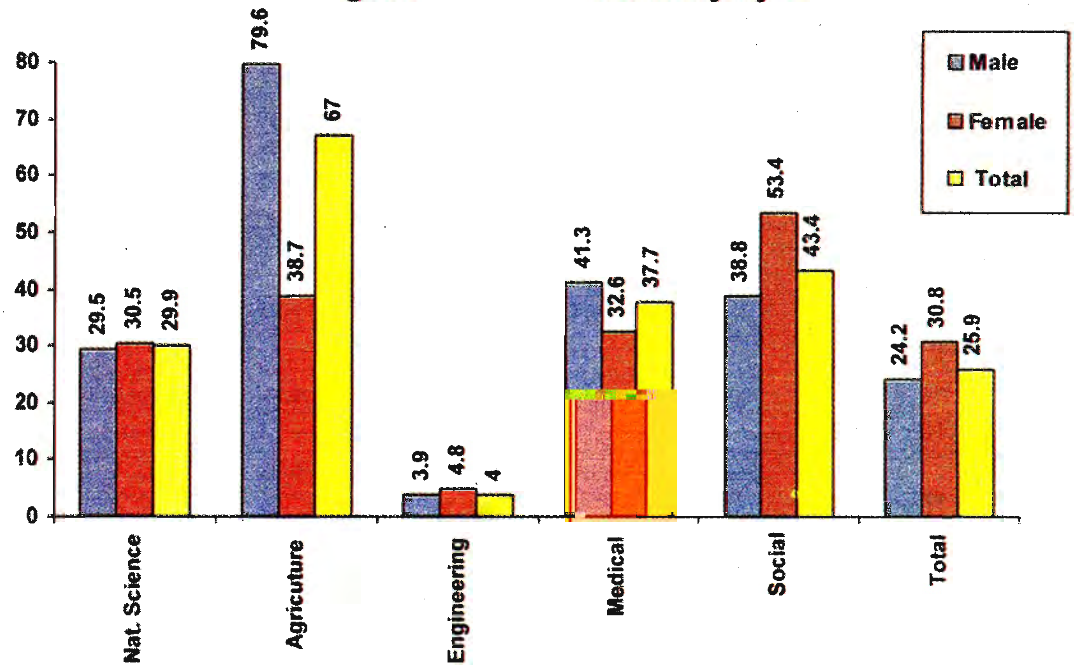
Discipline	R&D Scientists (Full Time Equivalent)				S&T Scientists				Research Intensity FTE / S&T		
	Male M	Female F	Total	% F	Male M	Female F	Total	% F	Male	Fe-male	Total
Natural Sciences	532	325	857	37.9	1,801	1,064	2,865	37.1	29.5	30.5	29.9
Agriculture	489	106	595	17.8	614	274	888	30.9	79.6	38.7	67.0
Engin-eering	170	34	204	16.7	4,402	714	5,116	14.0	3.9	4.8	4.0
Medical Sciences	528	295	823	35.8	1,278	905	2,183	41.5	41.3	32.6	37.7
Social Sciences	626	343	969	35.3	1,612	622	2,234	27.8	38.8	53.4	43.4
TOTAL	2,345	1,103	3,448	31.9	9,707	3,579	13,286	26.9	24.2	30.8	25.9

It is significant that females constitute nearly one third of the R&D workforce with high participation rates in natural (37.9), medical (35.8) and social sciences (35.3).

Not surprisingly the highest research intensity is in the field of agriculture (67.0), which is the backbone of the national economy and is well funded through several state sector research institutes. The next highest research intensity is in the social sciences (43.4) followed by medical sciences (37.7), which has a long tradition of research in the country and is also well funded by government and foreign sources. The lowest research intensity is in engineering (4.0).

A striking feature is that research intensity is higher for female scientists (30.8) compared to their male counterparts (24.2) with the highest differential of 53.4 for females against 38.8 for males in the social sciences. However, in the medical sciences males have a higher intensity of 41.3 compared to females 32.6 and in agriculture male research intensity (79.6) is more than double that of females (38.7).

Fig. 11 Research Intensity by Sex



The educational attainment of researchers has an important bearing on the quality and direction of research activities and is a vital index of growth and sustainability of R&D within a country. Table 4.13 gives the distribution of R&D scientists (FTE) by educational qualifications and discipline.

Table 4.13 Research Intensity by Educational Qualifications

Discipline	R&D Scientists (Full Time Equivalent)			S&T Scientists			Research Intensity FTE / S&T		
	Bach-elors	Masters	Doctoral	Bach-elors	Mas-ters	Doctoral	Bach-elors	Mas-ters	Doctoral
Nat. Science &Agriculture	807	390	255	2,144	847	614	36.8	46.0	41.5
Engineering	109	52	43	3,048	453	127	3.6	11.5	33.9
Medical Sciences	693	48	82	886	206	442	78.2	23.3	18.6
Social Sciences	585	324	60	888	610	290	65.9	53.1	20.7
TOTAL	2,194	814	440	6,966	2,116	1,473	31.4	38.5	29.9

The Research Intensity is highest in the master's degree category (38.5) and lowest in the doctoral category (29.9) due perhaps to senior scientists being over-burdened with administrative work, teaching loads and other responsibilities. The bachelor's category is inflated (31.4), particularly in medical and social fields due to the large numbers following postgraduate research.

Chart 4 Summary Indicators of Government Expenditure on Education

YEAR		1984	1989	1992	1995
1. GNP at current factor cost		136,638	222.399	379,179	591,245
2. Government Expenditure	Recurrent	31,842	56,014	90,215	142,869
	Capital	21,750	35,374	63,292	99,587
	Total	**53,592**	**91,388**	**153,507**	**242,456**
3. Expenditure on Education	Recurrent	2,746.7	6,389.4	11,367.1 (5,536.1)	16,972.3 (11,567.3)
	Capital	582.7	550.5	1,813.9 (338.9)	3,445.1 (427.9)
	Total	**3,329.4**	**6,939.9**	**13,181.0** (5,875.0)	**20,417.4** (11,995.2)
4. Expenditure on Higher Education	Recurrent	298.1	768.1	1,385.4	2,283.7
	Capital	393.5	420.6	965.7	630.3
	Total	**691.6**	**1,188.7**	**2,351.1**	**2,914.0**
5. Expenditure on University Education	Recurrent	249.8	634.2	1,229.6	2,213.8
	Capital	320.5	240.1	563.8	624.8
	Total	**570.3**	**874.3**	**1,793.4**	**2,838.6**
6. Education / GNP per cent	Recurrent	2.01	2.87	3.00	2.87
	Capital	0.43	0.25	0.48	0.58
	Total	**2.44**	**3.12**	**3.48**	**3.45**
7. Higher Education / GNP per cent	Recurrent	0.22	0.35	0.37	0.39
	Capital	0.29	0.19	0.25	0.11
	Total	**0.51**	**0.53**	**0.62**	**0.49**
8. University Education / GNP per cent	Recurrent	0.18	0.29	0.32	0.37
	Capital	0.23	0.11	0.15	0.11
	Total	**0.42**	**0.39**	**0.47**	**0.49**
9. Education / Total Government Expenditure per cent	Recurrent	8.63	11.41	12.60	11.88
	Capital	2.68	1.56	2.87	3.46
	Total	**6.21**	**7.59**	**8.59**	**8.42**
10. Higher Education / Education per cent	Recurrent	10.85	12.02	12.19	13.46
	Capital	67.53	76.40	53.24	18.30
	Total	**20.77**	**17.13**	**17.84**	**14.27**
11. University Education / Education per cent	Recurrent	9.09	9.93	10.82	13.04
	Capital	55.00	43.61	31.08	18.14
	Total	**17.13**	**12.60**	**13.61**	**13.90**
12. University Education / Higher Education per cent	Recurrent	83.80	82.57	88.75	96.94
	Capital	81.45	57.09	58.38	99.13
	Total	**82.46**	**73.55**	**76.28**	**97.41**

Source: Statistical Hand Book 1996 (UGC)

Chapter 5

DEVELOPMENT OF EDUCATION SECTOR

5.1 Overview

The present status of Science and Technology in Sri Lanka has to be reviewed against the background of the historical development of educational facilities and the establishment of an organizational structure for its administration throughout the island.

Sri Lanka invested significant financial resources in the development of an island-wide network of educational facilities since gaining Independence from colonial rule in 1948. The government had a virtual monopoly of educational services at primary, secondary and tertiary levels and has provided education in the national languages free of charge for all children since 1945. A network of primary and secondary government schools was set up throughout the island in the 1940s providing easy access to rural youth in the remotest villages. As a result there was a dramatic increase in school enrolment and a rise in literacy to levels comparable to those of developed countries.

However, the recent liberalization of the economy has led to the mushrooming of private educational institutes offering education in the English language at premium rates without adequate controls and this could result in lowering of standards.

5.2 Statistics on Secondary Education

Some relevant indicators of secondary education are given in Table 5.1.

Table 5.1 Statistics on Secondary Education

Indicator	1989	1991	1994	1995
Total No. of Schools	10,296	10,520	10,780	10,832
No. of schools with classes up to A/L	1,864	2,023	2,331	2,322
No. of schools with Science up to A/L	492	513	576	592
Per cent of A/L schools with Science	**26.4**	**25.4**	**24.7**	**25.7**
Total No. of students (in millions)	4.179	4.259	4.338	4.351
Total No. of teachers	150,057	173,811	190,957	195,210
Student/teacher Ratio	**27.8**	**24.5**	**22.7**	**22.3**
Total No. of graduate teachers	40,392	40,336	48,302	48,395*
Graduate teachers/total teachers	**26.9**	**23.2**	**25.3**	**24.8**
No. of Science graduate teachers(1)	3,528	3,502	4,730	n.a.
Science graduates/total grad. teachers	**8.7**	**8.7**	**9.8**	
Certificated science/math teachers(2)	15,641	17,207	19,633	n.a.
Uncertificated Science teachers (3)	2,824	4,529	1,146	n.a.
All Science teachers - (1), (2), & (3)	**21,993**	**21,736**	**20,779**	

Source: Statistical Abstract of Sri Lanka 1996 (* from Ministry of Education) n.a. not available

The total expenditure on education has increased from Rs. 6,940 million in 1989 to Rs.20,417 million in 1995 by the central government and a further Rs.11,995 million allocated under provincial councils. The expenditure on education as a proportion of total government expenditure has increased steadily from 7.5 per cent in 1989 to around 10 per cent in the 1990s in spite of heavy competing demands from other high priority sectors such as defence, agriculture and health. This trend reflects the country's continuing commitment to the development of human resources.

The total student population has increased steadily from 4.2 million in 1989 to 4.3 million in 1995. The number of teachers has increased from 150,000 in 1989 to 191,000 in1995, while the student teacher ratio has declined substantially from 28 in 1989 to 23 in 1995. The ratio of graduate teachers to total number of teachers is about 1 : 4 in 1995, while the ratio of science graduates to graduate teachers has risen from 8.7 per cent in 1989 to 9.8 per cent in 1995.

The number of science graduates employed as teachers in the work force in1995 is 4,700, while the total number of science and mathematics teachers, (including graduate, certificated and non-certificated) is 25,503, which is about 15 per cent of the total number of teachers. They are an important category of auxiliary personnel who have not been included in the STP analysis.

It is evident from these statistics that the number of science teachers working in the educational system is not adequate to accelerate the growth of science and technology and create a science culture throughout the country. One of the reasons for the paucity of science teachers is the higher job opportunities with better salary and promotional prospects available both in the private and public sectors to science graduates in preference to non-science graduates.

5.3 Expenditure on Higher Education

The expenditure on the Higher Education sector has increased steadily from Rs. 691.6 million in 1984 to Rs. 2,914 million in 1995 (see **Chart 4**). This represents an average annual increase of 14 per cent reflecting the importance attached by the government to investment in human resources. Within the Higher Education sector, capital expenditure has increased by 60 per cent from 1984 to 1995 while recurrent expenditure has escalated nearly eight-fold.

Other indicators of expenditure on Higher Education vis a vis other sectors are shown in Chart 4. The funds spent on Higher Education as a percentage of total education has declined from 21 per cent in 1984 to 14.3 per cent in 1995 reflecting a higher prioritization of secondary education in government policy planning. Expenditure on Higher Education as a percentage of GDP has remained more or less static at 0.5 per cent.

Foreign donor organizations have channeled substantial assistance to the Higher Education sector through direct grants to universities for teaching and research. Details of assistance for projects in operation during the year 1995 are given in **Annex 4**. The main beneficiaries are the Universities of Peradeniya (13 grants) and Colombo (12 grants). Some of the main donors are WHO, SAREC and IAEA. The key areas supported by foreign funding are medicine, agriculture, environment and archaeology.

5.4 Review of University System

The University system in Sri Lanka has undergone many vicissitudes since the first University of Ceylon was established in 1942 followed by a second campus at Peradeniya in 1949. Two prestigious ancient centres of Buddhist learning (pirivenas) were given university status in 1958 and re-named Vidyodaya University and Vidyalankara University, changing the established concept of a single university for the country. This led to the rapid expansion of science education and four university science faculties were in existence by 1967.

A major structural change in higher education came with the enactment of Act No. 1 of 1972 converting the four established universities and the College of Technology at Katubedde into five campuses of a single University of Sri Lanka reviving the old concept. A sixth campus was established in Jaffna in 1974. Under the provisions of this Act, tertiary education was further expanded by the creation of six specialized institutes including the Postgraduate Institutes of Agriculture and Medicine and the Institute of Ayurveda.

By the University Act of 1978 the six campuses were again converted into six autonomous universities. A unique feature of this Act was the creation of the University Grants Commission (UGC) as an apex body which allocates funds to all universities and institutes in the university system; monitors and reviews the system with a view to maintaining standards; and functions as the central admissions agency for undergraduate courses based on merit and district quotas set by government policy-makers.

At present the University system in Sri Lanka comprises the following institutions:

a) **National Universities** - At the end of 1996 there were 12 national Universities, viz. Universities of Colombo (1942), Peradeniya (1949), Kelaniya and Jayewardenapura (1958), Moratuwa (1972), Jaffna (1974), Ruhuna and Eastern (1984), Open University (1980), and Rajarata, Sabaragamuwa and South Eastern University College (1995).

b) **Postgraduate Institutes** - Six postgraduate institutes are in existence, namely: Postgraduate Institutes of Agriculture, Archaeology, Medicine, Management, Pali & Buddhist Studies and the newly established Postgraduate Institute of Science (1996).

c) **Other Institutes** - There are five other institutes of tertiary education in the university system, namely: Institutes of Aesthetic Studies, Computer Technology, Indigenous Medicine, Ayurveda and Worker's Education.

The conversion of three regional universities to national universities in 1995 to overcome regional disparities and the expansion of facilities by the creation of two new faculties and 21 new departments in existing national universities (see Table 5.2) to meet the growing demand for university education is ample evidence of the dynamism and vitality of the university system in Sri Lanka.

Table 5.2 New Faculties and Departments established in 1995*

University	Faculty	Department
Kelaniya	Commerce and Management	
Sri Jayewardenapura	Graduate Studies	
Kelaniya		Accountancy & Human Resource Management
		Commerce, Hindi
Open University		Health Sciences
Peradeniya		Agricultural Economics, Agricultural Extension
		Restorative Dentistry
Sri Jayewardenapura		Social Statistics, English
		Forestry, Marketing Management
		Faculty of Medical Sciences-6 existing departments were replaced by the following 15 departments: Anatomy, Biochemistry, Community & Family Medicine, Medicine, Forensic Medicine, Micro-biology, Pathology, Surgery, Obstetrics & Gynaecology, Paediatrics, Physiology, Parasitology, Pharmacology, Psychiatry, Medical Education

Other institutes have been set up from time to time as part of a continuous expansion programme to meet the insatiable demand for tertiary education in Sri Lanka. It is evident from the statistics of the UGC over the last four years presented in Table 5.3 that only about 16 per cent of those students who qualify for university entry are admitted to universities every year.

Table 5.3 Statistics of University Entrants*

Academic Year	No. of students satisfying minimum entry requirements	No. selected	Percent selected
1993/94	55,126	8,851	16.1
1994/95	59,292	9,460	15.9
1995/96	56,740	9,787	17.2
1996/97	70,111	11,200	16.0

In addition to free tuition, financial assistance in the form of Mahapola scholarships and government bursaries based on need is provided to the majority of undergraduates who come from non-affluent homes, as seen in Table 5.4

Table 5.4 Statistics of Financial Assistance to University Students*

Type of Assistance	No. of Students		
Year	**1994**	**1995**	**Increase**
Mahapola scholarships	15,661	16,796	+1135
Government Bursaries	14,601	15,700	+1101
TOTAL Assisted	30,261	32,496	+2236

*** Source; Statistical Hand Book 1996 (UGC)**

The apportionment of recurrent funds among the universities and institutes under the purview of the UGC is given in Table 5.5. It is seen that over 76 per cent of recurrent funds have been allocated to universities, 6 per cent to tertiary educational institutes and nearly 16 per cent for financial support of students. The distribution of students and staff among the institutions is also shown in Table 5.6. The average ratio of staff to full time undergraduate students in the conventional universities is 11.6 and the ratio of non-teaching to teaching staff is 2.4.

Table 5.5 Statistics on Higher Education - Funds, Student Enrolment and Staff (1995)

Institution	Recurrent Funds(Rs. million)	Total Enrolment Under-graduate	Total Enrolment Post-graduate	Total Enrol-ment Other	Acad-emic Staff*	Acad-emic Support Staff	Admin. Support Staff
a) Universities	**1,453**	**37,465**	**7,111**	**15,192**	**3,229**	**966**	**6,675**
Peradeniya	390	7,017	1,059	43	758	233	2,011
Colombo	200	6,083	1,852	116	542	94	851
Sri Jayewardenapura	125	5,413	364	30	398	93	601
Kelaniya	125	4,715	192	189	387	68	642
Moratuwa	118	1,848	274	1,133	236	133	537
Jaffna	110	1,804			302	54	530
Ruhuna	140	4,021	113		323	90	692
Eastern	40	974			113	31	225
Rajarata		93		501			
Sabaragamuwa	120	565		365			
South Eastern		267		70			
Sub Total	**1,368**	**32,800**	**3,854**	**2,447**	**3,059**	**796**	**6,089**
Open University	85	4,665	3,257	12,745	170	170	596
b) Institutes	**116**	**1,607**	**1,852**	**871**	**145**		**384**
Postgraduate	41	-	1,836	-	21	1	159
Other	75	1,607	16	871	124	45	225
c) University Grants Commission	**28**				6		**178**
d) Financial Assistance-Bursaries & Scholarships	303						
TOTAL Recurrent Funds	**1,900**						

Source: Statistical Hand Book 1996 (UGC) *Includes temporary staff

The total enrolment in 1995 comprised 32,800 undergraduate students and 3,850 postgraduate students in conventional universities; 4,330 students in the postgraduate and other higher educational institutes; and 20,667 students following postgraduate, undergraduate or diploma courses at the Open university. A further 76,000 were registered for external degrees at the Universities of Kelaniya, Peradeniya, Sri Jayewardenapura and Eastern university of which about 4,200 were following science courses.

The total enrolment in the university system in 1995 adds up to approximately 137,000. The full time undergraduate enrolment of 32,800 is an increase of 5% over the previous year, while total postgraduate enrolment in all universities and higher educational institutions has increased from 8,348 in 1994 to 8,863 in 1995.

5.5 University Undergraduate Admissions

The admissions for the year 1995/ 96 presented in Table 5.6 indicate an increase of 12 per cent over the previous year. It is seen that 54 per cent of the admissions are for Arts and allied streams while only 46 per cent are for Science based courses reflecting a mismatch with labour market demands. The University of Peradeniya has the highest intake of 18.6 per cent followed by the University of Jayewardenapura with 17 per cent and the University of Colombo with 15.2 per cent.

Table 5.6 University Undergraduate Admissions for year 1995/96

Discipline University	Arts/ Law	Commerce/ Management	Science	Medicine & Allied	Agric-ulture	Engin-eering	Total No.	Total %
Peradeniya	606		347	323	228	320	1,824	18.6
Colombo	679	250	373	184			1,486	15.2
Sri J'pura	500	794	226	140			1,660	17.0
Kelaniya	543	200	359	188			1,290	13.2
Moratuwa*						529	529	5.4
Jaffna	311	281	222	95	41		950	9.7
Ruhuna	358	205	313	117	134		1,127	11.5
Eastern	80	47	76		12		215	2.2
S. Eastern	70	39					109	1.1
Special Admissions	525	16	20	17	4	15	597	6.1
TOTAL	3,672	1,832	1,936	1,064	419	864	9,787	100.0
Per Cent	37.5	18.6	19.8	10.9	4.3	8.9	100.0	

Source: Sri Lankan Universities Year Book 1996

5.6 Output of University Graduates by Discipline and Sex

The output of graduates in the year 1995 by discipline and sex is presented in Table 5.7.

Table 5.7 Output of Graduates (Internal) by Discipline and Sex (1995)

Discipline University	Arts/Law		Com./ Mgt.		Science		Medicine & Allied		Agricul-ture		Engin-eering		Total	
	T	F	T	F	T	F	T	F	T	F	T	F	T	F
Peradeniya	532	283	16	4	179	74	216	107	163	78	220	27	1,326	573
Colombo	580	376	126	57	251	113	154	58					1,111	604
Sri J'pura	459	263	620	283	98	59							1,177	605
Kelaniya	527	252	110	44	173	80							810	376
Moratuwa*											294	54	294	54
Jaffna	n.a.	n.a.	n.a.	n.a.	167	79	60	27	n.a.	n.a.			227	106
Ruhuna	75	18	111	56	167	79	115	50	57	24			525	227
Eastern					74	28			6	2			80	30
TOTAL	2,173	1,192	983	444	1,109	512	545	242	226	104	514	81	5,550	2,575
Per Cent	39.2		17.7		19.9		9.8		4.1		9.3		100.0	
% Female		55		45		46		44		46		16		46

Source: Statistical Handbook 1996 (UGC) *Engineering includes Architecture & Quantity Surveying

n.a not available

Fig. 12 University GraduateOutput (1995)

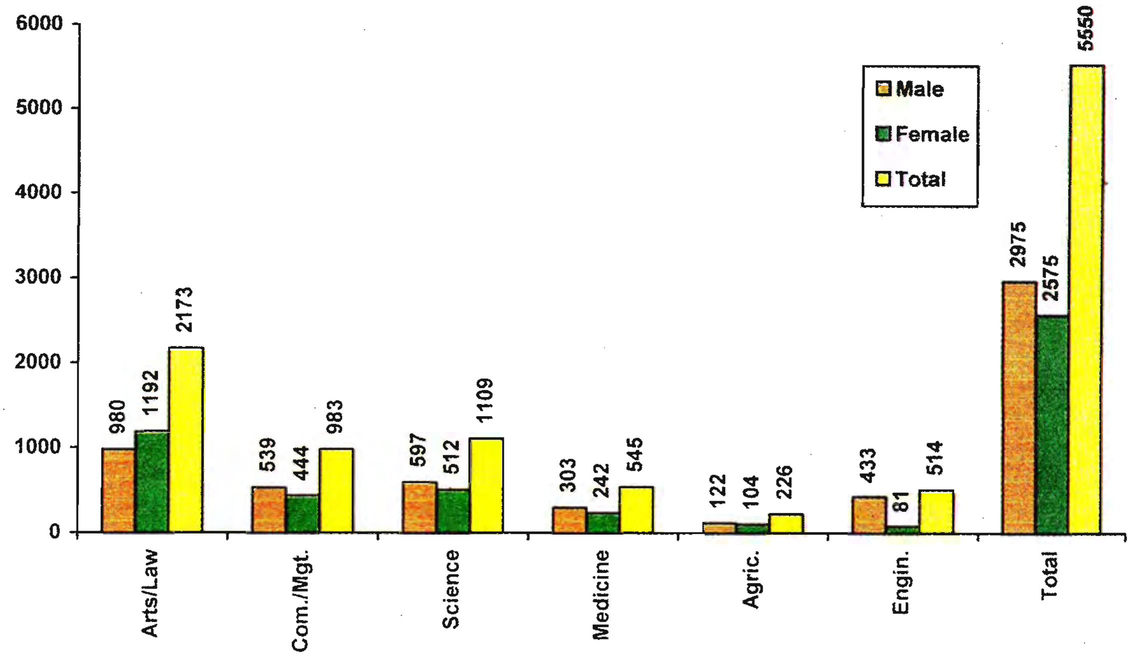
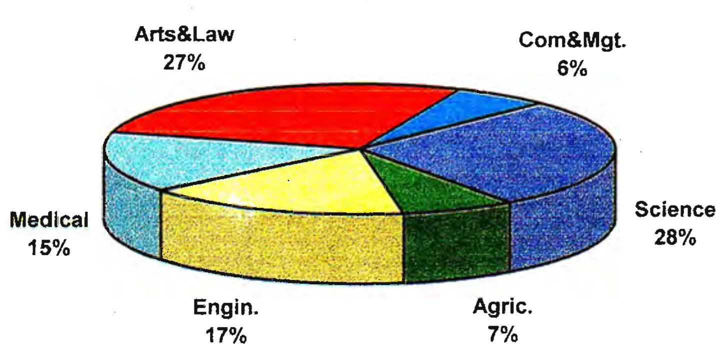


Fig. 13 Distribution of University Staff by Faculty



The percentage graduating in the arts streams is 56.9 while the total output in the science, medicine, agriculture and engineering streams is 43.1 percent. Science graduates account for 20 percent of total output while medical and engineering graduates constitute 10 and 9 per cent and agricultural graduates only 4 per cent. Females comprise about 46 per cent of the total output and this average is more or less consistent across disciplines except in Arts/Law where the percentage of females is as high as 55 per cent and Engineering where females constitute only 16 per cent of total output.

5.7 Distribution of Academic Staff among Universities and Faculties

The distribution of academic staff among Universities and Faculties shown in Table 5.8 indicates that the highest percentage is in the Science(27.6) stream followed by Arts(26.3) and Engineering (16.1).

Table 5.8 Distribution of Academic Staff by University and Faculty(1996)

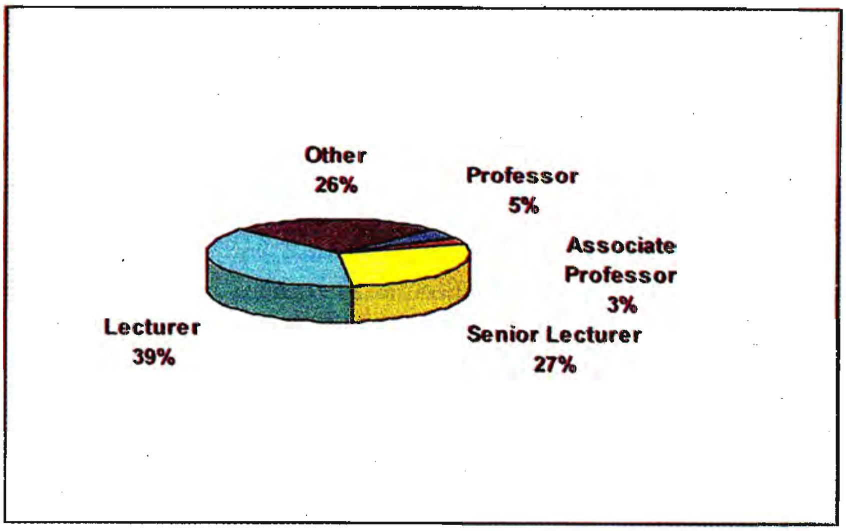
Faculty University	Science	Agriculture	Engineering	Architect.	Medicine	Dental	Veterin.	Arts	Law	Education	Com./ Mgt.	Total
Peradeniya	164	160	242		102	54	43	289				1,054
Colombo	192				119			143	36	27	38	555
Sri J'pura	61				51			112			100	324
Kelaniya	147				62			146			18	373
Moratuwa			275	34								309
Jaffna	130	24	1		37			93				285
Ruhuna	154	45			101			76				376
Eastern	47	33						27			13	120
Rajarata	23							12			15	50
S'gamuwa												7
South Eastern								11			6	17
Open Univ.	114		85					76				275
TOTAL	1,032	262	603	34	472	54	43	985	36	27	197	3,745
Per Cent	27.6	7.0	16.1	0.9	12.6	1.4	1.1	26.3	1.0	0.7	5.3	100.0

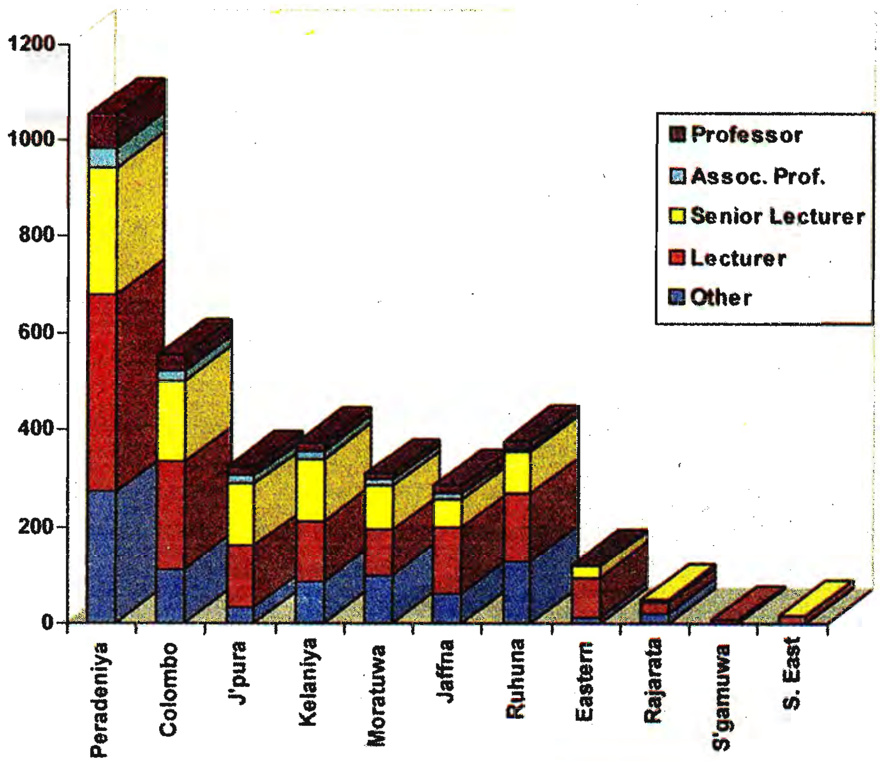
The distribution of academic staff according to staff category and university is given in Table 5.9. It is evident that nearly 42 per cent of the academic staff and 52 percent of the professorial staff are attached to the two oldest universities- Colombo and Peradeniya.

Table 5.9 Distribution of Academic Staff by Category and University

University Category	Perad -eniya	Colombo	Sri J'pura	Kela -niya	Moratuwa	Jaff -na	Ruh-una	East -ern	Raja -rata	S'ga muwa	S.E	Open	Total
Professor	70	35	20	17	13	18	15	2				8	198
Associate Professor	41	20	16	15	12	9	5					1	119
Senior Lecturer	265	167	128	131	91	58	86	23	6		1	66	1,022
Lecturer	407	222	126	124	92	136	140	81	24	7	15	67	1,441
Other	271	111	34	86	101	64	130	14	20		1	133	965
TOTAL	1,054	555	324	373	309	285	376	120	50	7	17	275	3,745
Per Cent	28.1	14.8	8.7	10.0	8.3	7.6	10.0	3.2	1.3	0.2	0.5	7.3	100.0

Fig. 14 University Staff by Category and University





5.8 Enrolment of Postgraduates in Science and Engineering Courses

Postgraduate institutes cater to the demand for higher qualifications in a socio-cultural ethos which has traditionally placed a premium on education as a means of personal fulfilment as well as a path to upward economic and social mobility. Postgraduate education has increased significantly over the past few years with the expansion of the postgraduate institutes and the postgraduate component in the universities including the Open university, which caters to a large number of external students. A number of new postgraduate courses were also started on a self-financing basis.

According to the statistics in Table 5.10, the total enrolment in postgraduate science courses has increased by 42 per cent in four years from 1,216 in 1991 to 1,730 in 1995. Medical courses account for nearly half the total enrolment while agricultural courses have expanded significantly from 6 per cent of total enrolment in 1991 to 25 per cent in 1995.

Table 5.10 Total Enrolment in Postgraduate Science and Engineering Courses

Year	1991				1995			
Course	Total No.	Total %	Female	% F	Total No.	Total %	Female	% F
Natural Sciences	281	23.1	108	38.4	87	5.0	38	43.7
Mathematics & Computing	151	12.4	57	37.7	128	7.4	29	22.7
Health related courses	504	41.4	38	7.5	828	47.9	330	39.9
Agricultural sciences	70	5.8	32	45.7	430	24.8	150	34.9
Engineering	136	11.2	29	21.3	185	10.7	20	10.8
Architecture and Town Planning	74	6.1	27	36.5	72	4.2	29	40.3
TOTAL	1,216	100.0	191	15.7	1,730	100.0	596	34.5

Source: World Science Report 1996

There is a dramatic decrease in percentage enrolled in natural sciences from 23 per cent in 1991 to a mere 5 per cent in 1995 which does not augur well for the development of basic research in the future. This trend is probably correlated to the increase in funding for agricultural and medical research and growing disaffection among natural scientists.

The number of females enrolling for postgraduate courses has increased three-fold with the highest increase being recorded in the medical field with the percentage of females increasing significantly from 8 per cent in1991 to 40 per cent in 1995, which is partly attributable to the inclusion of nursing and para-medical postgraduate courses. Other disciplines which have attracted women are natural sciences (44 per cent) and architecture (40 per cent). At the other end of the scale, female participation has declined in engineering from 21 per cent in 1991 to 11 per cent in 1995; in agricultural sciences from 46 per cent in1991 to 35 per cent in 1995 and in mathematics and computing fields from 38 per cent in 1991 to 23 per cent in 1995.

5.9 Technical and Vocational Education

Sri Lanka has a rich historical tradition of technological competence and excellence in the fields of irrigation, water storage and distribution, construction of dagobas and palaces, and production of iron and steel implements. However these traditional skills and technologies were eroded during 450 years of colonial rule which fostered an export-import economy based on plantation agriculture and devalued traditional technical skills.

The Ceylon Technical College which was established in1894 was the only recognized institution offering courses in engineering and technology. Some of the courses offered by this College were of high quality and it was later upgraded and absorbed into the University system.

Technical and Vocational education was the least developed component of the education system in Sri Lanka. Technical education programmes were conducted by the Ministry of Education up to 1978 and comprised mainly a) National Diploma courses of 3 years duration offered by the University of Moratuwa and the Hardy Senior Technical Institute which was established in 1956; and b) National Certificate courses of 1-3 years duration targeted at producing middle-level technical manpower in civil, mechanical and electrical engineering, rubber technology and geology, which were offered at polytechnics and junior technical colleges throughout the island.

In addition to these courses, the National Apprentice Board (NAB) which was established in 1971 to formulate, implement and supervise vocational training programmes was expanded in 1978 to cover a wide range of vocations and trades, in order to increase employment opportunities locally and abroad for unemployed youth. Craft training courses are held by the Department of Small Industries, vocational training courses by the Labour department and specialized technician training by the Ministries of Agriculture, Fisheries and Health to meet their own requirements.

The Technical and Vocational Education Act was enacted in1990 leading to the simultaneous establishment of the Tertiary and Vocational Education Commission (TVEC) and the National Apprenticeship and Industrial Training Authority (NAITA) as the successor to NAB.

The objectives of the TVEC are specified as:

a) the planning, coordination and development of tertiary and vocational education at all levels,
b) the development of a nationally recognized system for granting of tertiary and vocational training awards, certificates and other academic distinctions,
c) the maintenance of standards in all establishments providing tertiary and vocational education.

The main functions assigned to NAITA are the planning, organization and provision of vocational training, specifying standards, conducting examinations and competitions, issuing certificates, carrying out R&D, developing training capacities of institutions providing vocational training and establishing links with organizations in Sri Lanka and abroad with a view to standardization and validation of certificates diplomas and degrees issued.

Among the shortcomings identified in the existing system are the absence of a national policy on vocational and technical education and training, lack of an apex regulatory organization to match supply and demand of technical skills, inadequate harnessing of economic enterprises in delivery of vocational training, lack of career paths within the vocational sector and the low social image associated with technical and vocational skills.

The present structure of the technical training component can be broadly divided into several broad segments. The first segment comprises state sponsored formal technical training given in the University of Moratuwa (National Diploma in Technology), Open University (Diploma and Certificate courses), Aurthur C. Clarke Centre, Advanced Technical Colleges, Institute for Construction Training and Development (ICTAD) and the Labour Ministry and vocational training programmes provided by NAITA, National Youth Services Council (NYSC).

A second segment consists of in-service job-oriented training programmes within public sector institutions such as the Ceylon Electricity Board, Survey, Telecommunications and Health Departments. It should be noted that this is a large segment which services the major part of the state infrastructure.

A third segment which has expanded under the open economy is the various manufacturing sub-sectors such as garments, gems, jewellery and leather products which provide their own training programmes.

Finally, there are a large number of demand-driven private sector agencies and NGOs which provide training in hotel and catering services, tailoring, secretarial and computer skills, etc. to meet the escalating needs of the economy.

The challenge facing the government is the articulation of a clear-cut national policy integrating all these segments in a cost-effective strategy, providing incentives and mechanisms to up-grade and expand the training capacity which has evolved in the private and NGO sector and to utilize the substantial capacity of the public sector institutions to feed the private sector as well, thereby augmenting employment opportunities for talented youth.

a) Advanced Technical Training

Under a rationalization programme undertaken by the government, the Department of Technical Training was transferred from the Ministry of Higher Education to the Ministry of Labour and Vocational Training in 1995 and the Sri Lanka Institute of Advanced Technical Training was established in 1996. This Institute will function as the apex body responsible for advanced technical education policies and programmes, development of curricula, technical teacher training and disbursement of financial and human resources among the Advanced Technical Training Institutes.

Statistics on technical training provided at the Advanced Technical Colleges presented in Table 5.11 reflects the expansion in facilities and staff and increase in admissions and capital expenditure on technical education from 1986 to 1994.

In addition to these courses, the Arthur C. Clarke Centre for Modern Technologies provides training and R&D in science-based high technology areas including micro-electronics, satellite communications, robotics, computers and space technologies on a consultancy basis to the public and private sector.

Table 5.11 Statistics on Technical Training

ITEM	1986	1991	1994
Total No. of Technical Colleges	27	30	31
a) Grade 1 "	10	13	16
b) Grade 2 "	13	11	11
c) Grade 3 "	4	6	4
No. of Staff	**1,101**	**1,320**	**1,575**
a) Teaching Staff	529	686	778
b) Other Staff	572	634	802
New Admissions	**14,467**	**12,852**	**14,483**
Total Enrolment	**20,938**	**18,971**	**20,914**
a) Higher National Diploma	3,250	3,112	3,879
b) National Diploma	1,127	1,219	1,568
c) National Certificate	9,270	9,974	11,235
d) National Craft (Trade)	1,787	2,271	3,556
e) Other	5,504	2,395	676
Total Govt. Expenditure on Technical Education Rs. m	**289.8**	**221.8**	**659**
a) Recurrent " Rs. m	47.0	94.0	159
b) Capital " Rs. m	242.8	127.8	500

Source: Statistical Abstract of Sri Lanka 1995

A significant trend which is identified is the increase in proportion of women participating in technical training programmes from 2.6 per cent in 1965 to 43.1 per cent in 1995, as shown in Table 5.12.

Table 5.12 Enrolment in Technical Colleges by Sex

Year	Total Enrolment		
	Total	Female	% Female
1965	1,294	34	2.6
1975	4,670	577	12.4
1984	18,041	6,704	37.2
1992	18,068	7,355	40.7
1994	17,069	7,357	43.1

Source: Women and Men in Sri Lanka (Department of Census and Statistics)

b) Vocational Training

The vocational training component was also strengthened with the aid of a ILO-UNDP grant in 1995 to upgrade the institutional capacity of TVEC and the technical capability of NAITA to formulate standards and methods for testing and certification of skills. NAITA has expanded its enrolment by two thirds between 1990 and 1995 to reach 20,691 in 1995. Statistics of enrolment in vocational training programmes provided by NAITA, NYSC, Ministry of Labour and Sri Lanka Handicraft Board are given in Table 5.13.

TABLE 5.13 Total Enrolment in Vocational Training Programmes

Training Area	Total Enrolment	Percentage Female
Business Studies	5,636	57.1
Agriculture	563	18.8
Automobile Industry	2,960	0.2
Construction Industry	902	3.8
Draughtsmen, Quantity Surveying, etc.	3,977	27.6
Electrical/Electronic Technicians	1,550	3.9
Technicians	205	25.4
Shoe Industry	122	74.6
Jewellery	406	38.9
Handicrafts	2,678	97.6
Food & related	644	22.7
Printing & related	575	36.9
Secretarial	2,837	87.0
Textiles & Garments	8,363	92.6
Beauty Culture etc.	1,036	87.5
English etc.	1,791	65.2
TOTAL	34,245	58.6

Source: Women and Men - Department of Census and Statistics

The National Youth Services Council (NYSC) assists school-leavers to acquire vocational and technical skills at 21 vocational training centres distributed islandwide. About 3000 youth are trained annually at these centres in motor mechanism, welding, industrial sewing, carpentry, masonry etc., and short term training courses for females in dress-making, tailoring, hair dressing and beauty culture are conducted at 184 mobile training centres. In 1994 two diploma courses were started for school-leavers in computer skills and management studies.

The Vocational Training Authority was established in 1995 to coordinate the vocational skills training programmes of the Department of Labour, which trained over 6000 school leavers in 1995.

Although female participation in vocational training is as high as 58.7 per cent it is evident that there is gender stereo-typing in course selection with a high percentage of women in traditional female activities such as dressmaking, textiles and garments, secretarial work and handicrafts. Women's representation is very low in automobile and construction industry, electrical and electronic technician courses in conformity with traditional socio-cultural norms.

c) Migrant Workers

The increase in output of vocational and technical trained manpower has been accompanied by an increase in migration of middle level and skilled manpower for employment abroad due to higher remuneration and promotion prospects and a time lag in creating local employment opportunities. Hence a phenomenon similar to the brain drain of scientists is also occurring in the case of technicians, as seen from the statistics in Table 5.14. The total number of migrants in the skilled and higher level manpower categories has increased threefold from 10,141 in 1979 to 30,341 in 1996.

Table 5.14 Migration for Employment by Manpower Level

Manpower Level	1979			1996		
	Total No.	%	Per cent Female	Total No.	%	Percent Female
High Level	1,657	6.4	15.1	599	0.4	7.2
Middle Level	2,374	9.2	16.0	5,315	3.3	14.8
Skilled	6,110	23.6	1.8	24,327	14.9	19.6
Unskilled	2,672	10.3	-	21,738	13.4	15.0
House maid	10,131	39.2	100.0	110,593	68'0	100.0
Other	2,931	11.3	46.7	-	-	-
TOTAL	25,875	100.0	42.3	162,572	100.0	73.5

Source: Statistical Profile of Sri Lanka (Department of Census and Statistics)

d) Computer Education

The computer industry has shown rapid development in Sri Lanka during the last two decades with the advent of the free market economy and the necessity to keep abreast of worldwide developments in the Information Technology industry. The government realised the need for a national regulatory body and established the Computer and Information Technology Council of Sri Lanka (CINTEC) in 1984 as an apex agency with a wide mandate to advise the Minister of Science and Technology on formulation of a national IT policy; and to coordinate, monitor and accelerate the development of IT in strategic areas while maintaining standards.

CINTEC plays a catalytic role in creating public awareness of the potential of IT; promoting IT applications in industry, trade, commerce and agriculture and in the public sector; stimulating collaboration within the industry both locally and abroad in furthering development of IT based products and services; encouraging foreign exchange earnings through export of software and upgrading and maintaining standards for computer education and training to match the rapidly increasing demand for manpower resources and skills in the public and private sector.

A number of private sector institutions are providing need based computer education and training to school leavers and professionals with short-term and long-term courses. They have formed an Association of Computer Training Organizations and federated with Vendor and Software organizations to form the Federation of Information Technology Industry under the aegis of CINTEC to act as a conduit to channel information to its members.

In the public sector, from 1979 the National Institute of Business Management (NIBM) runs two high quality diploma courses of 12 and 15 months duration with an annual intake of 400 students, which are highly rated in the job market; and short term demand-driven courses for public and private sector institutions, which are followed by about 500 professionals annually. It is understood that NIBM has the capacity and professional expertise to expand its annual intake to about 2000 students and 1000 professionals, if funding is available for buildings and equipment.

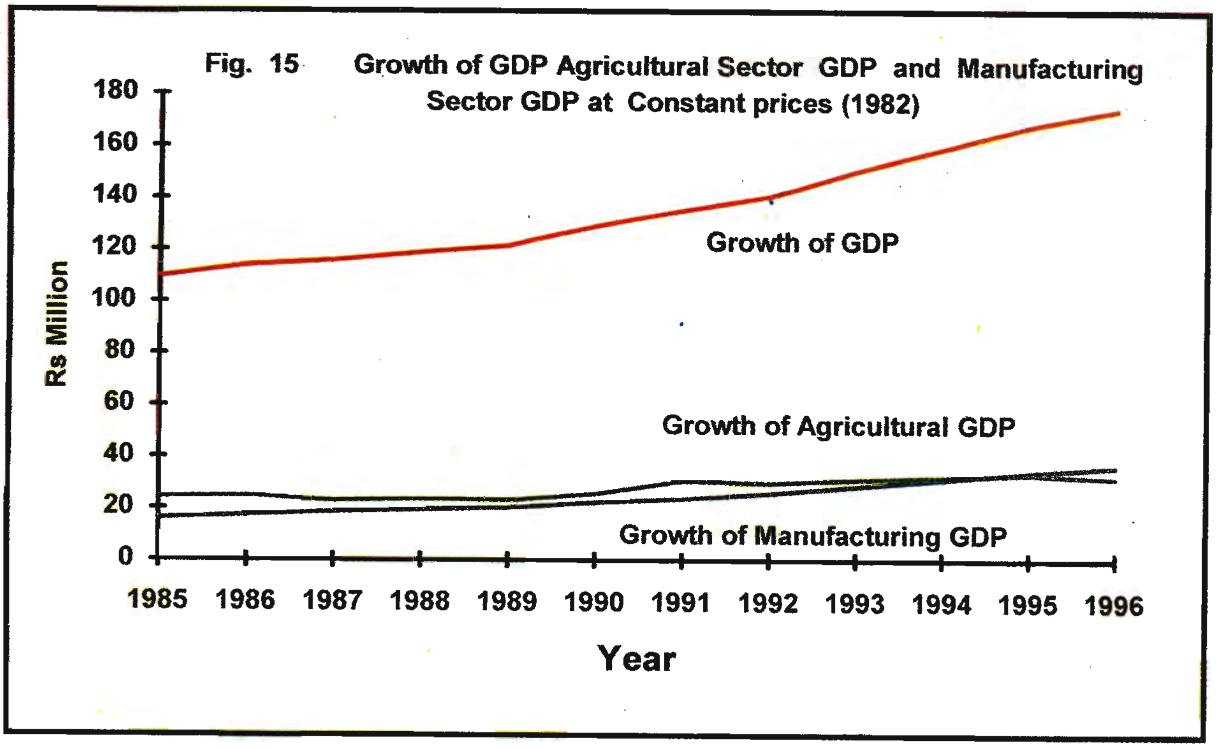


Table 6.1 Growth of GDP at Constant (1982)Prices - 1985 to 1996

	Gross Domestic Product		Contribution of Agriculture			Contribution of Manufacturing		
Year	Value (Rs. m.)	Annual Rate of Growth %	Value (Rs. m.)	Percent of GDP	Annual Rate of Growth %	Value (Rs. m.)	Percent of GDP	Annual Rate of Growth %
1985	169,570	5.0	24,504	22.4	9.4	16,193	14.8	5.2
1986	114,261	4.3	25,037	21.9	2.2	17,558	15.4	8.4
1987	115,922	1.5	23,003	19.8	8.1	18,748	16.2	6.8
1988	119,050	2.7	23,762	19.9	3.3	19,622	16.5	4.7
1989	121,729	2.3	23,311	19.2	1.9	20,488	16.8	4.4
1990	129,256	6.2	25,818	19.9	10.8	22,427	17.4	9.5
1991	135,389	4.8	30,869	22.8	2.9	23,979	17.7	6.9
1992	140,990	4.3	30,090	21.3	-1.6	26,059	18.5	8.8
1993	150,783	6.9	31,554	20.9	4.9	28,806	19.1	10.5
1994	159,269	5.6	32,593	20.5	3.3	31,418	19.7	9.1
1995	167,953	5.5	33,659	20.0	3.3	34,294	20.4	9.2
1996	174,261	5.8	32,109	18.4	-4.6	36,539	21.0	6.5

Source: Central Bank Annual Reports

Chapter 6

SOME INDICATORS OF RESEARCH OUTPUT (PUBLICATIONS) OF RESEARCH INSTITUTES

6.1 Historical Perspective

Agriculture has been the mainstay of the Sri Lankan economy from time immemorial. With diversification and liberalization of the economy in 1977 in conformity with global trends the dominance of agriculture has been eroded but it will continue to play a major role in the future.

It is seen from Table 6.1 that the contribution of the agriculture sector to GDP has declined steadily from 22.4 per cent in 1985 to 18.2 per cent in 1996, while the contribution of the manufacturing sector shows a reverse trend increasing from 14.8 per cent in 1985 to 21.0 percent in 1996. The percentage share of agricultural exports also declined from 52.5 per cent in 1985 to 23.5 per cent in 1996 while industrial exports increased from 41.9 per cent in 1985 to 76 per cent in 1996.

Table 6.1 shows the increase in GDP at constant prices (1982) and relative changes in sectoral composition during the period 1985 to 1996. Comparison of growth of GDP and growth of GDP in agricultural sector during the last decade is seen in Fig. 15. GDP has shown a 4.3 percent increase while the Agricultural GDP has increased only by 2.2 percent. During the same period the total R&D expenditure at current prices has increased by 3.6 percent which is slower than the growth of GDP.

However, 70 per cent of the population still earn their living directly or indirectly from agriculture. Improving the living standards of the farmers through modernization and rationalization of the agricultural sector is not only imperative from the sociological point of view but will also generate more purchasing power in the rural economy, create employment opportunities and fuel economic growth.

According to statistics published by the Food and Agricultural Organization (FAO) of the United Nations, the Agricultural Production Index (API) for Sri Lanka has declined from 108.3 in 1985 to 96.3 in1993, while other South Asian countries have shown an increasing trend over the same period.

As a result of the stagnation in agricultural production over the last two decades, Sri Lanka's food imports bill has risen to Rs. 36 billion in 1996, of which Rs. 11 billion was spent on wheat flour, Rs. 8 billion on cereals and Rs. 6 billion on milk and milk products.

Only about 50 per cent of the available land in the dry zone is being utilized effectively and there is a tremendous potential for research into cultivating additional acreages in the dry zone, where soil fertility is relatively higher than in the wet zone.

The application of S&T in agricultural research will result in improved technologies and agricultural practices and enable reduction in costs of production, increase productivity and quality of products making them more competitive in international markets and also help to protect the environment and conserve natural resources, while reducing food imports.

Historically the foundations of institutionalized scientific research and development were laid during the colonial era by the establishment of state sponsored research institutes and the creation of a supportive institutional framework for policy planning and its implementation. The chronological development of the network of research institutes, relevant government departments, scientific societies, professional associations and policy initiatives, is presented in **Chart 5** (pages 76-77). It is clear that the initial emphasis was mainly on agriculture and health.

6.2 Establishment of Research Institutes

Among the earliest research institutes to be established were the Rubber Research Institute (RRI) at Agalawatte in 1910, the Tea Research Institute (TRI) at Talawakelle in 1922 and the Coconut Research Institute (CRI) at Lunuwila in 1928, to serve British economic and commercial interests in the plantation industry. Prior to this some research activities commenced with the establishment of the Royal Botanical Gardens (1882) and the formation of the Ceylon Agricultural Society in 1904, which formed the nucleus of the Department of Agriculture set up in 1912 with a regional network of experimental stations.

In the field of health the Bacteriological Institute was set up in 1900 and the Pasteur Institute in 1918. They were later amalgamated to form the Medical Research Institute (MRI) in 1946.

The earliest attempts at industrial research originated much later with the Industrial Research Laboratory in 1941 and the Rubber Services Laboratory in 1948. Their resources were combined in 1948 to form the Ceylon Institute of Scientific and Industrial Research, which has emerged as the premier industrial research institute in the country.

6.3 Role of Sri Lanka Association for the Advancement of Science (SLAAS)

The Sri Lanka Association for the Advancement of Science (SLAAS) established in 1944 has played a patriarchal role within the scientific community, articulating their viewpoint on matters of national concern and providing a bridge to communication with the administrative and political hierarchy. SLAAS has taken the lead in promoting science and technology activities and creating a science culture in the country through promotional activities, dissemination of information and advocacy.

The membership of SLAAS which is open to all scientists is divided into seven major categories (sections) according to the field of science. A scientist can be a member of one or more sections.

The number of members registered in each section during the last four years is given in Table 6.2. The present membership exceeds 3,700 and a growth of 5% can be observed during the past three years.

Table 6.2 SLAAS Membership 1994-96

Section	1994	1995	1996	1997
Section A (Medical Sciences)	328	343	366	388
Section B (Agricultural Sciences)	604	648	676	731
Section C (Engineering)	537	581	591	596
Section D (Life Sciences)	561	567	602	645
Section E1 (Physical Sciences)	238	255	269	294
Section E2 (Chemical Sciences)	351	388	415	458
Section F (Social Sciences)	519	538	568	593
Total	3,178	3,325	3,487	3,705

Source: SLAAS Annual Reports

When compared to the total number of R&D personnel in the country which is estimated at 5,965, the SLAAS membership constitutes a considerable proportion of 62 per cent of the R&D scientists and engineers. Therefore, the members of SLAAS can be taken as a representative sample of the R&D personnel in the country.

a) Annual proceedings

Among it's diverse activities, the annual meeting of SLAAS provides a prestigious forum for presentation of papers on the investigations of researchers in the form of abstracts before a large and representative audience of peers. However, the analysis in Table 6.3 reveals that only a small proportion of the membership is involved in presentation of papers. In medical and chemical sciences one out of each four members are involve in presentations while in social and engineering sciences only one out of sixteen presents papers at SLAAS.

Table 6.3 No. of Abstracts presented and No. of Scientists involved (1994-96)

Section	No. of Abstracts			No. of Scientists involved			Average No. of Abstracts	No. of Abstracts per researcher	Percentage of members publishing
	1994	1995	1996	1994	1995	1996	1994-96	1994-96	1996
A	30	35	30	84	106	93	32	0.34	25.4
B	99	80	73	162	130	109	84	0.63	16.0
C	15	20	3	20	23	3	13	0.28	-
D	81	46	56	127	80	91	61	0.61	15.0
E1	27	21	21	51	47	51	23	0.46	18.9
E2	56	40	51	116	82	108	49	0.48	26.0
F	20	7	23	31	9	34	17	0.69	5.9
Total	328	249	257	591	477	489	279	0.53	14.0

Source: SLAAS Annual Proceedings

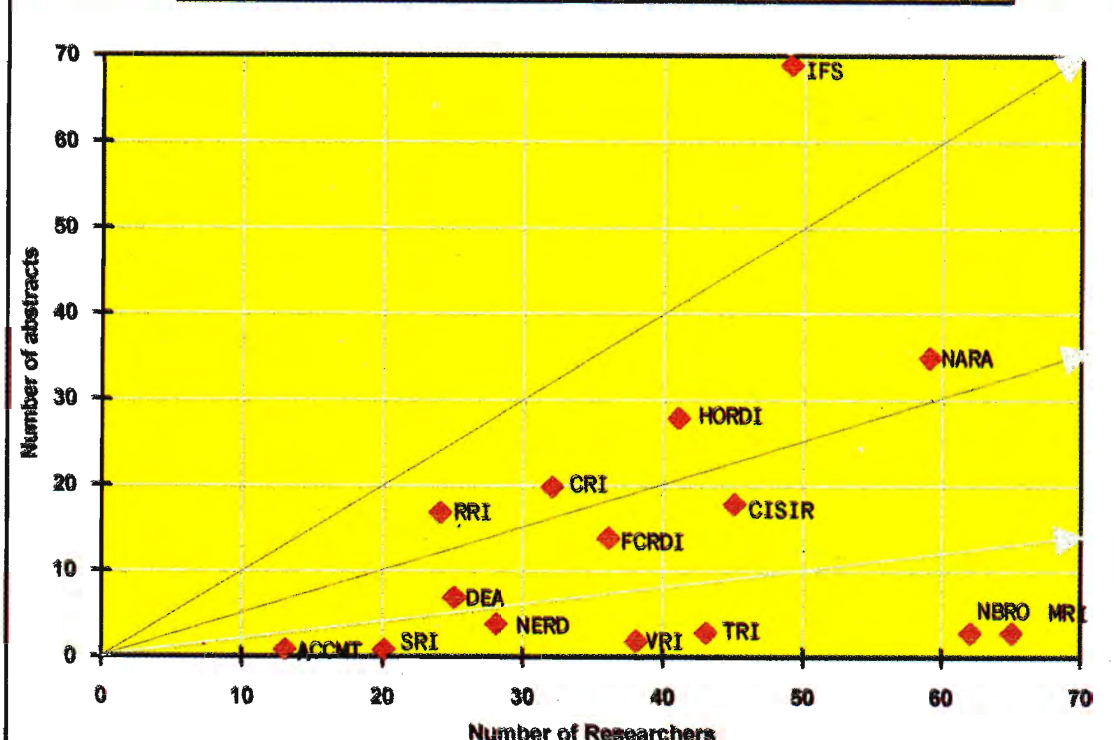
6.4 Performance of Research Institutes

The above presentations are analyzed to observe the contribution from the different research institutions. The number of papers during the period 1994-96 is plotted against the number of researchers for different institutions, in Fig.16. At the top end of the scale is IFS where the ratio of abstracts to researchers is greater than one. Four institutes namely, RRI, CRI, HORDI and NARA, have a ratio exceeding 0.5, while CISIR, FCRDI, DEA have a ratio between 0.2 and 0.5 . The remaining institutions have a ratio less than 0.2. It is observed that some of the institutes in the latter group, such as MRI and NBRO are more service oriented.

Furthermore, it is observed that the percentage of presentations with inter-institutional collaboration projects is as low as 15% - 20 %, except for section A and section E2. The highest collaboration with a foreign agency is observed in Section A, probably because medical sciences has attracted more foreign funding.

It should be emphasized that the above output cannot be taken as the sole criterion for evaluation of orientation to publish research papers at different institutions. However, it is one indicator of research intensity and demonstrates the researchers' motivation to present their results in advance.

Fig. 16 Presentations at SLAAS 1994- 96 by Researchers at R&D Institutions



The Journal of the National Science Council (JNSC) which is one of the most reputed scientific journals in Sri Lanka receives only 23 % of its articles from the research institutes compared to 70 % from the universities. During the period 1994-96, JNSC has published only 16 articles from research institutes. One reason for the lower rate of publishing at JNSC could be the availability of opportunities for publishing in their own journals, as shown in Table 6.4.

The research institutions such as VRI, SRI, NARA which have no formal institutional journal to facilitate researchers to publish their findings, have adopted the practice of organizing an annual session (Annual Research Seminars) at which the researchers present their findings. The unavailability of resources for publishing a journal is the main reason for holding Annual Research Review Seminars in these institutions. However, these meetings are also useful to provide opportunities for a scientist to address a large gathering (including peers) where he/she gets an instant response from the audience on methodology, results and future directions at a lesser cost than through publishing a journal.

Table 6.4 Journals published by Research Institutes and other selected Institutions/Organizations

Institution	Name of the Journal	Frequency (per annum)	Average No. of articles per volume
Research Institutions			
TRI	Sri Lanka Journal of Tea Science	2	5
	Tea bulletin	2	
CRI	Cocos	1	7 - 8
RRI	J. of RRI of SL	1	7- 10
	Rubber bulletin	1	
	Rubber puwath	1	
SRI	SRI Research report	1	
DOA	Tropical Agriculturists	Irregular	11
NARA	J. of National Aquatic Resources Agency	1 (only up to 1988)	9
MRI	Bulletin of MRI	1	
	Research Publications		47 (1989-93)
CISIR	S&T bulletin	4	
Other			
DF	Ceylon Forester	4	8
PGIA	Tropical Agricultural Research	1	
AFAR	Sri Lanka J. of Aquatic Sciences		11
UOC	Ceylon J. of Medical Sciences	2	4
NASSL	Sri Lanka J. of Agricultural Sciences	1	13
WNPS	Loris	2	10
UOP	Ceylon J. of Biological Sciences	1	6 - 7
	Ceylon J. of Physical Sciences	1	13
SLVA	Sri Lanka Veterinary Journal	1	4 - 5
IE	Engineer	2	8
I.Chem	Chemistry in Sri Lanka	2	5
NARESA	J. of National Science Council	4	5

The publishing pattern of the institutional journals in some selected research institutes is analyzed in Tables 6.5 and 6.6 . It is seen that external collaboration is highest in the articles published by researchers at MRI .

Table 6.5 Publishing Pattern of some Institutional Journals

Research Institution	Period	No. of Articles	No. of Scientists involved from within the research institution	No. of Scientists from outside
CRI	1991-96	22	27	9
RRI	1995-96	50	56	14
TRI	1992-96	33	34	2
VRI	1994	6	-	-
MRI	1989-93	43	30	39

Table 6.6 Researchers in Research Institutes publishing in other Local Journals

Name of Journal (Period)	Research Institute	Number of Scientists
Ceylon J. of Biological Sciences (1995)	PGRC	3
	RRI	4
Ceylon J. of Physical Sciences(1995 - Vol. 2)	IFS	10
J. of Agricultural Sciences	DOA	8
	CRI	4
	IFS	2
Chemistry in Sri Lanka (1992-97)	RRI	2
	SLSI	1
	CISIR	2
	IFS	3
	HORDI	1
S.L J. of Aquatic Sciences (1996-97)	NARA	11
	IFS	6
Engineers (1992-97)	-	-

6.5 Science Citation Index

The number of publications of scientific material in international journals is an useful indicator to identify the quality of the local scientific research base relative to world science. The majority of research scientists will give first priority to submission of an article to a recognized international journal in order to expose his research to the international scientific community. Hence it is reasonable to assume that the more important results coming from local research efforts are published in reputed international journals.

Investigations into the Science Citation Index (SCI) database provides insight into the level of internationalisation of Sri Lankan science. The SCI database covers more than 4,000 journals published worldwide. According to the SCI database, Sri Lanka is in the 59th position having 0.022 percent of world science publications. Our neighbouring country, India holds 12th position having 1.2 percent of world publications. It may also be worthwhile to bear in mind that the share of publications by developing countries is only 5 percent of the total.

The growth of publications from Sri Lanka in international journals is shown in Table 6.7.

Table 6.7 Growth of Publications in International Journals

Year	No. of publications
1982	111
1986	84
1990	179
1994	142
1995	149

An analysis of a sample of international publications reveals that a higher percentage of publications have arisen from collaborative research with foreign countries. The quality of those papers (measured from the citation analysis) are also significantly higher than the other publications, especially in the fields of medical and chemical sciences. Frequency of research collaboration by country in the sample shown in Table 6.8 reflects the strong orientation of local scientists towards U.K. and USA.

Table 6.8 Research Collaboration with Frequencies (1991-95)

Collaborative Country	No. of Publications	Percent
U.K.	125	21.8
USA	74	12.9
Sweden	26	4.5
Australia	25	4.4
Canada	17	2.9
Japan	32	5.6
India	8	1.4
Thailand	5	0.9
Total International Publications	574	100.0

The international publications by each research institute, according to the SCI reveals a pattern similar to SLAAS presentations (Table 6.9). IFS (45) contributes heavily to the Sri Lanka share of world publications while MRI (10), RRI (8), NARA (8) and CISIR (7) have shown some potential. This factor could be a guide to policy makers when making decisions to improve the research capacity of research institutions in Sri Lanka.

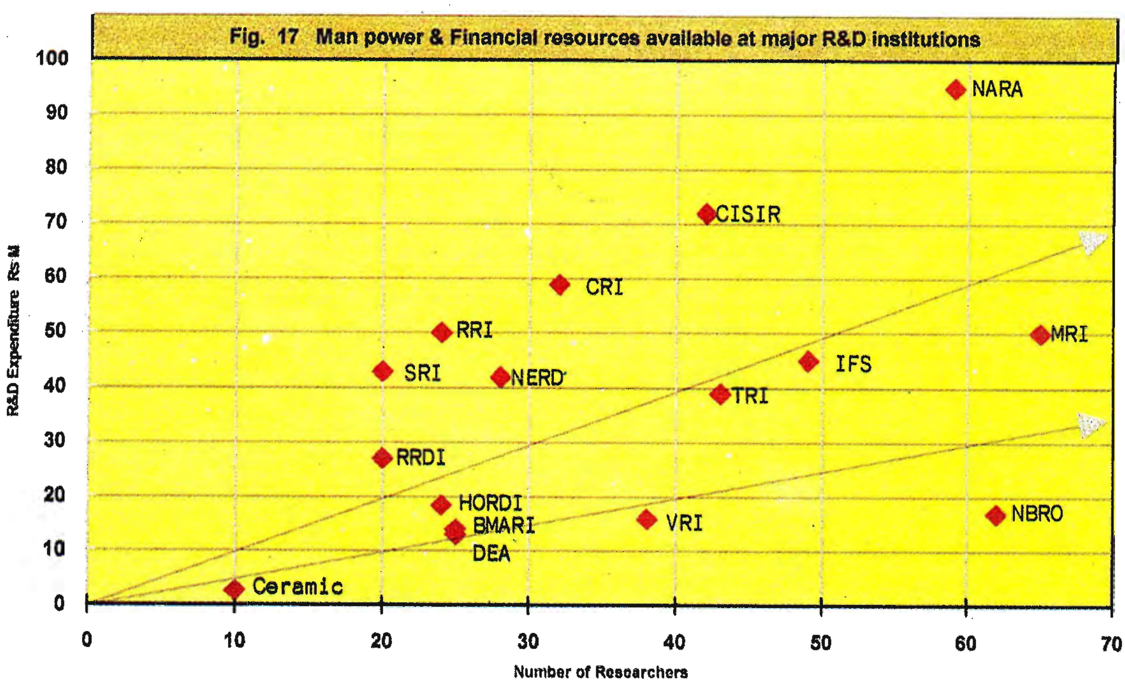
Table 6.9 Number of International Publications by Research Institute

Research Institute	1994	1995	1996 *	1997 (up to Sept.)	Total
IFS	14	14	9	8	45
RRI	2	1	2	3	8
CRI	1	1	0	0	2
SRI	0	0	0	1	1
TRI	1	0	0	0	1
CISIR	3	1	2	1	7
DEA	0	1	0	2	3
HORDI	1	1	0	1	3
PGRC	1	0	0	0	1
CARP	0	1	0	0	1
VRI	1	1	1	0	3
NARA	0	0	7	1	8
MRI	3	6	1	0	10
BMARI	0	1	0	0	1

Source : Science Citation Index * Excluding Oct- Dec 1996

6.6 R&D Institutions by Capacity

The R&D expenditure in 1996 and S&T personnel in some of the major research institutions is shown in Table 6.10.



Most of the R&D institutions falls within the category with R&D staff of 20 - 30 persons. The plot of R&D expenditure against number of researchers in Fig. 17 reflects the relative capacity of different institutions to conduct research. Research institutions with more researchers and adequate funding which produce a lesser number of publications implies diversion of funds and staff to perform activities other than research.

There are seven institutions above the centre diagonal headed by NARA followed by CISIR which receive over Rs.1 million per researcher. At the other end of the scale are institutes such as NBRO and VRI which have less funds and more staff.

A comparison between Fig.16 and Fig.17 indicates unutilized research capacity on the part of some institutions and potential for research output in other institutions if adequate resources are provided. Brief profiles of major research institutes are given in Annex 5.

Table 6.10 R&D Expenditure and S&T Personnel at Research Institutes

Institution	S&T Personnel	R&D Expenditure Rs. million
Department of Export Agriculture	25	13
Hector Kobbekaduwa Agrarian Research & Training Institute	41	18
Rubber Research Institute	24	50
Coconut Research Institute	32	60
Tea Research Institute	43	38
Veterinary Research Institute	38	16
Sugar Research Institute	20	44
Medical Research Institute	65	50
National Aquatic Resources & Development Agency	59	95
Rice Research & Development Institute	20	27
National Building Research Organization	62	13
National Engineering Research & Development Centre	28	43
Bandaranaike Memorial Ayurvedic Research Institute	25	14
Ceylon Institute for Scientific & Industrial Research	45	72
Institute of Fundamental Studies	46	35
Horticulture Research & Development Institute	41	75
Field Crops Research & Development Institute	36	56
Department of Agriculture (excluding HORDI, RRDI and FCRDI)	147	46

6.7 Role of NARESA Research Grants

The NARESA research grants scheme which commenced in 1970 has supplemented the research budgets of universities, research institutes and government departments. NARESA adminsters local grants to individual scientists as well as negotiates foreign grants for scientists in universities and research institutes. NARESA has released an annual allocation of Rs.20 m. from treasury funds during the recent past. This allocation has been almost matched by funds received for research from foreign donor agencies every year.

Treasury funds are allocated for research grants which are scrutinised by specialist panels before qualifying for awards. Foreign funds are received for specific projects under collaborative programmes which give high priority to building research capability. The university sector which has a very meagre research budget is the major recipient of NARESA grants consuming 80% of the total allocations.

In addition to many research publications based on the findings of the research grantees, enhancement of the potential to carry out research, through training personnel under a M.Sc./ M.Phil. or Ph.D. programme, is a significant achievement of the NARESA research grants programme. An average of two Ph.D.s and eight Master's degrees have been awarded per year under NARESA research projects.

Table 6.11 Performance of NARESA Research Grants Scheme (1972-96) by Discipline

Indicator / Discipline		Natural Sciences	Agriculture	Engineering *	Medical Sciences	Social Sciences	Total
Completed Grants:	No.	309	104	49	188	136	786
	%	**39.3**	**13.2**	**6.3**	**23.9**	**17.3**	**100.0**
Total Expenditure (in Rs '000)		29,662	5,753	5,048	11,366	2,652	54,481
	%	**54.4**	**10.5**	**9.3**	**20.9**	**4.9**	**100.0**
Masters Degrees	No.	192	12	17	37	59	317
	%	**60.6**	**2.8**	**5.3**	**11.7**	**18.6**	**100.0**
Doctoral Degrees	No.	14	01	04	15	03	37
	%	**37.8**	**2.7**	**10.8**	**40.6**	**8.1**	**100.0**
Publications(International)	No.	107	08	40	23	23	201
	%	**53.2**	**4.0**	**20.0**	**11.4**	**11.4**	**100.0**
Publications(Local Journals)	No.	91	20	17	70	41	239
	%	**38.1**	**8.4**	**7.1**	**29.3**	**17.1**	**100.0**
Communications	No.	277	24	23	59	09	392
	%	**70.7**	**6.1**	**5.9**	**15.0**	**2.3**	**100.0**

Source: NARESA *** Includes Physical Sciences**

According to the statistics in Table 6.11, natural sciences is the leading discipline consuming more than half the expenditure on research grants and accounting for 39 percent of the completed grants. The other major discipline is medical sciences which has utilized 21 percent of the research allocation and accounted for 24 percent of the completed grants.

Natural sciences is also the most productive field, responsible for 61 percent of master's and 38 percent of doctoral degrees; and nearly half the publications in local and international journals.

There is also a high demand for financial support to attend international gatherings which enable local researchers to keep in touch with global developments in their specialities. More than 60 travel grants are awarded per year to local scientists who present papers at regional and international meetings. It is difficult to develop indicators to evaluate the benefits received by the researcher and the country as a whole from such participation.

Chapter 7

ROLE OF S&T IN ECONOMIC DEVELOPMENT

7.1 Background

Sri Lanka emerged as an independent sovereign nation in 1948 with an agriculture based economy highly dependent on external trade due to its small size, low per capita income and limited resources. The commercial plantation sector - tea, rubber and coconut, almost exclusively accounted for foreign exchange earnings while food imports constituted 50 per cent of merchandise imports.

After various attempts at diversification of the economy, industrialization, import substitution and controls(1960-65) and de-regulation (1965-70) followed by strict controls (1970-77), decisive changes of policy came in 1977 with the introduction of an open economic policy, liberalization and structural reforms.

During the last two decades from 1977 to 1997 there has been bi-partisan political support for open economic policies in harmony with global trends. The new policy environment has enabled mobilization of unprecedented levels of concessionary aid from multilateral donor agencies and also attracted foreign direct investment from multinational companies.

7.2 Sectoral Composition of GDP

The sectoral composition of GDP is presented in Table 7.1

Table 7.1 Composition of Gross Domestic Product

Sector	Current Prices (Rs. M.)			Constant (1982) Prices (Rs. M.)				
	1982	1992	1996	1992		1996		Growth Rate
				Amount	%	Amount	%	1991-96
Agriculture, Forestry & Fishing	24,964	100,080	156,108	30,090	21.3	32,109	18.4	1.6
Mining and Quarrying	2,238	6,757	13,927	3,300	2.3	4,408	2.5	2.5
Manufacturing	13,001	59,346	112,724	26,059	18.5	36,539	21.0	8.3
Construction	7,959	28,485	48,234	9,765	6.9	11,957	6.9	6.0
Electricity,Gas, Water etc	1,089	4,630	9,171	1,897	1.3	2,522	1.4	7.1
Transport, Storage & Communications	10,666	38,587	73,784	16,606	11.8	20,213	11.6	5.1
Wholesale and Retail Trade	19,694	83,904	155,316	30,074	21.3	37,765	21.7	6.4
Banking , Insurance etc.	3,715	20,827	49,675	7,241	5.2	10,687	6.1	9.1
Ownership of Dwellings	3,250	9,146	14,232	3,795	2.7	3,989	2.3	1.3
Public Admin. and Defence	2,899	18,141	35,215	6,449	4.6	7,579	4.4	4.0
Services	4,604	17,096	27,548	5,714	4.1	6,493	3.7	4.2
GDP	94,679	386,999	695,934	140,990	100.0	174,261	100.0	

Source: Central Bank Reports

The manufacturing sector has grown at the rate of 8.3 per cent and emerged as the lead sector increasing its contribution to the GDP from 18.5 per cent in 1992 to 21 per cent in 1996, while the contribution of the agricultural sector has declined from 21.3 to 18.4 per cent, according to the statistics in Table 7.1.

The industrial sector comprising about 400 large scale, around 25,000 small and medium scale industries and over 100,000 micro-enterprises and self-employment units islandwide, has emerged as the most dynamic sector with the highest growth potential and employment generation capability.

It is seen from Table 7.2 that the value of Industrial Production has nearly doubled from Rs.m. 136,106 in 1992 to Rs. m 260,247 in 1996, while value added has increased by 90 per cent during the same period. The growth in industrial production came mainly from the three major sub-sectors, namely food and beverages; textiles and leather products and chemical, petroleum, rubber and plastic products, which together accounted for 77 per cent of the growth. These sectors comprise mainly low technology industries. However, there were marginal increases in some non-traditional export oriented areas such as jewellery, machinery and electrical and electronic goods, which are more technology intensive.

It is significant that the private sector expanded by 6.9 per cent and accounted for 90 per cent of the industrial production in 1996 according to the Central Bank.

Table 7.2 Industrial Production by Sub-sector

Sub-sector	Value of Industrial Production				Value Added in Industry				Capacity Utiliz-ation
	1992		1996*		1992		1996*		1996*
Food, beverages and tobacco	34,157	25.1	68,209	26.2	18,688	37.1	32,891	34.5	90
Textiles, apparel and leather prod.	53,929	39.6	101,627	39.1	14,630	29.0	31,184	32.7	82
Wood & Wood products	1,005	0.7	2,171	0.8	677	1.3	1,250	1.3	79
Paper & Paper products	2,586	1.9	5,069	1.9	1,397	2.8	2,580	2.7	88
Petroleum, chemi-cals, rubber etc.	23,817	17.5	46,936	18.0	3,989	7.9	8,957	9.4	66
Non-metallic mineral products	10,582	7.8	18,997	7.3	5,918	11.8	10,537	11.0	87
Basic metal prod.	1,424	1.0	2,248	0.9	263	0.5	450	0.5	47
Fabric. metal prod. machinery&equip.	5,948	4.4	8,807	3.4	3,629	7.2	4,809	5.1	88
Manufac. product	2,658	2.0	6,183	2.4	1,196	2.4	2,763	2.9	90
TOTAL	136,106	100.0	260,247	100.0	50,367	100.0	95,421	100.0	83

Source: Central Bank Annual Report 1996 *Provisional

The production structure of the manufacturing sector has undergone substantial structural changes as shown in Table 7.3. The share of the plantation crop export processing sector declined by half from 41 per cent in 1976-80 to 20 per cent in1991-95 and cottage industries declined from 11 per cent to 7 per cent in the same period. On the other hand, the share of factory industries escalated substantially from 48 per cent in 1976-80 at the commencement of the open economy to 73 per cent in 1991-95 due mainly to the expansion in the garment industry.

7.3 Structure of Manufacturing Sector

Period	1976-1980	1981-1985	1986-1990	1991-1995
Manufacturing	100.0	100.0	100.0	100.0
Export Processing (tea, rubber, coconut) .	41.4	35.9	28.4	20.5
Factory Industries	47.6	54.4	63.6	72.5
Cottage Industries	11.0	9.7	8.0	7.0

***Source: Statistical Profile of Sri Lanka (Department of Census & Statistics)**

7.3 Foreign Direct Investment

Since Sri Lanka does not have a high savings rate it relies on foreign investment to supplement domestic savings. The Board of Investment (BOI) is a statutory institute charged with the responsibility of promoting foreign participation and facilitating investment by offering a package of incentives, including generous tax holidays and duty free import concessions to both local and foreign investors for setting up manufacturing establishments with export orientation.

This policy has yielded dividends and Sri Lanka was able to attract substantial foreign capital, mainly from South East Asian countries, India, Australia, USA, Germany and Italy with concomitant introduction of new technologies and improved access to global markets. The level of Foreign Direct Investment has risen from SDR 42 m. in 1981 to SDR 111 m. in 1994.

Table 7.4 Realised Investments in BOI projects in 1996

Rs. Million

Category	No. of Enterprises		Foreign Investment		Total Investment	
	1995	1996	1995	1996	1995	1996
Food, beverages and tobacco	53	77	1,290	2,274	1,974	4,437
Textile, apparel and leather products	109	117	11,064	12,351	12,821	15,045
Wood and wood products	17	19	488	474	551	564
Paper and paper products	9	12	167	326	362	550
Chemical,petroleum, rubber ,plastic prod.	52	66	4,945	5,762	5,633	6,877
Non-metallic mineral products	39	42	774	972	2,345	2,783
Fabricated metal products, machinery, equipment	19	20	615	605	978	1,180
Manufactured products (n.e.s.)	91	102	2,919	3,499	4,068	4,647
Services	217	255	28,108	34,694	43,487	55,539
TOTAL	606	710	50,370	60,957	72,219	91,622

Source: Central Bank Annual Report 1996 n.e.s - not elsewhere specified

In 1996 Sri Lanka's investment was about 25 per cent of GDP, with national savings at 19 per cent and foreign investment accounting for the difference. The realised investments in BOI industrial projects increased by 56 per cent in 1996 arresting a 46 per cent decline in1995, as seen in Table 7.4

7.4 Exports and Imports

Although export earnings have risen substantially under the open economic strategy, import expenditure has increased at a higher rate resulting in an overall trade deficit since 1975. Export earnings from BOI industries rose significantly from 42 per cent in 1992 to 61 per cent in 1995 (see Table 7.5).

While the balance of trade from BOI enterprises is positive and increased from about US $ 108 m. in 1995 to US $ 642 m. in 1996, the balance of trade from non- BOI enterprises shows a deficit which has increased from US $ 1,074 m. in1992 to 1,785 m. in 1996, contributing to an overall deficit.

Table 7.5 Exports and Imports

Year	Exports (US $ million)		Imports (US $ million)	
	BOI	non BOI	BOI	non BOI
1992	1,024	1,429	916	2,503
1993	1,678	1,182	1,277	2,482
1994	1,848	1,363	1,327	3,156
1995	2,327	1,464	1,726	3,041
1996	2,494	1,603	1,852	3,388

Source: Statistical Profile of Sri Lanka - Department of Census and Statistics

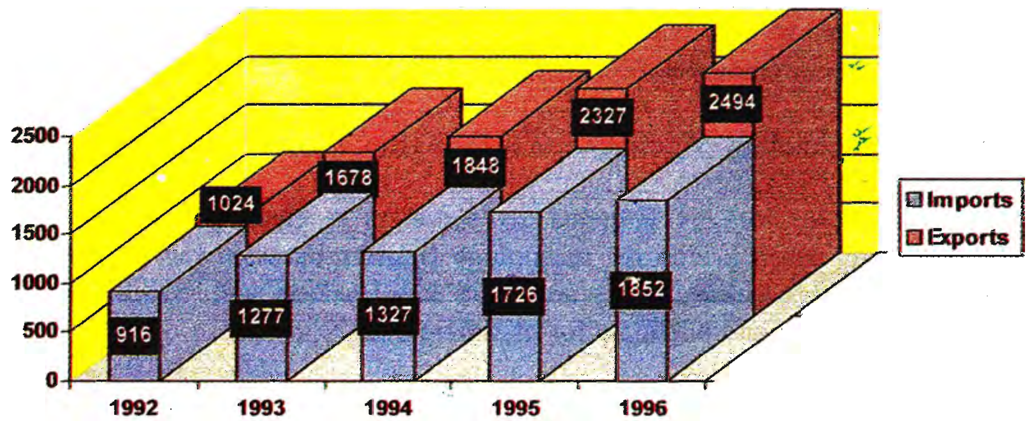
The composition of exports has changed considerably with industrial exports dominating the export scene and contributing 74 per cent of the value of total exports in 1995. Real growth of industrial exports has amounted to 13 per cent in1995. Garments have been the premier foreign exchange earner in the last decade and constituted 60 per cent of industrial exports and 48 per cent of all exports in 1995. However, value added in this sub-sector is only about 35 per cent due to high expenditure on imports of fabric and accessories for the industry.

7.5 Export Promotion and Access to Technology

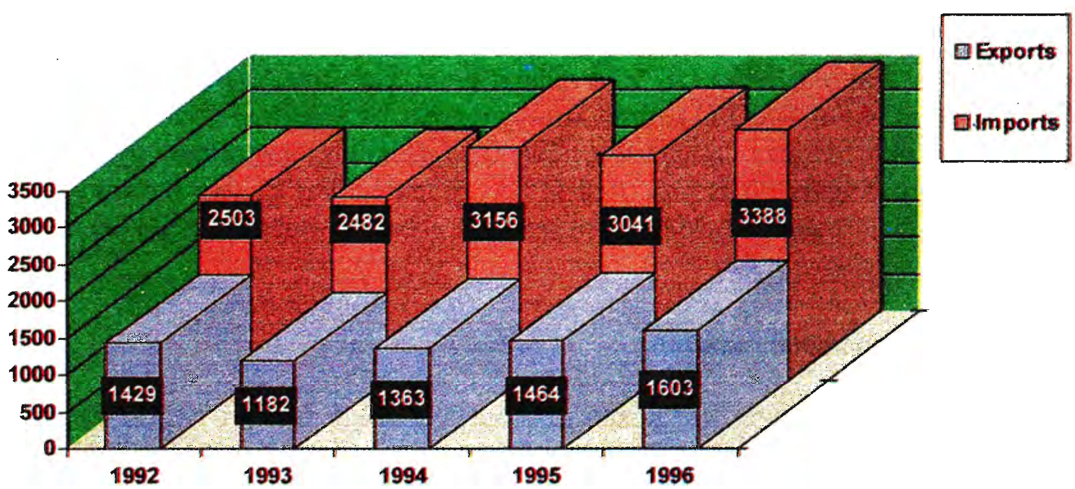
The state is committed to ensure a stable policy environment to promote private sector investment and expansion as the main engine of economic growth. Within this liberalized environment the private sector is expected to increase productivity and generate the major share of employment opportunities for youth entering the labour market.

Fig. 18

Imports and Exports (BOI)



Imports and Exports (non BOI)



The following projects have been initiated by the government with foreign donor assistance to improve access to technology, improve productivity and quality of exports.

1. Technology Initiatives for the Private Sector (TIPS)

A grant of US $ 12 million has been given to help the manufacturing community in collaboration, technology sourcing, etc. on a cost sharing basis. The TIPS project has been extended up to the year 2000 with additional grants for micro-enterprise development and environmental technology.

2. Industrial Technology Management Information Network (ITMIN)

This information network is intended to serve as a clearing house for customer information needs and a bridge for technology transfer between the private and public sectors. The project is assisted by a grant of US & 1.2 million and local funds raised from a consortium of private and public sector organizations.

3. Private Sector Programme (PSP)

German assistance has been channelled through this programme to increase the competitiveness of private sector industries by providing integrated advisory services, technology transfer, consultancy etc. in selected areas such as wooden toys, rubber, footwear and essential oils.

4. ADB Grant

The government has received a US $ 34 million grant from the Asian Development Bank for the improvement of R&D in certain strategic areas of industrial technology, in which Sri Lanka has demonstrated competitive advantage including bio-technology, electronics, agriculture and garments. It is proposed to set up ten centres in selected universities to improve R&D facilities islandwide and to train an adequate number of technical staff to man these R&D facilities.

7.6 Challenge of Globalization

The process of globalization has posed a strong challenge to third world countries to become competitive in international markets in the next millenium. Sri Lanka's industrial and agricultural products will have to compete with foreign goods on equal terms once tariff protection is removed by the year 2005, when the World Trade Organization (WTO) Agreement is scheduled to be fully implemented.

Unless the quality of export products reaches international standards by application of improved technology and prices remain competitive through increased productivity, Sri Lanka can become marginalized in the global economy. Hence it is imperative to re-think and re-formulate economic strategies at the macro and micro level to meet these challenges.

The strategy must lay emphasis on effective utilization of science and technology inputs, facilitation of technology transfer and fusion with necessary management and marketing skills to produce high value added innovative products which are competitive in the global market.

While technology transfer will inject a vitally important degree of dynamism into export oriented industries, indigenous initiatives must be protected and nurtured within the system. Multinational Corporations (MNC) are ready to invest in third world countries with selective technology transfers and capital inflows which are essential requisites for increasing productivity, improving competitiveness of local products in global markets and generating employment opportunities.

However, MNCs are guided by profit motives rather than social concerns and they must be closely monitored to ensure that their investments lead to sustainable growth and they do not resort to short term exploitation of local resources and quick repatriation of profits.

The recent Trade Related Intellectual Property Rights (TRIPS) agreement which is part of the General Agreement on Tariffs and Trade (GATT) extends the scope of intellectual property to cover plant and animal resources, posing a further threat. It is imperative for third world countries to develop an effective strategy to preserve and protect their rich genetic bio-diversity and traditional knowledge from the possibility of predatory exploitation by MNCs.

Sri Lanka should be alerted by the recent experience of the Indian Council of Scientific and Industrial Research (CSIR), which has challenged successfully the application of an American university for patenting the healing properties of turmeric, a popular local remedy and is now challenging the application for patenting a variety of Basmathi rice by a Texan firm.

There should be a firm commitment to absorption and adaptation of imported technologies through adequate investment in R&D infrastructure and establishment of strong linkages between the academic, R&D and industrial sectors.

In accord with this strategy the Presidential Task Force on Science and Technology has laid guidelines for market orientation and re-structuring of research institutions and industrial laboratories and reorganization of S&T training institutions to respond to market demand. At the same time there should be a joint regulatory mechanism between the state and private sector to protect local resources and knowledge.

Chart 5

ESTABLISHMENT OF S&T INSTITUTIONAL AND POLICY FRAMEWORK IN CHRONOLOGICAL ORDER

S&T INSTITUTIONS

1800	-	Survey Department
1870	-	Ceylon Medical College
1882	-	Royal Botanical Gardens
1893	-	Department of National Museums
1894	-	Ceylon Technical College
1900	-	De Soyza Bacteriological Institute
1900	-	Department of Irrigation
1903	-	Mineral Surveys of Sri Lanka
1904	-	Government Analysts Department
1904	-	Ceylon Agricultural Society - Nucleus of Department of Agriculture
1907	-	Dry Zone Research Station at Maha Illuppallama now Field Crop Research & Development Institute (FCRDI)
1910	-	Rubber Research Institute (RRI) at Agalawatta
1912	-	Department of Agriculture with 6 Technical Divisions- Research, Extension, Education & Training, Farms, Agricultural Economics & Royal Botanical Gardens
1918	-	Pasteur Institute
1921	-	University College
1922	-	Tea Research Institute (TRI) at Talawakelle
1928	-	Coconut Research Institute (CRI) at Lunuwila
1937	-	Veterinary Research Laboratory (VRL)
1941	-	Industrial Research Laboratory (IRL)
1942	-	University of Ceylon (amalgamating Ceylon Medical College and University College)
1946	-	Medical Research Institute (MRI) combining Pasteur Institute and Bacteriological Institute
1947	-	Anti Malaria Campaign
1947	-	Anti Filariasis Campaign
1948	-	Rubber Services Laboratory (RSL)
1948	-	Department of Meteorology
1948	-	Ceylon Cancer Society
1948	-	Ceylon National Association for the Prevention of Tuberculosis (CNAPT)
1949	-	Department of Wildlife Conservation
1952	-	Central Rice Breeding Station, Batalagoda (now Rice Research Development Institute RRDI)
1955	-	Ceylon Institute of Scientific and Industrial Research (CISIR)
1962	-	Geological Survey Department
1962	-	State Engineering Corporation (SEC)
1962	-	Bandaranaike Memorial Ayurvedic Research Institute (BMARI)
1967	-	Veterinary Research Institute (VRI) upgrading VRL
1968	-	National Institute of Business Management (NIBM)
1968	-	Family Health Bureau
1969	-	Industrial Development Board (IDB)
1969	-	Atomic Energy Authority (AEA)
1969	-	Ceylon Electricity Board (CEB)
1971	-	Agrarian Research and Training Institute (now HARTI)
1972	-	Department of Export Agriculture (DEA)
1973	-	Ceylon Engineering Consultancy Bureau (CECB)
1973	-	Demographic Training and Research Institute
1974	-	Sri Lanka Foundation Institute (SLFI)
1975	-	Water Resources Board
1975	-	National Water Supply & Drainage Board (NWSDB)
1977	-	National Engineering Research & Development Centre (NERD)
1978	-	Palmyrah Development Board
1979	-	Sri Lanka Export Development Board (SLEDB)

1979	-	Sri Lanka Scientific and Technical Information Centre
1979	-	National Institute of Health Services (NIHS)
1979	-	Mahaweli Authority of Sri Lanka
1980	-	Department of Telecommunications
1980	-	Coconut Development Authority
1981	-	Institute of Fundamental Studies (IFS)
1981	-	Sugar Research Institute (SRI) at Kantalai
1982	-	National Aquatic Resources Research and Development Agency (NARA)
1984	-	National Building Research Organization (NBRO)
1984	-	Ceramics Corporation Laboratory (now Ceramics Research Institute)
1984	-	Sri Lanka Standards Institute (SLSI)
1984	-	Sri Lanka National Designs Centre (NDC)
1984	-	Coast Conservation Department
1985	-	Arthur C. Clarke Centre for Modern Technologies (ACCMT)
1985	-	National Institute of Education (NIE)
1987	-	Institute of Computer Technology (ICT)
1988	-	International Union for Conservation of Nature (IUCN), Sri Lanka Office
1989	-	Intermediate Technology Development Group (ITDG)
1990	-	Institute of Policy Studies (IPS)
1990	-	National Drug Quality Assurance Laboratory
1990	-	National Apprenticeship and Industrial Training Authority
1992	-	Institute for Construction Training And Development (ICTAD)

INSTITUTIONAL POLICY FRAMEWORK
(Some Highlights)

1942 - Scientific Advisory Committee to British Govt.
1945 - **Free Primary, Secondary & Tertiary Education**
1966 - National Science Council (NSC)
1966 - National Council for Higher Education
1970 - Research Grants Scheme of NSC
1971 - University Grants Commission (UGC)
1978 - Science Policy Statement by President of S.L.
1978 - Agricultural Development Authority
1978 - Greater Colombo Economic Commission (now Board of Investment
1979 - Forestry Review of S.L.
1980 - Central Environment Authority (CEA)
1981 - Natural Resources Energy & Science Authority of Sri Lanka (NARESA)
1982 - Forest Resources Development Plan
1984 - Computer Information & Technology Council (CINTEC)
1986 - Science Policy Document (9 Vol.Sessional Paper)
1987 - Council for Agricultural Policy Research(CARP)
1987 - Human Resources Development Council (HRDC)
1988 - Agriculture Master Plan
1990 - Coastal Zone Management Plan
1990 - Technical & Vocational Education Commission
1991 - Presidential Task Force on Science & Technology
1991 - National Education Commission
1994 - National Forestry Plan
1994 - Industrial Policy Statement by Government
1994 - Presidential Task Force on Science and Technology
1995 - National S&T Policy and a Plan of Action

PROFESSIONAL ASSOCIATIONS

1887 - Sri Lanka Medical Association (SLMA)
1906 - Institute of Engineers
1926 - Surveyors Institute
1932 - Sri Lanka Dental Association (SLDA)
1940 - Chemical Society
1944 - Ceylon Association for the Advancement of Science (now SLAAS)
1944 - Ceylon Economic Research Association
1948 - Sri Lanka Veterinary Association (SLVA)
1957 - Sri Lanka Institute of Architects (SLIA)
1971 - Institute of Chemistry
1975 - Organization of Professional Associations (OPA)
1977 - Computer Society of Sri Lanka (CSSL)
1978 - Social Scientists Association
1981 - Institute of Physics
1983 - Sri Lanka Economic Association
1984 - Institute of Biology
1988 - National Academy of Sciences

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