National Survey of Research and Development in Sri Lanka 2004

National Science Foundation

47/5, Maitland Place,
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PREFACE

National Research and Development Survey 2004 is the detailed technical report which was compiled using the information collected through a questionnaire based National Survey of Research and Development 2004. This survey was conducted by the Science and Technology Policy Research Division (STPRD) of the National Science Foundation (NSF), Sri Lanka.

The National Research and Development Survey 2004 is the fifth in a series of surveys conducted in Sri Lanka. The first study was conducted by the Ceylon Institute of Scientific and Industrial Research (CISIR) in 1970 which was followed by the second and third surveys carried out in 1978 and 1986 by the National Science Council (NSC) and the Natural Resources Energy and Science Authority (NARESA) respectively. The fourth survey conducted by the National Science Foundation (NSF) in 2000, only had a partial coverage.

This report is based on the information gathered from the State, University and the Private sectors engaged in scientific and technological activities. The definitions and methods used in the survey were conformed to the internationally accepted OECD and UNESCO guidelines to facilitate national and international comparability. The S&T indicators or statistical data identified are aimed at policymakers, planners, researchers, scientists and technologists requiring a quantitative overview of national S&T activities. The report also analyzes the S&T indicators so developed and explains the issues in question when and where applicable.

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

Finally, we wish to record our deep appreciation for the encouragement and advice given by the Advisory Board appointed to the STPRD and the Board of Management of the National Science Foundation during this survey.

Dr P.R.M.P.Dilrukshi
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March 2007

FOREWORD

The National Science Foundation (NSF), Sri Lanka is mandated to meet the requirements stated in the Science and Technology Development Act No. 11 of 1994, viz; to maintain a current register of scientific and technical personnel, and in other ways to provide a central clearing house for the collection, interpretation and analysis of data, on the availability of and the current and projected need for scientific and technical resources in Sri Lanka, and to provide a source of information for policy formulation on science, technology and other related fields.

The Science and Technology Policy Research Division (STPRD) was established at NSF in 2005 with a view to meet the requirements stated above. The National Research and Development Survey of 2004 is one of a number of activities undertaken by the STPRD to provide information on science, technology, higher education and other related fields to the policymakers and others nationwide.

Prior to the above survey, the NSF and its predecessors, the National Science Council (NSC) and the Natural Resources, Energy and Science Authority (NARESA) have been compiling statistical data on Science and Technology (S&T) relevant to Sri Lanka since 1970s. However, the last detailed publication was done in 1996.

Based on the information collected through this survey, a handbook namely "Sri Lanka Science and Technology Statistical Handbook 2004" has already been published meeting the international standards as far as possible. This booklet is a full colour publication with the latest graphic designing and is a useful quick reference to readers, in the light of the renewed interest in science and technology in the country.

"National Survey of Research and Development 2004" is the detailed technical report that has analyzed the results and the S&T indicators developed according to the OECD and UNESCO manuals. Perhaps there may have been gaps in the private sector although a tremendous effort was expended to obtain information from that sector. Also, there may have been an over-assessment or under- assessment of expenditure on research due the reasons that have been discussed in detail in this report. The survey revealed that Sri Lanka had spent only 0.2 per cent of the GDP for Research and Development (R&D) in the country in 2004 which is far too low from the one per cent of GDP that has been recommended for the developing countries. Lack of a critical mass of scientists engaged in research, education and service sectors in the country is another issue that needs attention, along with the downward trend seen in the number of S&T personnel with postgraduate qualification. We also need a shift in policy on R&D expenditure in view of the very low amount (10.6 of total GERD) that has been spent on development oriented research. Strategies should also be brought into improve the poor research mechanism in the private sector which had employed only 11 per cent of total R&D personnel in the country and invested only 0.6 per cent of GERD during 2004. The chapter 5 on research output highlights the problems related to technology development and transfer. This clearly shows the demand for sound operational framework for technology transfer at the national level.

I take this opportunity to acknowledge the efforts of the Science and Technology Policy Research Division (STPRD) and the consultant Mrs. C.M. Fernando in conducting the 2004 survey amidst much constraints and coming up with this publication within a reasonable time frame.

Prof. Sirimali Fernando
Chairperson
National Science Foundation
Colombo, Sri Lanka. 01 March 2007

HIGH LIGHTS

1. The national Gross Expenditure on Research and Development (GERD) has increased to Rs.3,807.5 million in 2004.

2. The GERD/GDP ratio reached 0.21 in 2004.

3. The national Expenditure on Research and Development according to the source of funding in 2004 was: Government 67.5 per cent, Private 0.6 per cent , Foreign sources 17.7 per cent and other sources 9.3 per cent.

4. R&D Expenditure according to the sector of performance in 2004 was, 61.0 per cent in State sector 33.5 per cent in Higher Education sector, and 5.5 per cent in Private sector.

5. R&D Expenditure according to nature of research activity was 13.6 per cent for Basic Research, 75.8 per cent for Applied Research, and 10.6 per cent for Experimental Development Research.

6. R&D Expenditure in 2004 by discipline was Natural Sciences 16.5 per cent, Engineering & Technology 16.1 per cent, Medical Sciences 14.0 per cent, Agriculture Sciences 26.3 per cent, Social Sciences & Humanities 26.3 per cent and Other Sciences 0.9 per cent.

7. The R&D expenditure in Higher Education sector in 2004 by discipline was Natural Sciences 24.6 per cent, Engineering and Technology 32.5 per cent, Medical Sciences 36.2 per cent, Agriculture Sciences 6.3 per cent, Social Science & Humanities 5.0 per cent.

8. The R&D expenditure in State sector in 2004 by discipline was Natural Sciences 10.7 per cent, Engineering and Technology 7.2 per cent, Medical Sciences 2.8 per cent, Agriculture Sciences 37.8 per cent, Social Science & Humanities 40.3 per cent and Other Science 1.2 per cent.

9. The R&D expenditure in Private sector in 2004 by discipline was 31.7 per cent in Natural Science 15.8 per cent in Engineering and Technology, 1.5 per cent in Medical Sciences, 22 per cent Agriculture Sciences, 27.3 per cent Social Science & Humanities and 1.7 per cent for Other Sciences.

10. The total Science and Technology Personnel (STP) in 2004 was 28,432 and by the category, it included 34.2 per cent S&T Scientists, 43.3 per cent Technicians, 22.5 per cent Other Supporting Staff.

11. The distribution of STP by sector was in Higher Education 15.1 per cent, State sector 44.6 per cent and Private Sector 40.3 per cent.

12. Number of technicians per Scientist was 1.26 in Higher Education sector, 0.21 in State sector 0.16 and in Private sector 39.5.

13. Total number of Persons involved in R&D was 9,705 and this comprised 4,602 Researchers, 2,034 Technicians and 3,069 of Other Supporting Staff.

14. Total R&D Personnel (FTE) was 5,475 and this comprised 2,679 of Researchers, 1,474 of Technicians, 1,322 of Other Supporting Staff.

15. According to the discipline, the highest number of Science and Technology personnel (STP) was found in the area of Engineering and Technology (29.0 per cent) followed by Natural Sciences (28.9 Per cent), Agriculture sciences (20.3 per cent), Social Sciences (5.4 per cent), Medical Sciences (4 per cent), and other sciences (12.4 per cent).

16. The educational qualification of S&T Scientists amounted to 10.3 per cent of Ph.Ds, 14.4 per cent M.Phil./M.Sc., 42 per cent B.Sc. plus Postgraduate Diploma, 65.4 per cent with B.Sc. special degree only and 5.7 per cent with B.Sc. general degree only.

17. 72 per cent of the scientists in the higher education sector were female while 20.9 per cent in State sector and 6.6 per cent in Private sector were recorded to be female.

18. Highest percentage of female scientists were recorded in Natural Sciences discipline (43 per cent) followed by 20 per cent female in medical sciences, 18 per cent in agriculture sciences, 12 per cent in Engineering & Technology, 7 per cent in Social science and humanities and 1 per cent in Other sciences.

19. Highest percentage (48.7 per cent) of female scientists full time engaged in R&D activities were recorded in Medical Sciences followed by Social Science and Humanities (39.9 per cent), Natural Sciences (38.7 per cent), Agriculture sciences (30.8 per cent), Engineering &Technology (18.7 per cent) and other sciences (31.7 per cent).

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Chapter 3 Financial Resources for Research and Development

Chapter 4 Scientific and Technology Manpower Resources

Chapter 5 R&D Output

Chapter 6 Development of Education Sector in the Country

LIST OF ABBREVIATIONS

ADB	Asian Development Bank
Agric.	Agriculture
Arch.	Architecture
B.Sc.	Bachelor of Science
CARP	Council for Agricultural Research Policy
CD	Central Dispensary
CDMH	Central Dispensary and Maternity Home
CIMA	Chartered Institute of Management Accountants
CISIR	Ceylon Institute for Scientific & Industrial Research
Com.	Commerce
Eng.	Engineering
EUSL	Eastern University of Sri Lanka
F	Female
FTE	Full Time Equivalent
GDP	Gross Domestic Product
GERD	Gross Expenditure on Research and Development
GNP	Gross National Product
GOSL	Government of Sri Lanka
GWAI	Gampaha Wickremaarachi Ayurvrdic Institute
HEI	Higher Education Institutes
HORDI	Horticulture Crop Research and Development Institute
HRH	Human Resources of Health
ICAS	Institute of Charted Accounts of Sri Lanka
ICTA	Information and Communication Technology Agency of Sri Lanka
IFS	Institute of Fundamental Studies
IIM	Institute of Indigenous Medicine
IT	Information Technology
ITI	Industrial Technology Institute
IUCN	International Union of Conservation of Nature
IWMI	International Water Management Institute
M	Male
M.Phil.	Master of Philosophy
M.Sc.	Master of Science
Med.	Medicine
MOH	Medical Office of Health
Mt.	Management
NARESA	Natural Resources Energy and Science Authority
NERDC	National Engineering Research and Development Centre
NGOs	Non Government Organizations

NHRC	National Health Research Council
NIBM	National Institute of Business Management
NIHS	National Institute of Health Science
NRC	National Research Council
NSC	National Science Council
NSF	National Science Foundation
OECD	Organization for Economic Co-operation and Development
PU	Peripheral Unit
R&D	Research and Development
RH	Rural Hospital
RRI	Rubber Research Institute
RUSL	Rajarata University of Sri Lanka
S&T	Science and Technology
SAREC	Swedish Agency for Research Co-operation
Sc.	Science
SEUSL	South Eastern University of Sri Lanka
SIDA	Swedish International Development Agency
SLAAS	Sri Lanka Association for the Advancement of Science
SLIDA	Sri Lanka Institute of Development Administration
SLIIT	Sri Lanka Institute of Information Technology
SLIM	Sri Lanka Institute of Marketing
STP	Science and Technology Personnel
SUSL	Sabaragamuwa University of Sri Lanka
T	Total
TRI	Tea Research Institute
UGC	University Grant Commission
UOC	University of Colombo
UOJ	University of Jaffna
UOK	University of Kelaniya
UOM	University of Morotuwa
UOP	University of Peradeniya
UOR	University of Ruhuna
UOSJ	University of Sri Jayawadenapura
USA	United States of America
USPTO	United States Patent Office
WHO	World Health Organization
WUSL	Wayaba University of Sri Lanka

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Chapter 1

INTRODUCTION

1.1 Overview

A strong correlation between the rate of growth in a country's Research and Development (R&D) and its rate of growth in GDP has been established by many developed countries. The creation of knowledge through R&D is economically useful because of the product or process that directly results, and also because it fosters greater capabilities to use other technologies and gives access to more knowledge. Today, all industrialized countries devote an increasing amount of resources, both public and private, to improve their competitive positions globally through Science and Technology. The final goal of R&D activities are to raise technological standards as a whole and use the results of research to promote economic growth, improve people's standards of living and improve the nations autonomous defense capability. As a consequence, comparisons of R&D resources and their outcomes figure prominently in the performance of the Science and Technology (S&T) system in a particular country. Therefore constant monitoring of the S&T system in a country is essential for its improvements.

Science and Technology indicators are the tools that are used to measure the performance of the S&T system. These indicators are based on the systematic collection and interpretation of information about science and its social impact, for the purpose of formulating science policies which are to be implemented at national level as well as at organization level.

Science and Technology indicator analyses have been developed since early 1970s with the release of the first Science and Engineering Indicator publication by the National Science Foundation, USA. Since then many countries have produced documents that attempt to capture the essence of their national knowledge and innovation systems. Though the documents take different forms, the purpose and scope of data used is almost universal. Holbrook (1992) observed that Science and Technology indicators are also considered as an important policy issue in their own right, and not just an adjunct to other policy initiatives.

1.2 National Perspectives

Sri Lanka is one of the countries in South Asia which has a long tradition in developing science and technology statistics and indicators. The mandate to collect S&T statistics was provided to the National Science Council (NSC) of Sri Lanka (Presently the National Science Foundation) in 1967. Early studies on S&T indicators were carried out in 1970 to asses the scientific resources in Sri Lanka in terms of public expenditure on research and development by the Ceylon Institute for Scientific & Industrial Research (CISIR) (now known as the Industrial Technology Institute-ITI) followed by a survey on scientific and technical manpower in Sri Lanka carried out in 1972 by the Ceylon Association for the Advancement of Science presently known as the Sri Lanka Association for the Advancement of Science (SLAAS).

However, the first systematically designed survey on scientific and technical manpower potential in the country was carried out in 1974, by the National Science Council following the guidelines prepared by the UNESCO to assess, monitor and forecast the scientific and technical manpower in the country. In 1977, the National Science Council (NSC) carried out its second major survey which included an

assessment of funding for basic and applied research in the country for the 10 year period 1956-1965, and the technical manpower during 1977.

The third study in the series was carried out in 1984 by the Natural Resource Energy and Science Authority (NARESA) which was the successor to NSC. The fourth comprehensive survey on research and development in Sri Lanka was then carried out by the NARESA in 1996. This survey covered higher education, public S&T sector and private sector institutions. A subsequent study carried out by the NSF in 2000 only covered the higher education sector and S&T public sector (unpublished data).

These studies have shown the trend in the development of S&T sector in the country and have always provided information to policy makers.

The Present survey is focused on the development of input indicators, Output indicators also a few Impact indicators for the year 2004.

1.3 Objectives

The main Objective of this study was to assess the trends in R&D Expenditure and to incorporate S&T indicators to measure the impact of the Science and Technology sector in the country.

The specific objectives of the study were:

1. Measure the R&D expenditure and the sources of income in the country in the year 2004
2. Measure the R&D expenditure in different sectors in the country in the year 2004
3. Measure the Human Resource involved in S&T activity in the country in 2004
4. Measure the Human Resources involved full time in the R&D activity in 2004
5. Measure the R&D out put in term of publications, Patents and Postgraduate output
6. Measure the impact of R&D activities in terms of economic indicators.

Chapter 2

METHODOLOGY

2.1 Overview

The main purpose of this study was to assess the trends in R&D Expenditure and to incorporate S&T indicators to measure the impact of the Science and Technology sector in the country in the period of 1st January 2004 – 31st December 2004 in the country. These indicators will provide a reliable basic database to national S&T policy planners in framing and amending a viable and sustainable Science & Technology Policy for the country.

2.2 Methodology

The questionnaires for data collection were prepared for different sectors such as Higher Education sector, the State sector R&D Institutions and other S&T related Institutions and the Private sector including Industries and the Non Government Organizations (NGOs). The key terms used in this questionnaire were based on the main definitions and the conventions for measurement in the "Manual of Research and Experimental Development" (Frascati Manual, 1993) and the "Manual for the measurement of human resources devoted to S&T" (Canberra Manual, 1995) which was published by the Organization for Economic Co-operation and Development (OECD). The guidelines developed by UNESCO for the developing countries were also followed. The following basic input and output indicators were measured:

2.2.1 Input Indicators

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1. Stock of R&D personnel (FTE) by sector and discipline
2. Stock of economically active STP engaged in R&D-Full time equivalent (FTE) by discipline and sex

2.2.2. Research and Development Output Indicators

1. Number of Patents registered locally 1995-2004
2. Number of Technological Innovations and New Process Developments in 2001- 2004.
3. Number of Research Publications (Local and International) in 2001- 2004
4. Postgraduate output

A large number of more sophisticated Indicators have been identified and are extensively used in the developed industrialized countries in their efforts to identify and quantify with increasing precision the thrust areas of S&T which contribute to their economic development. However, in view of the lack of reliable and up-to-date secondary databases and limitations of primary data collection through surveys faced by developing countries, the validity and reliability of interpretation and analysis may decrease sharply with increasing differentiation and sophistication of indicators.

2.3 Survey Design

The institutions that are likely to carry out S&T activities were identified according to UNESCO and OECD definitions. All institutions that can be categorized as "Higher Education", "State", "Private and "Non Government Organizations (NGOs)" were included. A structured four part questionnaire was sent to each institution seeking information on, R&D Expenditure, R&D Human Resources, R&D Output and Human Resources supporting directly on R&D activity or involved in providing services that are related to S&T. A contact person was assigned by each institute except for the organizations in the private sector to coordinate the data collection process in their respective institutions. Each institution was visited by the R&D survey team of the S&T Policy Research Division (STPRD) of the NSF. Issues and definitions regarding the information expected from each institution were explicitly clarified to the contact person to ensure accuracy and comparability of data. The data collection in the university sector was done by the Graduate Research Assistants who had in-house training at the NSF on the measurement of R&D and S&T indicators used in the survey. Every effort was made to ensure that the data gathered in this survey could be considered as reliable and accurate.

Since the initial response of the Industrial Sector organizations was extremely low, it was decided to out-source the collection of data to an umbrella organization that had close contacts with the industrial sector. But the outcome was not very satisfactory.

2.4 Sources of Error

The following sources of errors were identified.

a. Coverage

In identification of S&T institutes, maximum coverage was ensured as any major omission could lead to distortions in analysis. It must be mentioned that 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 the State sector research institutions and several key government departments. Other than these research institutes, the universities play a major role in the area of research in the country. There are several government sponsored or foreign funded or international organizations and export-oriented Private sector firms which are also involved in work relevant to R&D. Attempts were made to cover all the relevant institutions under the survey and details of the coverage are given below:

b. Higher Education Sector

The Higher Education sector of the country comprised 15 universities and two major institutions that provide higher education. The University Grant Commission (UGC) is the over-arching administrative body that governs the higher education sector in Sri Lanka. The Survey covered 13 Universities as other 02 were new additions after 2004, the affiliated institutes and two higher education institutions, along with the UGC (Annex 1).

c. State Sector

There are 29 Research Institutes directly involved in R&D that function under various Departments and Ministries of the State. All these institutes were covered in this survey.

Hundred and nineteen institutes (119) in the state sector were recognized for providing services related to S&T. Some of these organizations have units which also engage in R&D activities. The available information on R&D expenditure of these units as well as the S&T personnel of the whole Institute was covered in this survey.

d. Private Sector

As mentioned earlier, the Private sector organizations can be categorized as Industries and NGOs. The Private sector has also increased its R&D component to meet the challenges of globalization especially in the key export-oriented thrust areas of textiles, computer soft-ware, gems and jewellery, ceramics and food technology. Out of all industries listed in the country, 298 organizations were identified as institutions that may be involved in R&D related work. Of these institutions the industries that responded to the survey are listed in Annex 1. A large number of industries surveyed mentioned that they were not currently doing any research or development work within the country. Others did not respond in spite of several reminders.

Eventually the data collection in the Industrial sector was out-sourced to the National Chamber of Industries which is structured to maintain close liaison with the industrial sector organizations, but the increase in response due to this attempt was only marginal.

In the field of Information Technology, there are some organizations that do innovative work in the area of software development catering to local and foreign requirements. Similar problems were encountered during the data collection from these organizations as they do not consider this type of activities related to R&D and therefore accurate information was not made available.

There are a number of NGOs operating in the country that are involved in a wide range of activities including humanitarian, social, human development and environment conservation activities. Some of these organizations are also involved in doing research activities, mostly surveys that are related

to their mission. All these organizations were contacted during this survey and the organizations reporting R&D activities are listed in Annex 1.

e. Identification of target population

In identification of target population for the S&T personnel survey, two types of errors can occur. Type I error can occur in rejecting scientists who should be included while Type II error can occur if individuals who cannot be considered as S&T personnel are included.

To minimize Type I and Type II errors in this survey, a detailed list of disciplines and specialties under each discipline was prepared using the UNESCO and OECD (Canberra Manual) guidelines. The same was sent to each institution surveyed along with the relavant questionnaire. Respondents were encouraged to clarify any doubts with the NSF staff before finalizing responses to the questionnaires.

f. Sampling Error

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

g. Non –sampling Error

Two common types of non-sampling errors may occur in this type of surveys. They are the errors due to non-response and errors of measurement.

i) Non-response

Non-response is a major problem which should be tackled at both institutional level and individual level. Every effort was made to reduce unit non–response by making several follow up visits and telephone calls and by sending postal reminders.

Item non-response, where certain variables like research discipline, qualifications, sex, age etc., were omitted in some responses, was another source of error which could lead to distortion of the disaggregated analysis. Proportionate allocation was used to minimize this distortion effect.

ii) Measurement errors

Measurement errors can arise in computing R&D expenditure since most institutions do not have separate accounts for capital expenditure on R&D work only. Therefore, efforts were made to identify and measure the actual level of R&D activities in such organizations and apportion the total expenditure on R&D and related activities. This computation was undertaken in close consultation with the management and the accounting personnel of the institution. The differentiation has to be reckoned with in the comparison with the previous surveys.

2.5 Analysis of data

In the next chapters, data from the present survey is analyzed against the backdrop of previous studies but for comparison purposes, it must be borne in mind that survey procedures have been continuously refined and up-dated. Hence earlier data may not have the same degree of precision or comparability. Attempts were also made to examine the survey data from the perspective of deployment of S&T activities in the key areas of the national economic infrastructure and to identity significant dynamics and trends which could have an impact on the future economic growth.

Chapter 3

FINANCIAL RESOURCES FOR RESEARCH AND DEVELOPMENT (R&D)

3.1 Growth of R&D Expenditure

Table 3.1 gives summary of GERD, GDP and population statistics during the 38 years period covered by R&D surveys undertaken in Sri Lanka.

Table 3.1

GROWTH OF R&D EXPENDITURE IN SRI LANKA

Year	GDP Current Prices (Rs.m)	GERD Rs.m (US$)	GERD as Percent of GDP	Total Population (million)	GERD per million population Rs. million
1966	7,529	19.8 (4.1)	0.30	11.5	1.7
1975	11,100	45.1 (6.4)	0.40	13.5	3.3
1984	142,700	257.0 (9.7)	0.18	15.6	16.5
1993	499,800	649.0 (13.1)	0.13*	17.6	36.8
1996	769,900	1,410.0 (23)	0.18	18.3	77.0
2000	1,258,000	1,810.0 (22.9)	0.14*	18.4	98.4
2004	1,800,750	3,807.5 (40.9)	0.21	19.4	196.2

Source: National R&D Surveys Sri Lanka 1996 (NARESA), 2000 & 2004 (NSF)
*Estimates

According to the records, the Gross National Expenditure on Research and Development (GERD) has increased in absolute terms sharply and reached an all time high of Rs.3,807.5 million in 2004 (Table 3.1, Figure 3.1).

3.2. GERD/GDP Ratio

The GERD/GDP ratio, which is a measure of the commitment of the government to the promotion of R&D in the country, decreased gradually from 0.3 in 1966 to 0.13 in 1993. The ratio increased to 0.18 in 1996 and decreased again to 0.14 in year 2000. The decrease in 2000 may due to partial coverage of the particular survey. In year 2004 the ratio has increased once again to 0.21 The escalation of GERD in absolute terms which has taken place in recent years, is nullified in real terms due to the effect of inflation (Figure 3.1).

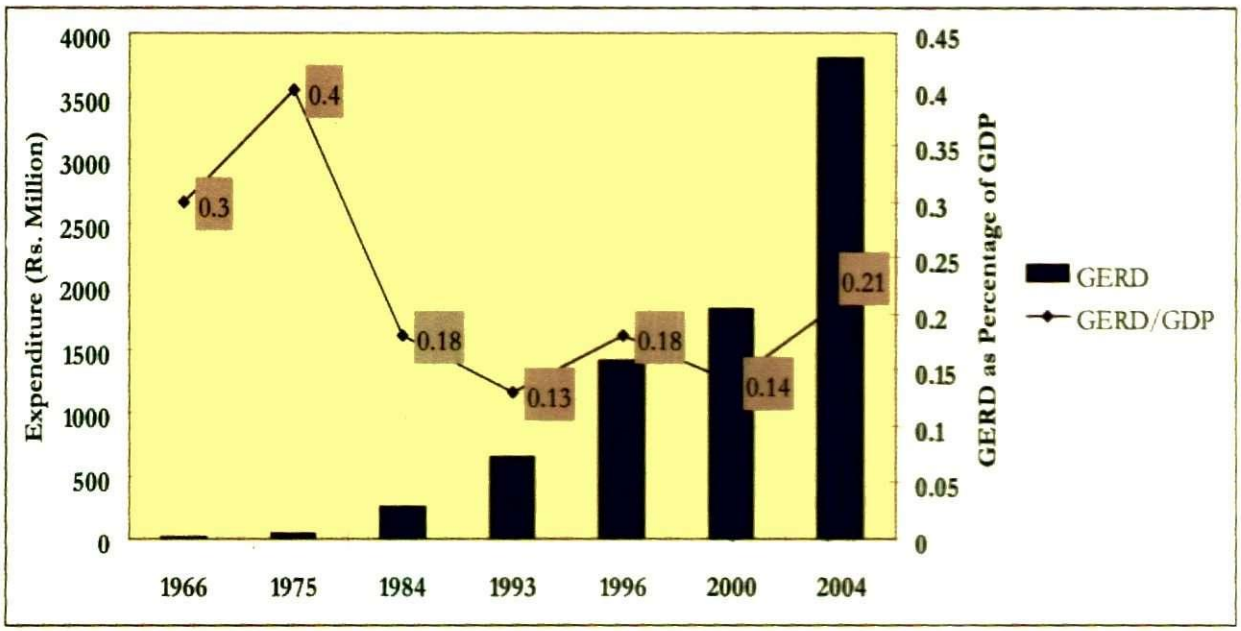

Figure 3.1

GROWTH OF R&D EXPENDITURE

In international comparisons shown in Table 3.2, the GERD/GDP ratio of 0.21 recorded in 2004 in Sri Lanka was one of the lowest in the region while some other fast developing countries in the Asian region have recorded impressive growth in GERD in past 10 years.

Notably, GERD/GDP ratio in Singapore increased from 1.38 in 1996 to 2.25 in 2004. Similarly, Malaysia showed a steady increase in GERD/GDP ratio from 0.22 per cent in 1996 to 0.69 per cent in 2002. India also has increased its GERD/GDP ratio from 0.55 in 1996 to 0.85 in 2000. India has set its goal on crossing the 2 per cent threshold in the coming years (UNESCO Science Report, 2005). Notably, the GERD/GDP ratio of newly industrialized countries in the Asian region has reached the average level of other developed countries (2.3 per cent). The GERD/GDP was highest in Israel (4.9 per cent), Japan (3.1 per cent) and United States of America (2.8 per cent). Gross Expenditure for R&D recorded in Sri Lanka for 2004 was less than average recorded for the less developed countries (0.5) (Table 3.3).

Table 3.2

OVERVIEW OF INTERNATIONAL COMPARISON OF R&D PERFORMANCE

Country	Year	GERD (Local Currency, 000')	R&D Expenditure (000 PPP $)	%GERD/GDP	Precipitate GERD (PPA $)
Australia	1996	8,792,400	6,766,400	1.66	372.6
	2000	10,417,100	7,795,202	1.51	408.7
	2002	12,842,700	9,499,196	1.7	486.8
China	1996	40,448,000	19,919,511	0.60	16.2
	2000	89,566,500	48,300,013	1.00	37.9
	2002	128,760,000	71,339,469	1.22	55.2
	2003	153,963,000	84,618,281	1.31	65.1
	2004	196,661,000	-	1.44	78.5
India	1996	74,838,800	10,229,064	0.55	10.7
	1998	129,015,400	15,760,060	0.74	16.0
	2000	176,602,100	20,740,315	0.85	20.3
Indonesia	2000	940,776,000	467,842	0.07	2.2
	2001	783,045,000	343,868	0.05	1.6
Japan	1996	14,155,058,000	82,979,517	2.78	569
	2000	15,304,423,000	98,606,097	2.99	776.2
	2002	15,551,513,000	106,631,451	3.12	836.2
	2003	15,683,403,000	112,221,817	3.15	878.5
Korea	1996	10,878,050,000	14,038,947	2.42	309.2
	2000	13,848,501,000	17,101,694	2.39	365.6
	2002	17,325,082,000	20,777,322	2.53	439.6
	2003	19,068,682,000	22,761,539	2.64	479.6
Malaysia	1996	549,196	353,784	0.22	16.9
	2000	1,671,500	1,014,543	0.49	44.1
	2002	2,500,600	1,539,498	0.69	64.2
Nepal	2002	2,807,000	221,728	0.66	8.7
Pakistan	1997	3,779,750	349,645	0.16	2.6
	2000	4,908,030	343,957	0.13	2.4
	2002	9,785,470	649,951	0.22	4.4
Singapore	1996	1,792,140	974,189	1.38	271.5
	2000	3,009,520	1,801,481	1.91	448.4
	2002	3,404,660	2,153,730	2.15	517.3
	2003	3,424,470	2,239,000	2.15	530.6
	2004	4,061,900	.....	2.25	627.3
Sri Lanka	1996	1,410,000	88,931	0.18	4.7
	2000	1,810,000	91,852	0.14	4.6
	2004	3,807,529	152,237,547	0.21	7.4
Thailand	1996	5,528,134	452,306	0.12	7.7
	2000	12,406,290	971,897	0.25	15.8
	2002	13,302,039	1,054,507	0.24	16.8
	2004	15,499,201	1,230,952	0.26	19.5
UK	1996	14,336,000	22,733,835	1.88	392.9
	2000	17,718,000	27,060,829	1.86	461.2
	2002	19,816,700	29,401,081	1.9	497.7
	2003	20,821,400	30,503,580	1.89	514.5
USA	1996	197,792,150	199,840,988	2.55	733 ?
	2000	267,767,450	264,007,955	2.47	929.1
	2002	276,260,200	274,417,590	2.65	946.9
	2004	312,535,430	.....	2.68	1,063.2

Sources: UNESO Science Indicators, 2005;
National R&D Surveys Sri Lanka 1996 (NARESA) & 2004 (NSF)

Table 3.3

KEY INDICATORS ON WORLD GDP, POPULATION AND GERD, 2002

	GDP (in billions)	% World GDP	Population (in million)	% World population	GERD (in billion)	% World GERD	% GERD /GDP	GERD per Capita
World	47,599.4	100.0	6,176.2	100.0	829.9	100.0	1.7	134.4
Developed Countries	28,256.5	59.4	1,195.1	19.3	645.8	77.8	2.3	540.4
Developing Countries	18,606.5	39.1	4,294.2	69.5	183.6	22.1	1.0	42.8
Less-developed countries	736.4	1.5	686.9	11.1	0.5	0.1	0.1	0.7
European Union	10,706.4	22.5	453.7	7.3	195.9	23.6	1.8	431.8
Comm. of Ind. States in Asia	207.9	0.4	72.6	1.2	0.7	0.1	0.4	10.3
Newly Industrialized Asia	2,305.5	4.8	374.6	6.1	53.5	6.4	2.3	142.8
Arab States Asia	556.0	1.2	103.9	1.7	0.6	0.1	0.1	6.2
Other Asia	1,720.0	3.6	653.7	10.6	1.4	0.2	0.1	2.1
Brazil*	1,300.3	2.7	174.5	2.8	13.1	1.6	1.0	75.0
China	5,791.7	12.2	1,280.4	20.7	72.0	8.7	1.2	56.2
Germany	2,226.1	4.7	82.5	1.3	56.0	6.7	2.5	678.3
India*	2,777.8	5.8	1,048.6	17.0	20.8	2.5	0.7	19.8
Sri Lanka	193.4	0.4	19.4	0.3	0.4	0.05	0.2	2.1
Israel	124.8	0.3	6.6	0.1	6.1	0.7	4.9	922.4
Japan	3,481.3	7.3	127.2	2.1	106.4	12.8	3.1	836.6
Russian Federation	1,164.7	2.4	144.1	2.3	14.7	1.8	1.3	102.3
South Africa	444.8	0.9	45.3	0.7	3.1	0.4	0.7	68.7
United Kingdom	1,574.5	3.3	59.2	1.0	29.0	3.5	1.8	490.4
United States of America	10,414.3	21.9	288.4	4.7	290.1	35.0	2.8	1,005.9

Source: UNESCO Institute for Statistics estimations, December 2004.

* GERD figures for Brazil and India are all for 2000.

Note: For Asia, the sub-regional totals do not include China, India or Japan

R&D Survey 2004, NSF Sri Lanka

3.3 R&D Expenditure by Source of Funding

The breakdown of expenditure by source of funds in different sectors is presented in Table 3.4. According to the data collected, the major source of funds for Research and Development (R&D) is the government. The contribution of the government sector was 68 per cent of the total funds. There are four major state sector organizations that are directly involved in disseminating state funds for Research and Development in Sri Lanka. The National Science Foundation (NSF) is a multidisciplinary research funding organization that provides funds for all types of institutions including higher education, government and private sector. The National Research Council (NRC) also funds research activities in the country. The Council

for Agriculture Policy (CARP) provides funds for R&D activities in the agriculture sector while, the National Health Research Council (NHRC) provides funds for health sector research in the country.

Table 3.4

NATIONAL EXPENDITURE ON R & D BY SOURCE OF FUNDING – 2004.

Rs. million

Source of Funding	Recurrent	Capital	Total
Government	2,115.3 (55.6 %)	456.0 (12.0%)	2,571.3 (67.5%)
Private	17.1 (0.5 %)	4.7 (0.1%)	21.9 (0.6 %)
Foreign	675.7 (17.7 %)	186.2 (4.9 %)	861.8 (22.6 %)
Other	276.4 (7.3 %)	76.1 (2.0 %)	352.5 (9.3 %)
Total	**3,084.5 (81.0 %)**	**723.0 (19.0%)**	**3,807.5 (100.0 %)**

Significantly, 23 per cent of funds for R&D in the country come from foreign funding sources such as SAREC, SIDA, IFS, ADB, WHO and other agencies. It can be assumed that the contribution of foreign donor organizations could be appreciably more than what is recorded here for reasons outlined below.

It was observed that some of the foreign funds come directly to individual researchers who are rather reluctant to disclose the actual amount they receive as they feel that it would lead to a reduction in the government funding for their research. Also, some foreign funds come by means of donations of equipment, chemicals, reading materials etc. that are not usually recorded under R&D expenditure.

There are some large multidisciplinary projects that were funded by foreign donor organizations involving more than one local organization in its implementation. The incorporation of data on this type of project was extremely difficult as it involved more than one organization and such data might be either duplicated or left out in provision of data for the Survey. There are a few international organizations like IUCN and IWMI that operate as R&D organizations within the country. They also do collaborative research work with local institutions and researchers. The Survey covered the R&D activities of IUCN while the other organization did not provide information though several requests were made.

The contribution by the private sector was 0.6 per cent. This includes funds from the Industrial Sector organizations and the Private Non Profit Organizations (e.g. NGOs) (Figure 3.2). This figure is a gross under-estimation for reasons outlined earlier. Though there are number of NGOs operating in Sri Lanka, only a few actually fund R&D activities in the country. Many were involved in humanitarian activities and only occasionally involved in R&D activities which constitute mostly the surveys falling into the area of Social Sciences and Humanities.

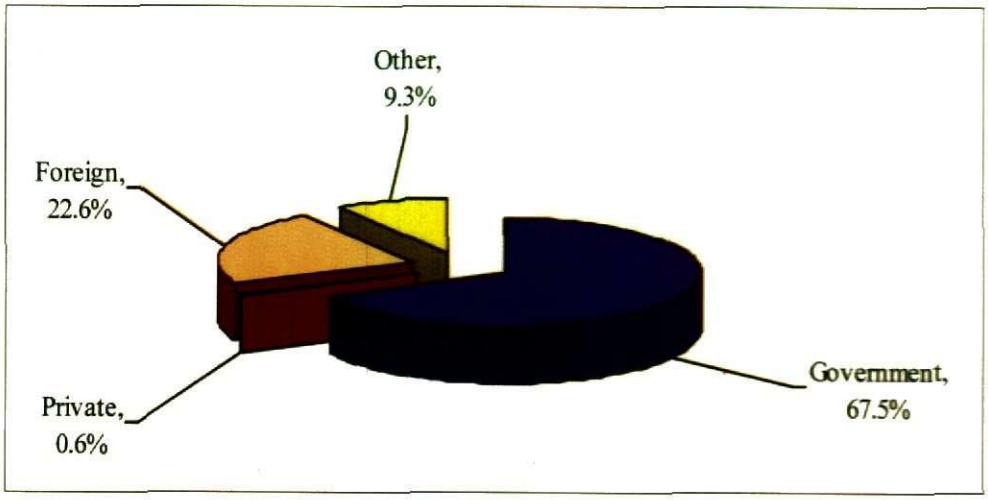

Figure 3.2

NATIONAL EXPENDITURE ON RESEARCH AND DEVELOPMENT (R&D) BY SOURCE OF FUNDING-2004

Some of the large multi-national companies that operate in Sri Lanka are known to have developed new technologies or have transferred technologies from other countries through their parent organizations. This information is not documented and not included in the data provided for this survey due to the reluctance to disclose such information which may be used by their competitors.

Table 3.5

R&D Expenditure by Source of Funding 1984-2004

Rs. million

	Year		
Source of Funding	1984	1996	2004
Government	239.4 (93.2%)	981.0 (69.6%)	2,571.3 (67.5%)
Private	17.4 (6.8%)	21.5 (1.5%)	21.9 (0.6 %)
Foreign	-	324.5 (23.0%)	861.8 (22.6 %)
Other*		82.6 (5.9%)	352.5 (9.3 %)
Total	**256.8 (100.0%)**	**2,647.7 (100.0%)**	**3,807.5 (100.0%)**

Sources: National R&D Surveys Sri Lanka 1996 (NARESA) & 2004 (NSF)

*Other: funds generated by the institution itself by providing services etc.

It can be seen that over the last 20 years there is a considerable variation in the distribution of sources of funding, with the decline of government funding from 93 per cent in 1984 to 70 per cent in 1996 and further to 67 per cent in 2004 (Table 3.5, Figure 3.3). Similarly, the Private Sector contribution also shows a decline from 6.8 per cent in 1984 to 1.5 per cent in 1996 to 0.6 percent in 2004. However, funds from foreign sources have remained constant at 23 per cent in 1996 and in 2004. The other sources of funds, which constitute mainly the funds generated internally by providing services to other institutions or individuals, have also increased from 6 per cent in 1996 to 9 per cent in 2004 (Table 3.5). This is a healthy trend which should be encouraged.

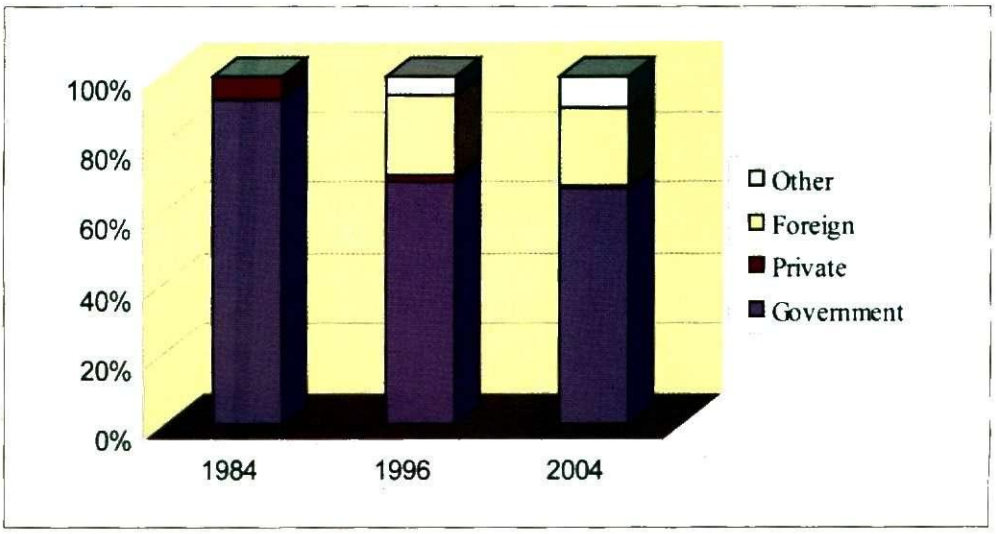

Figure 3.3

SOURCES OF NATIONAL RESEARCH AND DEVELOPMENT FUNDING 1984-2004

3.4 R&D Expenditure by Sector

The distribution of R&D expenditure by sector of performance at current prices in 2004 is shown in figure 3.4. According to the utilization of funds for R&D in the country, the government sector organizations are the major consumers of R&D funds (61 per cent). The higher education sector utilized 34 per cent of the R&D funds in 2004 while the private sector organizations utilized only 6 per cent of funds (Table 3.6).

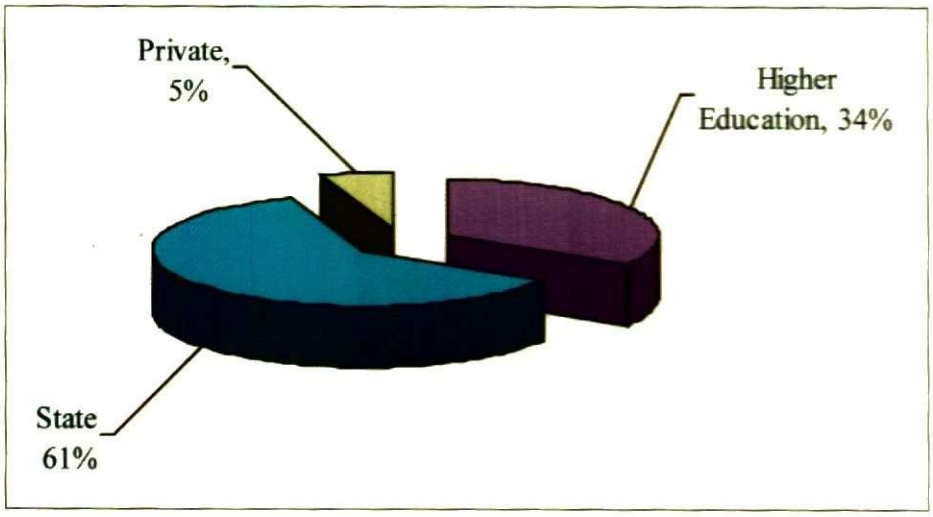

Figure 3.4

R&D EXPENDITURE BY SECTOR

Table 3.6

R&D EXPENDITURE BY SECTOR OF PERFORMANCE- 2004

Rs. million

Sector	Recurrent	Capital	Total
Higher Education	1,150.0	127.6	1,277.6
	(30.2%)	(3.3%)	(33.5%)
State	1,319.9	1,001.2	2,321.1
	(34.7%)	(26.3%)	(61.0%)
Private	132.4	76.4	208.8
	(3.5%)	(2.0%)	(5.5%)
Total	**2,602.3**	**1,205.2**	**3,807.5**
	(68.3%)	**(31.7%)**	**(100.0%)**

When compared with the previous studies, it is evident that funds utilized by the Higher Education sector have increased over the years (Table 3.5). This development may be partly a reflection of the salary increases which took place in the Higher Education sector as well as the inclusion of new departments and incorporation of affiliated institutes into the university sector. These new additions to universities have contributed to the expansion of R&D activities in this sector in new directions such as Biotechnology, Information Technology, and Indigenous Medicine etc., which have enormous potential for future development.

The percentage of time spent on research by the academic staff was used to calculate the proportion of salaries which were to be to be included in the recurrent R&D expenditure. Information on expenditure on salaries provided by the university Registrars and accounts divisions for the academic and non academic staff in the relevant Faculties and Institutions were used in the calculation. The time spent on research activities by the university staff depends on their academic workload. The academic workload varies among different faculties and universities, according to the number of students, disciplines and the resources available at the universities. It was noted during the survey that most of the academic staff at the newly established universities with no tradition of research spent very little time on R&D activities and some were only involved in teaching. Whereas, in the older established universities with a research culture, the proportion of staff involved in R&D activities was very high sustaining the established momentum. Therefore, taking into consideration these extremes, it was decided to take 25 per cent of the salaries of academic staff as recurrent expenditure on R&D, as a whole.

The technical and supporting staff in the universities provides technical and direct support to the academic staff in carrying out research activities at the universities. However, as they are mostly involved in the academic supporting activities, only 10 per cent of their salaries was taken as recurrent expenditure on R&D in the Higher Education sector.

In addition, the researchers use equipment which are usually categorized as the laboratory and teaching equipment used for both research and teaching purposes. Therefore, a part of such expenditure together with a part of the expenditure on new buildings should be added to the R&D capital expenditure on the Higher Education sector. Again there is no universally valid formula to measure the actual allocation of these resources. Therefore, taking into the account of the proportion of usage of these resources, 15 per cent of this expenditure was further added to the capital expenditure on R&D in the Higher Education sector.

With regard to the Industrial sector, inquiries from institutions such as EDB and BOI revealed that many incremental process/product development activities are taking place in the export oriented private sector firms, which are not being captured in the estimate of R&D expenditure. It must be emphasized that they should be the subject of a special study that would focus on innovations and new technologies, which are the precursors of future R&D.

To compensate for deficiencies in the data collected from the Private sector, some proxy indicators of industrial growth are presented in Chapter 7, which will enable the identification of thrust areas which have potentials for future development.

When comparing the type of funding across the years, it can be clearly seen that the recurrent expenditure on Research has always been higher compared to the capital expenditure which is indicative of shortfalls in investment for the future. According to the statistics, in 1984 the recurrent expenditure was double compared to the capital expenditure and in 1996 this had further increased in the ratio of 4:1 but decreased once again to 2:1 according to the present survey (Figure 3.5).

When comparing the type of funding by sector (Table 3.7), a differential pattern emerges across the sectors. In the Higher Education sector, the ratio of recurrent to capital expenditure had decreased from 9:1 in 1984 to 5:1 in 1996 but again increased sharply to the ratio of 9:1 in 2004. This could be attributed to the increased expenditure due to the revised salary structure in the university sector.

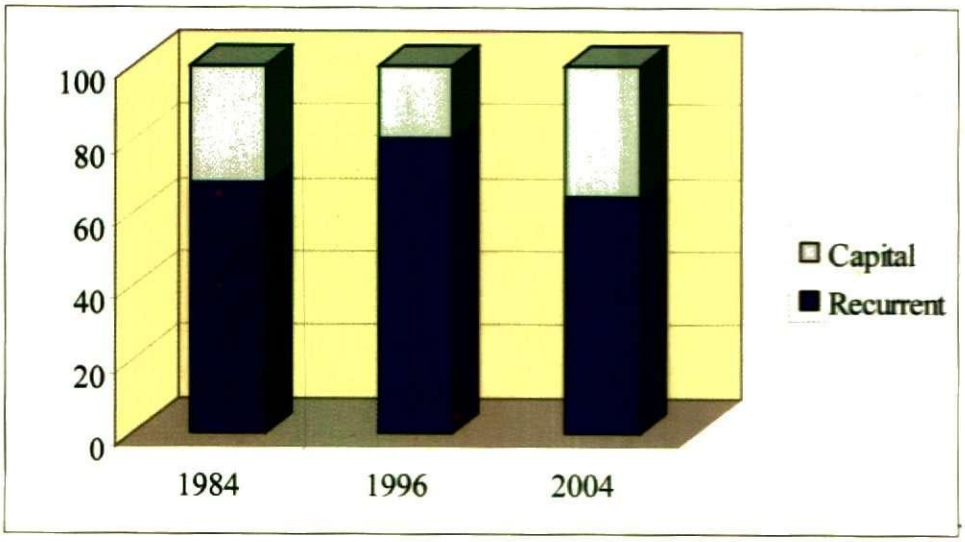

Figure 3.5

R&D EXPENDITURE BY TYPE

Table 3.7

NATIONAL R&D EXPENDITURE BY TYPE AND SECTOR OF PERFORMANCE

Rs. million

Sector	Year								
	1984			1996			2004		
	Recurrent	Capital	Total	Recurrent	Capital	Total	Recurrent	Capital	Total
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%)	1,150.0 (30.2%)	127.6 (3.3%)	1,277.6 (33.5%)
State	143.8 (56.0%)	72.5 (28.3%)	216.3 (84.3%)	827.2 (58.7%)	203.2 (14.4%)	1,030.4 (73.1%)	1,319.9 (34.7%)	1,001.2 (26.3%)	2,321.1 (61.0%)
Private	15.9 (6.2%)	8.3 (3.2%)	24.2 (9.4%)	3.0 (0.2%)	18.5 (1.3%)	21.5 (1.5%)	132.4 (3.5%)	76.4 (2.0%)	208.8 (5.5%)
Total	**174.3 (67.9%)**	**82.4 (32.1%)**	**256.7 (100.0%)**	**1,129.5 (80.1%)**	**280.1 (19.9%)**	**1,409.6 (100.0%)**	**2,602.3 (68.3%)**	**1,205.2 (31.7%)**	**3,807.5 (100.0%)**

Sources: National R&D Surveys Sri Lanka 1996 (NARESA) & 2004 (NSF)

In the state sector, a salient feature is that the ratio of recurrent expenditure to capital expenditure doubled from 2:1 in 1984 to 4:1 in 1996 but declined substantially to the ratio 1:1 in 2004. This is due to a sharp increase in the capital investment, which argues well for the future, while salaries have not increased to the same extent as seen in the university sector.

In the Private sector, the recurrent expenditure was double the amount of capital expenditure in 1984. However, in 1996 there was a reversal in trend and the capital expenditure had increased to six times that of the recurrent expenditure. In the present survey it was observed however, that the recurrent expenditure was nearly double the amount of the capital expenditure in the Private sector (Table 3.7). These trends must be interpreted with caution because of the inadequate coverage of the Private sector.

3.5 R&D Expenditure according to Nature of Research Activity

The research activities performed in a country are categorized generally into three areas depending on the nature of research viz: basic research, applied research and experimental development. The accepted definitions are as follows:

a. Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations phenomena and observed facts, without any particular application or use in view. Basic research analyses properties, structures, and relationships with a view to formulating and testing hypothesis, theories or laws. The results of basic research are not generally sold but are usually published in scientific journals or circulated among interested colleagues. Basic research may be "classified" for security reasons.

b. Applied research is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective. The results of applied research are intended primarily to be valid for a single or limited number of products, operations, methods, or systems. Applied research develops ideas into operational form. The knowledge or information derived from applied research is often patented but may also kept secret.

c. Experimental development is systematic work, drawing on existing knowledge gained from research and practical experience that is directed to producing new materials, products and devices; to installing new process, systems and services; or to improving substantially those already produced or installed.

Table 3.8

NATIONAL R&D EXPENDITURE BY NATURE OF RESEARCH PERFORMED AND SETOR IN 2004.

Rs. million

	Sector				
Research Type	Higher Education	State	Private	Total	%
Basic Research	55.6	433.8	30.2	519.6	13.6
Applied Research	1,178.2	1,663.1	44.8	2,886.10	75.8
Experimental Development	43.8	224.2	133.8	401.8	10.6
Total	**1,277.6**	**2,321.1**	**208.8**	**3,807.5**	**100.0**

According to the distribution of R&D expenditure by nature of research activity, 76 per cent of the research carried out falls into the category of applied research. The proportion of basic research conducted amounted to 14 per cent while the experimental development research constituted 11 per cent (Table 3.8).

It is significant that in the Higher Education sector, which is the traditional bastion of pure research, only 4.4 per cent had been expended on basic research while 92 per cent of the funds had been utilized for applied research and 3.4 per cent on experimental development research. This trend indicates that while the university academics are aware of the importance of carrying out basic research, they are more oriented towards the development oriented research in accordance with the national priorities and local needs which are of an applied nature.

In the state sector organizations, the percentage of funds utilized for applied research was much less than that was used in the universities viz 72 per cent while 19 per cent has been spent on basic research and 10 per cent on experimental research. In the Private sector, the pattern is significantly different and most of the research carried out in these organizations falls into the experimental development category (64 per cent) while applied research accounted for 22 per cent and basic research amounted to 14 per cent.

In developing countries the applied research component is as high as 70-80 per cent of R&D while the basic research and the experimental development areas are given low priority.

When comparing the data with previous years, it is seen that the resources devoted overall to applied research has increased from 61 per cent in 1996 to 76 per cent in 2004. The percentage of basic research carried out has decreased from 32 per cent in 1996 to 14 per cent in 2004. The percentage of experimental development activities also shows a slight increase from 7 per cent in 1996 to 11 per cent in 2004 (Table 3.9 and Figure 3.6).

Table 3.9

NATIONAL R&D EXPENDITURE BY NATURE OF RESEARCH ACTIVITY 1984-2004

Rs. million

	Year					
Nature of Research	1984		1996		2004	
	Amount	Percentage	Amount	Percentage	Amount	Percentage
Basic Research	24.8	10.0	446.3	32.0	519.6	13.6
Applied Research	185.2	72.0	867.3	61.0	2,886.1	75.8
Experimental Development	46.9	18.0	96.0	7.0	401.8	10.6
Total	**256.8**	**100.0**	**1,409.6**	**100.0**	**3,807.5**	**100.0**

Sourse: National R&D Surveys Sri Lanka 1996 (NARESA) and 2004 (NSF)

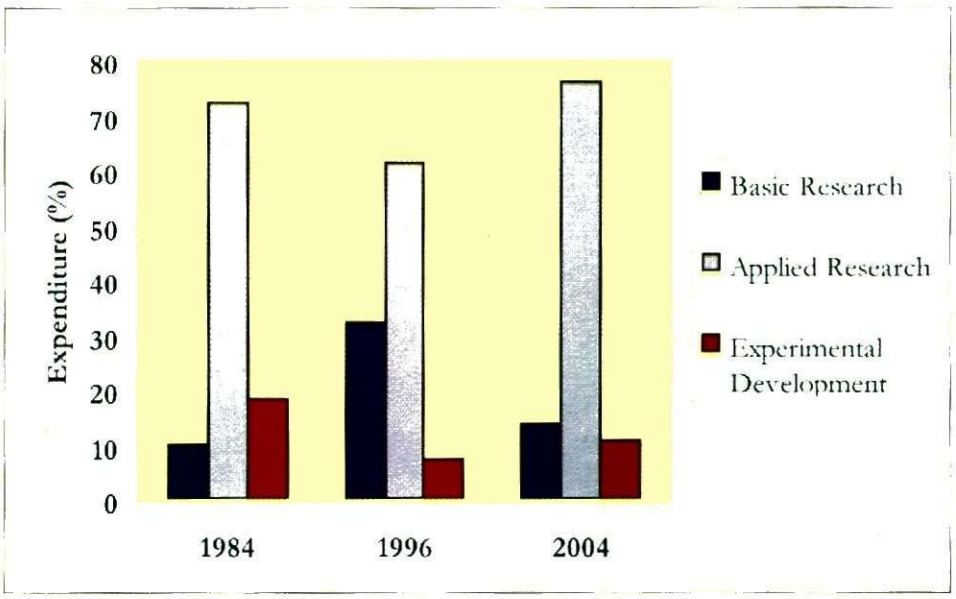

Figure 3.6

NATIONAL R&D EXPENDITURE BY NATURE OF RESEARCH PERFORMED

3.6 R&D Expenditure by Discipline

Table 3.10 gives the breakdown of R&D expenditure by discipline for 2004 with comparative figures for 1996 and 1984.

Table 3.10

NATIONAL R&D EXPENDITURE BY DISCIPLINE 1984-2004

Rs. million

	Year		
Discipline	1984	1996	2004
Natural Sciences	30.7 (12.0%)	318.3 (22.6%)	627.6 (16.5%)
Engineering & Technology	32.8 (12.8%)	164.3 (11.6%)	614.0 (16.1%)
Medical Sciences	13.3 (5.2%)	136.6 (9.7%)	531.4 (14.0%)
Agricultural Sciences	153.4 (59.8%)	669.2 (47.5%)	1,002.5 (26.3%)
Social Sciences and Humanities	26.5 (10.2%)	121.2 (8.6%)	999.5 (26.3%)
Other	-	-	32.4 (0.9%)
Total	**256.7**	**1,409.6**	**3,807.5**

National R&D Surveys Sri Lanka 1996 (NARESA) and 2004 (NSF)

The breakdown of the R&D expenditure by discipline for 2004 with the comparative data in 1996 and 1984 showed variations. The R&D in the areas of agriculture sector and the social science and humanities dominated the country scenario each consuming 26 per cent of total R&D. However, compared with previous surveys, the relative share of the agriculture sector has declined from a high value of 60 per cent in 1984 to 47 per cent in 1996 and only 26 per cent in 2004. However, in absolute terms the total expenditure on Agriculture has increased over 30 per cent from Rs. 669.2 million in 1996 to Rs. 1,002.5 million in 2004.

When compared with previous studies, the relative share of social sciences and humanities increased considerably from 9 per cent in 1996 to 26 per cent in 2004. In absolute terms total expenditure has increased from Rs 121.2 million in 1996 to Rs. 999.5 million (Figure 3.7).

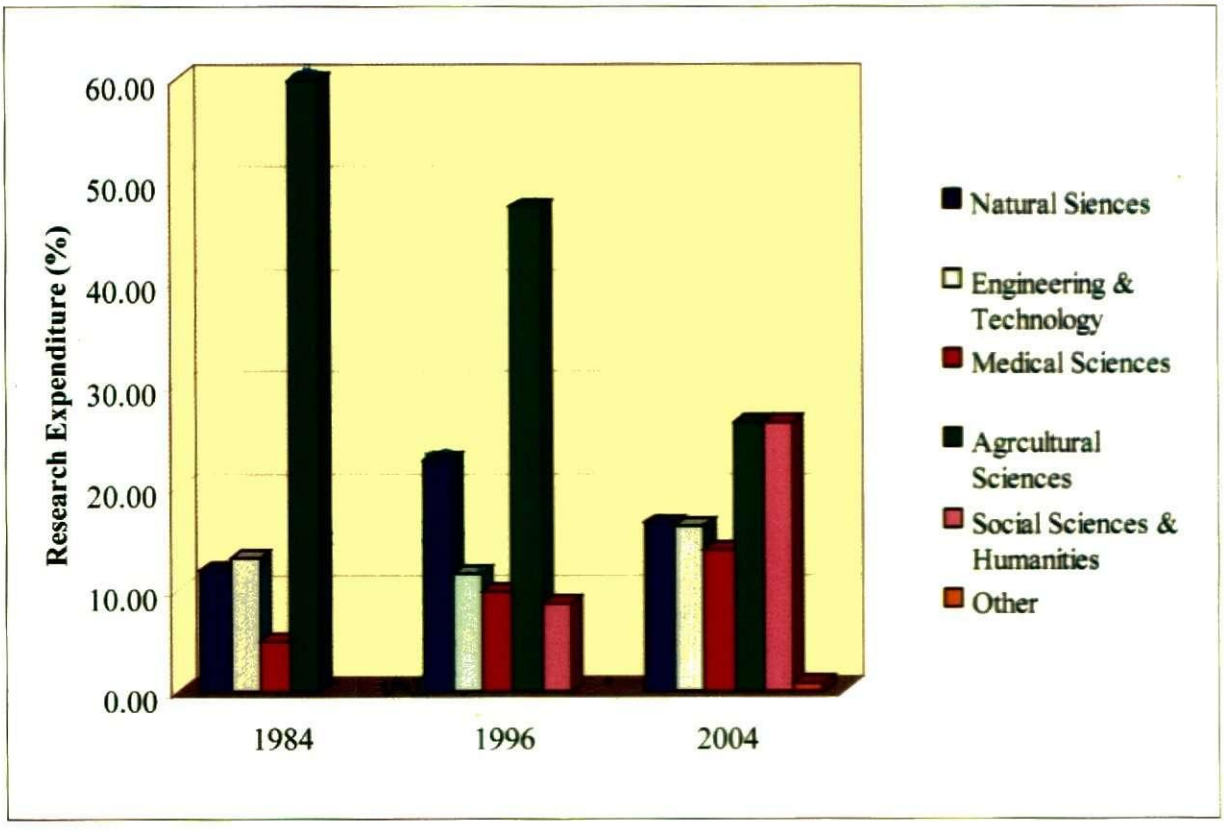

Figure 3.7

NATIONAL R&D EXPENDITURE BY FIELD OF SCIENCE 1984-2004

In absolute terms the amount expended on natural sciences has nearly doubled from Rs. 318.3 million in 1996 to Rs. 627.6 million in 2004. The expenditure on research in the area of engineering & technology has increased from 164.3 million in 1996 to Rs. 614 million in 2004. However, the relative expenditure on natural science research shows a decline from 22.6 per cent in 1996 to 17 per cent in 2004. In contrast the relative share of engineering & technology research increased from 11.6 per cent

1996 to 16.1 per cent 2004. The relative expenditure on medical research has also increased steadily from 9.7 per cent in 1996 to 14 per cent in 2004 indicating a tendency to shift from natural sciences to more applied sciences consonant with national priorities. When compared with previous years it can be said that the research funding has been distributed in all disciplines more or less equally in 2004 and therefore, the dominance of agricultural research has declined.

The table 3.11 gives the desegregation of expenditure in different sectors according to the research discipline. In the Higher Education Sector, the expenditure on research was heavily skewed towards the areas of medical sciences (36.2 per cent), engineering & technology (32.5 per cent) and natural sciences (24.6 per cent). The research expenditure in agriculture and social sciences was very low (Table 3.11).

Table 3.11

NATIONAL R&D EXPENDITURE IN 2004 BY DISCIPLINE AND SECTOR

Rs. Million

Discipline	Sector			
	Higher Edu.	State	Private	Total
Natural Sciences	314.0	247.2	66.4	627.6
	(24.6%)	(10.7%)	(31.7%)	(16.5%)
Engineering & Technology	415.1	166	33	614.1
	(32.4%)	(7.2%)	(15.8%)	(16.1%)
Medical Sciences	462.2	66	3.2	531.4
	(36.2%)	(2.8%)	(1.5%)	(14%)
Agricultural Sciences	80.2	877	45.3	1,002.5
	(6.3%)	(37.8%)	(22%)	(26.3%)
Social Sciences & Humanities	6.1	936	57.4	999.5
	(0.5%)	(40.3%)	(27.3%)	(26.2%)
Other	0.00	28.9	3.5	32.4
	(0.0%)	(1.2%)	(1.7%)	(0.9%)
Total	**1,277.5**	**2,321.00**	**209.00**	**3,807.50**
%	33.5	61.0	5.5	100.0

In contrast to the Higher Education sector, the State sector organizations in the country spent more on research in the areas of social sciences (40.3 per cent) and agricultural sciences (37.8 per cent). This is because most of the research institutes in the country come under the agriculture sector and therefore, they carry out research in the area of agriculture and address issues related to social and economic aspects in the field of agriculture. Therefore, R&D expenditure by these organizations contributed to

the total expenditure in the disciplines of agriculture and social sciences. The funds expended in the area of medical sciences was low in the State sector organizations (Figure 3.8) as there are very few institutions that are directly involved in research activities related to medical sciences.

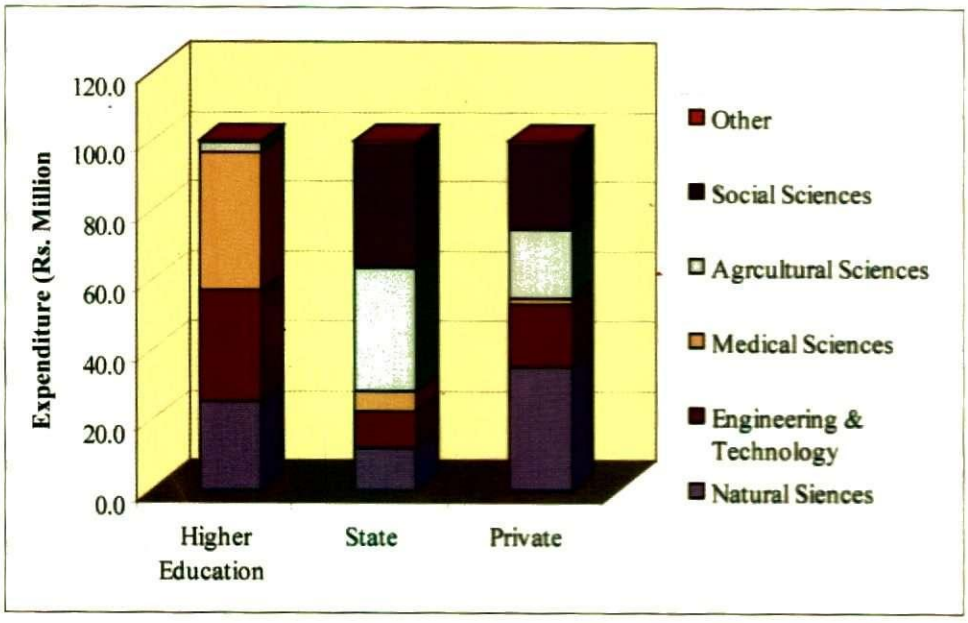

Figure 3.8

NATIONAL R&D EXPENDITURE IN 2004 BY DISCIPLINE AND SECTOR

In the Private sector organizations, 31.7 per cent of the expenditure was in the natural sciences and 27 per cent on social science research. A considerable proportion of funds was also expended on research activities in the area of agriculture (22 per cent) and engineering & technology (15.8 per cent). Only 2.8 per cent of the expenditure on R&D was spent on research in the area of medical sciences. The contribution of the Industrial sector to medical research was mainly based on pharmaceutical activities. There are several large pharmaceutical Industries in Sri Lanka that are involved in the area of Ayurvedic medicine. A number of attempts made to collect information from these industries failed and therefore, it can be concluded that the funds expended by the Private sector on research in the field of medical sciences is under estimated in this survey.

Chapter 4

SCIENTIFIC AND TECHNOLOGY MANPOWER RESOURCES

4.1 General Definitions

The trend in the number of Researchers and Technical persons (STP) is a key indicator of the growth of scientific and technical capability in the country. The S&T personnel can be broadly categorized into three types, namely: Scientists, Technicians and Other Supporting Staff.

The term 'scientist' includes any person engaged in S&T activities who has received scientific and technical training at any field of science (natural sciences, engineering, medical, agricultural, social sciences and humanities) in accordance with the UNESCO definitions 1985. Accordingly, this group includes the scientists involved in research and other scientific work in the S&T service and management.

The term "technician and equivalent staff" includes any persons with technical knowledge and experience who participate in R&D by performing scientific and technical tasks involving the application of concepts and operational methods, normally under the supervision of researchers (UNESCO, 2006).

The term "other supporting staff" includes skilled and unskilled craftsmen, secretarial and clerical staff participating in R&D projects or directly associated with such projects (UNESCO, 2006).

4.2 General Trends

The data gathered in this survey was analyzed on the basis of the above conceptual frame- work in the context of the local scenario.

Accordingly, 28,432 number of Science and Technology Personnel were recorded (STP) in this survey (Table 4.1). This includes 9,746 scientists comprising research scientists as well as scientists who work in the area of S&T management and administrative activities, along with engineers, 12,302 technicians, and 6,384 supporting staff.

Table 4.1

SCIENCE AND TECHNOLOGY PERSONNEL (STP) BY CATEGORY

Employers category	1996			2004		
	Total Number	Per cent of STP	Per million inhabitants	Total Number	Per cent of STP	Per million inhabitants
S&T Scientists	13,286	47.8	726	9,746	34.2	502.3
Technicians	14,514*	52.2*	793*	12,302	43.3	634.1
Other Supporting staff				6,384	22.5	329.1
STP	27,800	100.0	1,519	28,432	100.0	1,465.5

Source: R&D Survey National Science Foundation Sri Lanka, 1996 (NARESA) & 2004 (NSF)

*not categorized separately, includes Technicians and Other Supporting Staff

In comparison to previous studies, the total number of economically active scientists has decreased substantially from 13,286 in 1996 to 9,746 in 2004. The number of technicians also has decreased from 14,514 in 1996 to 12,302 in 2004 (Table 4.1). This could be a substantial under-estimation since accurate data on scientists and technicians employed in the Private sector could not be obtained due to non-response.

According to Table 4.1 the number of technicians per million population was 634 in 2004 while the supporting staff was 329 per million population. The total STP per million inhabitants has decreased from 1,519 in 1996 to 1,466 in 2004.

It is noted that there is a considerable number of scientists and scientific professionals leaving the country annually for better job prospects, working conditions, recognition and more stable socio-economic environments. The external Brain Drain can be identified as one of the main reasons for the decline in the number of scientists shown in this survey. The internal Brain Drain also may cause a decline in the number of scientists actively working in the S&T sector in the country. At present, the internal Brain Drain has become a serious problem in S&T institutes in the country. Most of the scientists working in the S&T sector are attracted to the Private sector to work as Bankers, Managers or Administrative Officers for higher salaries and other benefits offered by these organizations, which operate outside the S&T sector. Therefore, S&T institutions face a constant crisis in shortage of trained S&T staff and continuous turnover of employees. Since this survey covered only the S&T sector, the S&T qualified persons working in the non S&T occupations were not included in the data collection as indicated in UNESCO guidelines.

4.3 Deployment of S&T Personnel by Sector of Performance

As presented in Table 4.2, the majority of scientific personnel are employed in the State sector organizations (44.6 per cent) which provide a wide range of S&T services such as quality control, testing, standardization and training, in addition to research and development activities. The Private sector organizations especially the industrial sector also employs a large number of S&T Personnel, particularly technical manpower (40 per cent). The Higher Education sector employed 15 per cent of S&T personnel according to the survey statistics.

Table 4.2

DISTRIBUTION OF S&T PERSONNEL (STP) BY SECTOR -2004

Year	1984		1996		2004	
Sector	STP	Percent	STP	Percent	Total	Percent
Higher Education	2,264	15.6	3,990	14.3	4,285	15.1
State	8,620	59.5	18,645	67.1	12,685	44.6
Private	3,603	24.9	5,165	18.6	11,462	40.3
Total	**14,487**	**100.0**	**27,800**	**100.0**	**28,432**	**100.0**

Source: R&D Survey National Science Foundation Sri Lanka, 1996 (NARESA) & 2004 (NSF)

Note: Total STP includes all Researchers, other Scientists in the Service sector Institutions, Technicians and Supporting Staff

The comparative statistics for 2004 shows that the stock of S&T Personnel in the Private sector has increased considerably from 18.6 per cent in 1996 to 40 per cent in 2004 while the S&T stock in the State sector declined from 67 per cent in 1996 to 45 per cent in 2004 (Table 4.2), indicating a growing involvement in the Private sector R&D activities.

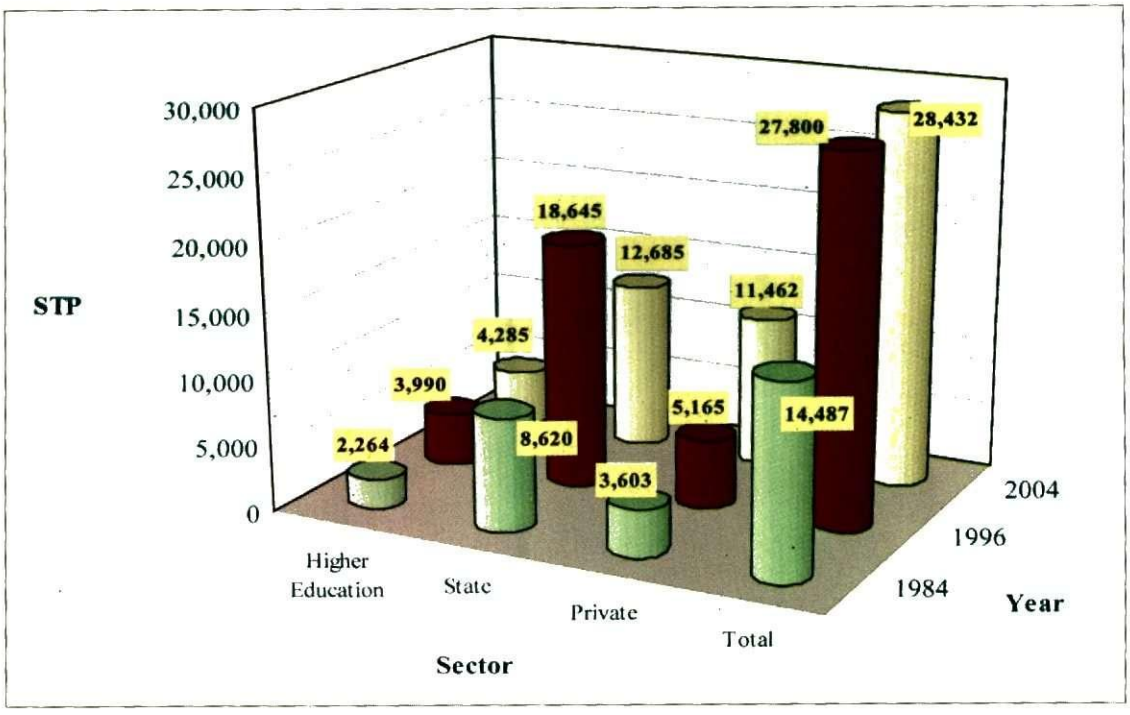

Figure 4.1

STP BY SECTOR

4.4 Distribution of S&T Scientists and Technicians by Discipline

The distribution of scientists, technicians and other supporting staff by discipline is shown in Table 4.3. The highest percentage of STP is located in the engineering (29 per cent) and natural sciences (29 per cent) fields followed by agricultural sciences (20 per cent). The STP in the medical sciences was 4 per cent and social sciences and humanities 5.4 per cent (Table 4.3). However, it must be noted that the percentage of STP in the fields of engineering & medical sciences has decreased by nearly 50 per cent from 1996. A considerable decrease is shown in the field of social sciences as well (Figure 4.2). 12.4 per cent had not specified the discipline of their work.

Table 4.3

DISTRIBUTION OF STP BY DISCIPLINE 1984-2004

Discipline	1984		1996		2004	
	No	%	No	%	No	%
Natural Sciences	2,914	20.1	6,705	24.1	8,227	28.9
Agricultural Sciences	3,234	22.3	3,239	11.7	5,766	20.3
Engineering &Technology	6,569	45.4	12,631	45.4	8,244	29.0
Medical Sciences	190	1.3	2,991	10.8	1,126	4.0
Social Sciences and Humanities	1,580	10.9	2,234	8.0	1,540	5.4
Other /Not specified	-	-	-	-	3,529	12.4
Total	**14,487**	**100.0**	**27,800**	**100**	**28,432**	**100.0**

Source: R&D Survey National Science Foundation Sri Lanka, 1996 (NARESA) & 2004 (NSF)

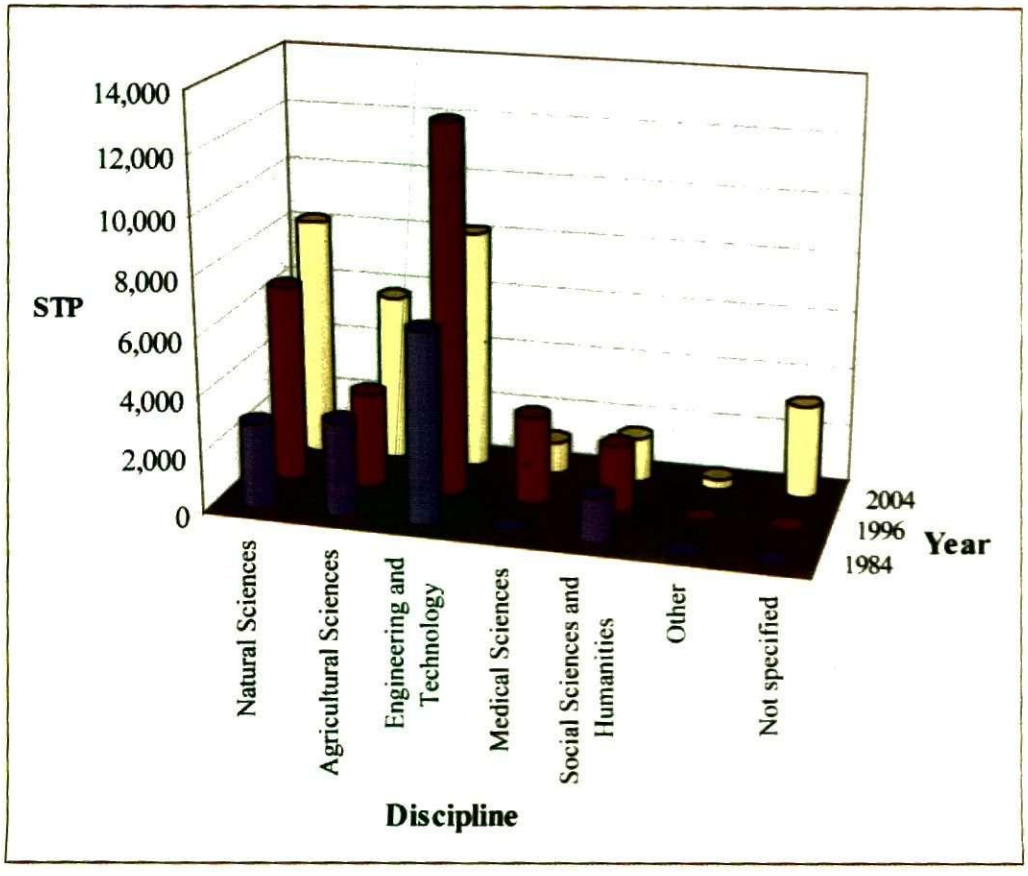

Figure 4.2

STP BY DISCIPLINE

4.5 Educational Attainment of S&T Personnel

The breakdown of scientists by level of education is a key indicator of the depth and vitality of S&T capacity in the country. Table 4.4 gives details of the academic qualifications of the scientists in the S&T sector in the country in 2004.

Table 4.4

EDUCATIONAL QUALIFICATIONS OF S&T SCIENTISTS

Year	1984		1996		2004	
Qualifications	No.	%	No.	%	No.	%
Ph.D.	719	8.3	1,473	14.0	1,001	10.3
M.Phil./ M.Sc.	1,016	11.7	2,116	20.0	1,407	14.4
B.Sc. + PG Diploma	408	4.7	6,966	66.0	410	4.2
B.Sc. Special	6,570	75.3			6,377	65.4
B.Sc. General					551	5.7
Total	**8,713**	**100.0**	**10,555**	**100.0**	**9,746**	**100.0**

Source: R&D Survey National Science Foundation Sri Lanka, 1996 (NARESA) & 2004 (NSF)

The number of scientists with doctoral degrees recorded was 1,001. This was less than the number recorded in the 1996 survey (1,473). However, in the 1996 survey, the scientists with MD had been also included in the category of scientists with doctoral degree. But in the present survey they were included in the category of M.Phil/M.Sc. The number of scientists with B.Sc. or equivalent degrees and Postgraduate Diploma has increased from 6,966 (66 per cent) in 1996 to 7,538 (75 per cent) in 2004.

Though, there are several postgraduate institutes related to the S&T sector in Sri Lanka and there is a continuous output of postgraduates annually from these institutes, the country's stock of postgraduate scientists engaged in S&T has declined considerably from 34 per cent in 1996 to 24.7 per cent in 2004. This can be explained by the migration data, and could be due to the low GERD per scientist and other related factors.

4.6 Distribution of STP by Sex and Discipline

The distribution of STP by sex and discipline is presented in Table 4.5. Accordingly, the female participation was higher in the areas of Medical Sciences (49 per cent) and Social Sciences.

Table 4.5

DISTRIBUTION OF STP BY SEX AND DISCIPLINE -2004

Discipline	STP			
	Male	Female	Total	Percent Female
Natural Sciences	5,870	2,357	8,227	28.6
Engineering & Technology	7,110	1,134	8,244	13.8
Medical Sciences	573	553	1,126	49.1
Agricultural Sciences	5,109	657	5,766	11.4
Social Sciences and Humanities	972	568	1,540	36.9
Other	1,670	1,859	3,529	52.7
Total 2004	**21,304**	**7,128**	**28,432**	**25.07**

The distribution of scientists (excluding technicians) by sector and sex presented in Table 4.6 shows that the proportion of female scientists is highest (73 per cent) in the Higher Education sector while the State sector employed 21 per cent. The female scientists employed in the Private sector organizations was only 6.6 per cent.

When compared with previous statistics, the percentage of female scientists employed in the Higher Education sector has almost doubled from 38 per cent in 1996 to 73 per cent in 2004. In the Private sector and the state sector, the trend is reversed showing a steep decline of female participation in employment over the years. However, overall percentage of female scientists in the S&T sector has increased from 16 per cent in 1984 to 36 per cent in 2004 (Table 4.6, Figure 4.3).

Table 4.6

DISTRIBUTION OF SCIENTISTS BY SEX AND SECTOR 1984-2004

Year	1984		1996		2004	
Sector	Total	Female%	Total	Female%	Total	Female%
Higher Education	2,013	23.5	3,290	37.5	2,920	72.5
State	6,107	16.5	5,897	29.1	6,557	20.9
Private	2,459	7.5	4,099	15.2	269	6.6
Total	**10,579**	**15.7**	**13,286**	**26.9**	**9,746**	**35.9**

Source: R&D Survey National Science Foundation Sri Lanka, 1996 (NARESA) & 2004 (NSF)

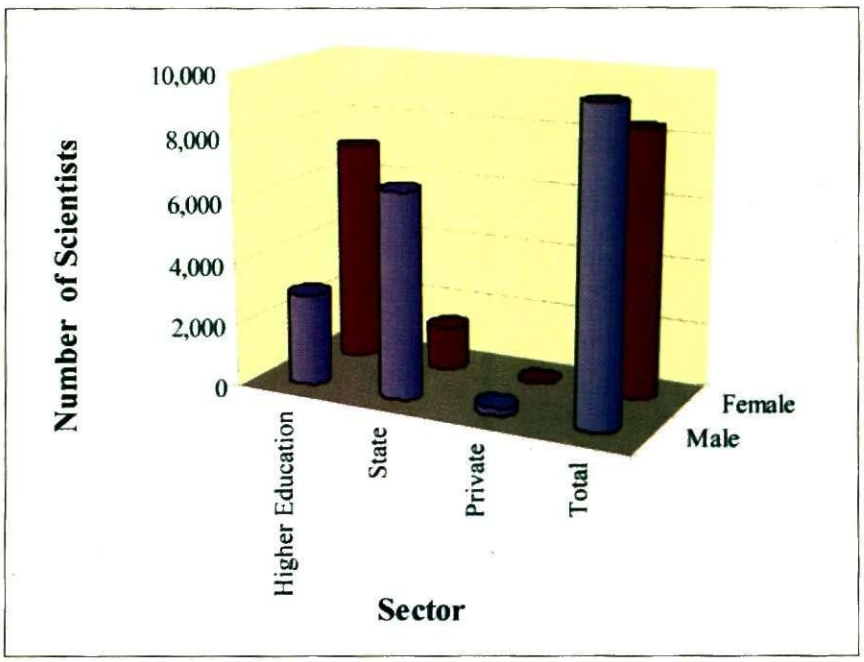

Figure 4.3

DISTRIBUTION OF SCIENTISTS BY SEX AND SECTOR 2004

4.7 Technical Support Index

The ratio of technicians to scientists defined as the Technical Support Index, is an important indicator of the support extended to researchers. The technical support staff carries out a great deal of the routine work associated with research and thereby the support extended by this category towards research is significant, especially for the development of countries like Sri Lanka where there is a shortage of top level researchers.

Table 4.7

Technical Support Index by Sector-2004

Sector	Scientists	Technicians	Index
Higher Education	2,920	622	0.21
State	6,557	1,043	0.16
Private	269	10,637	39.5
Total	**9,746**	**12,302**	**1.26**

The breakdown of the Technical Support Index by Sector is given in Table 4.7. The Private sector has a high technical support index of 39.5 because this sector includes the Industrial Sector which employs a large number of technically qualified human resources. However, the number of scientists in this sector is low. In the Private sector, it was observed that most of the scientists were employed in

the executive grade where they are mainly involved in the supervisory and planning processes while the routine research and development work is carried out by the technical staff working under their guidance and supervision. It seems that this model is very cost effective for the Private sector organizations. In contrast, the technical manpower in the state sector is less than one sixth the number of scientists in that sector.

In the Higher Education sector too, the number of technicians was only a very small proportion of the number of scientists (0.21). The reason for this may be that most of the research conducted in the universities was carried out by postgraduate students who were also categorized as scientists in the survey. The temporary assistants who assisted in the field-work related to research are employed on an ad hoc basis and therefore no records were available of this type of support.

It is seen from Table 4.8 that the Technical Support Index is highest in the disciplines of agriculture (3.58) and natural sciences (3.00). However, it should be noted that in the field of Medical Sciences, the ratio would be much higher if paramedical staff and other categories in the medical sector were included (see table 4.18). In the field of social sciences and humanities, field investigators are used for data collection and verification. Their services were also used in a temporary capacity on project basis, and therefore no data on their numbers were available.

Table 4.8

TECHNICAL SUPPORT INDEX BY DISCIPLINE -2004

Discipline	Scientists	Technicians	Index
Natural Sciences	2,022	6,076	3.00
Engineering & Technology	4,311	1,284	0.29
Medical Sciences	784	295	0.38
Agricultural Sciences	1,242	4,443	3.58
Social Sciences and Humanities	1,353	126	0.09
Other	34	78	2.2
Total	**9,746**	**12,302**	**1.26**

4.8 Research and 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, innovation, and solutions to problems which enhance S&T capabilities in the country and ensure that it is geared to the nation's 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.

The total R&D personnel counted in 2004 survey was 9,705 and this was 34 per cent of the total STP (Table 4.9). It is noted that the proportion of R&D personnel in the STP work force is very small in the

developing countries compared to the strength in the developed and highly industrialized countries. This contributes to the continuing syndrome of under-development to some extent (See Table 4.12).

The total Head Count of scientists engaged in research and development activities in 2004 is estimated as 4,602 and this is 16.2 per cent of the total STP and 47.2 per cent of the total scientists recorded in the survey. The distribution of R&D personnel (Head Count) by sector is presented in Table 4.9.

The Higher Education sector has the highest number of researchers when compared with the other sectors. This is because almost all the academics devote some time of their academic schedule for research as an essential requirement. Also, they have more opportunities to do research than the scientists in the State service sector organizations. R&D scientists in the State sector work full time in the research institutions in the country. 51 per cent of the technicians recorded are from the State Sector organizations.

Table 4.9

R&D PERSONNEL BY SECTOR OF EMPLOYMENT AND OCCUPATION

	Researchers		Technicians		Other supporting		Total	
Sector	No	%	No	%	No	%	No	%
Higher Education	2,920	63	622	31	728	24	4,270	44
State	1,413	31	1,043	51	1,957	64	4,413	46
Private	269	6	369	18	384	13	1,022	11
Total	**4,602**	**47**	**2,034**	**21**	**3,069**	**32**	**9,705**	**100**

When compared with the previous studies, the total number of R&D scientists recorded has decreased from 5,965 in 1996 to 4,602 in 2004. There was a decline in the number of R&D scientists in State Sector from 32 per cent in 1996 to 21 per cent in 2004. Similarly, Higher Education sector also shows a decline in the number of researchers from 67 per cent in 1996 to 63 per cent in 2004. The proportion of R&D scientists in the Private sector has not changed very much from 1996 to 2004 (Table 4.10).

The number of R&D technicians in the country has increased from 999 in 1996 to 2,034 in 2004. This increase has clearly occurred in the Private sector. The R&D technicians increased from 6.4 per cent in 1996 to 18 per cent in 2004 (Table 4.10).

The distribution of R&D scientists according to discipline is presented in Table 4.11 Accordingly, most of the R&D scientists were engaged in the area of natural sciences research (38 per cent) followed by engineering (21 per cent), agriculture (19 per cent), medical sciences (6 per cent) and social sciences and humanities (6 per cent) respectively.

Table 4.10

DISTRIBUTION OF R&D SCIENTISTS (HEAD COUNT) BY SECTOR 1996-2004

Year	1996				2004			
Sector	Scientists		Technicians		Scientists		Technicians	
	No.	%	No.	%	No.	%	No.	%
Higher Education	3,993	66.9	402	40.2	2,920	63	622	31
State	1,916	32.2	533	53.4	1,413	31	1,043	51
Private and NGO	56	0.9	64	6.4	269	6	369	18
Total	**5,965**	**100.0**	**999**	**100.0**	**4,602**	**100**	**2,034**	**100**

Source: R&D Survey National Science Foundation Sri Lanka. 1996 (NARESA) & 2004 (NSF)

Table 4.11

DISTRIBUTION OF R&D SCIENTISTS (HEAD COUNT) BY DISCIPLINE AND SEX

Discipline	Head Count of R&D Scientists (1996)						Head Count of R&D Scientists (2004)					
	Male		Female		Total		Male		Female		Total	
	No	%	No	%	No	%	No.	%	No.	%	No.	%
Natural Sciences	923	23	564	29	1,487	25	1,032	35	696	43	1,728	37
Agriculture	547	14	119	6	666	11	569	19	288	18	857	19
Engineering	344	9	69	3	413	7	774	26	193	12	967	21
Medical Sciences	939	23	524	27	1,463	24	369	12	318	20	687	15
Social Sciences	1,251	31	685	35	1,936	33	167	6	109	7	276	6
Humanities												
Other							63	2	24	1	87	2
Total	**4,004**	**100**	**1,961**	**100**	**5,965**	**100**	**2,974**	**100**	**1,628**	**100**	**4,602**	**100**

Source: R&D Survey National Science Foundation Sri Lanka. 1996 (NARESA) & 2004 (NSF)

Most of the female scientists were engaged in the area of natural sciences (43 per cent), followed by medical sciences (20 per cent), agricultural sciences (18 per cent), engineering (12 per cent) and social sciences and humanities (7 per cent) as shown in the Table 4.11.

The highest percentage of male scientists were engaged in research in the area of natural sciences (35 per cent) followed by 26 per cent in the field of engineering and technology, 19 per cent in agricultural sciences, 12 per cent in medical sciences and 6 per cent in social sciences. The highest percentage of female scientists were also engaged in the area of natural sciences and medical sciences while male participation was higher in the areas of natural sciences and engineering and technology (Table 4.11).

Table 4.12 indicates the international comparison of researchers. According to the indicators derived from the present survey the number of researchers per million inhabitants in Sri Lanka was 237 (Table 4.1), which is higher than the average researchers per million recorded for India which was 112 or other Asian countries which was 100 in 2002. Sri Lanka is ahead in its stock of researchers in comparison to less developed countries which only have 4.5 researchers per million population. The USA records the highest number of researchers per million population (4,374) in 2002.

Table 4.12

WORLD RESEARCHERS- 2002

	Researchers (thousands)	% world researchers	Researchers per million inhabitants	GERD per researcher (US$ thousands)
World	5,521.4	100.0	894.0	150.3
Developed countries	3,911.1	70.8	3,272.7	165.1
Developing countries	1,607.2	29.1	374.3	114.3
Less-developed countries	3.1	0.1	4.5	153.7
Europe	1,843.4	33.4	2,318.8	122.7
Africa	60.9	1.1	73.2	76.2
Comm. of Ind. State in Asia	83.9	1.5	1,155.0	8.9
Newly Indust. Asia	291.1	5.3	777.2	183.7
Arab States Asia	9.7	0.2	93.5	66.6
Other Asia	65.5	1.2	100.2	20.9
China	810.5	14.7	633.0	88.8
Germany	264.7	4.8	3,208.5	211.4
India*	117.5	2.1	112.1	176.8
Israel*	9.2	0.2	1,395.2	661.1
Japan	646.5	11.7	5,084.9	164.5
Russian Federation	491.9	8.9	3,414.6	30.0
South Africa	8.7	0.2	192.0	357.6
United Kingdom*	157.7	2.9	2,661.9	184.2
United States of America*	1,261.2	22.8	4,373.7	230.0
Sri Lanka (2004)**	4.6	0.08	237.2	8.9

Source: UNESCO Institute for Statistics estimations, December 2004

* India 1998, Israel 1997, United States 1999, United Kingdom 1998, Brazil 2000, Mexico 1999

** Sri Lanka - R&D survey 2004

In this context it should be noted that multiple definitions of scientists are used in USA for analytical purposes. Scientists are classified according to education, occupation and field of employment. This broad-based definition encompasses non-degree holders in S&T occupations as well as science degree holders in non- S&T occupations. The rationale is that the majority of them have indicated that they use their S&T training in non-S&T jobs, especially teachers (89 per cent) and managers (73 per cent) in a recent US Survey. However, in the Sri Lankan estimation only degree holders in the field of Science and Technology who worked in the area of S&T were considered as scientists.

However, the proportion of GERD per researcher in Sri Lanka is recorded as US$ 8,900 in the present survey, which is the lowest recorded and is less than 5 per cent of the world average of US$ 150,300 (Table 4.12). This clearly indicates one of the main reasons for the extensive Brain Drain in Sri Lanka and the recent trend of local scientists to deviate to other fields, which place a higher value on their knowledge and skills.

4.9 R&D Personnel – FTE & Research Intensity

R&D may be a primary function for some scientists and it may be a secondary function for other scientists. To count only the persons who are employed in R&D establishments would result in under-estimation of the effort devoted to R&D. Similarly, to take a headcount of everyone spending some time on R&D would lead to an over-estimation. The number of persons engaged in R&D should, therefore, be expressed in full-time equivalent (FTE). One FTE may be considered as one person per year (Frascati Manual, 1993).

According to the above definitions, the FTE for Higher Education sector and State sector organizations other than the Research Institutions was calculated as a coefficient of the time spent by scientists. This was approximately twenty five per cent for the Higher Education sector. The FTE for scientists in Research Institutes was estimated as hundred per cent.

The technical and supporting staff involved in full time research activities also was estimated taking into account the time they spent on research activities. Accordingly, the total R&D personnel (FTE) was estimated as 5,475 (Table 4.13).

On conversion to Full Time Equivalent (FTE), the total number of researchers engaged in full time R&D in 2004 works out to 2,679 (FTE). The highest percentage of researchers (FTE) was estimated in the Higher Education sector followed by the state sector. The number of researchers (FTE) in the Private sector was comparatively low (Table 4.13).

The number of technicians and other supporting staff involved in full time research activities was higher in the State sector than the other sectors as most of them worked in the Research Institutes or Research Units in S&T Service sector organizations on a full -time basis. However, in the Higher Education sector, the number of technicians and supporting staff involved in full time research was comparatively very low as their primary function is to support academic work rather than get involved in research work. Therefore, the time they spent on research activities were very low compared to other sectors.

Table 4.13

R&D PERSONNEL (FTE) BY SECTOR OF EMPLOYMENT AND OCCUPATION

Sector	Researchers		Technicians		Other supporting		Total	
	No	%	No	%	No	%	No	%
Higher Education	1,569	59	63	4	70	5	170	3
State	841	31	1,043	71	1,135	86	3,019	55
Private	269	10	368	25	117	9	754	14
Total	**2,679**	**100**	**1,474**	**100**	**1,322**	**100**	**5,475**	**100**

The number of researchers (FTE) according to discipline is given in the table 4.14. The highest number of Researchers (FTE) worked in the area of engineering and technology fields (28 per cent) followed by the field of natural sciences (27 per cent), agriculture sciences (21 per cent), medical sciences (8.4 per cent) (Table 4.14). The male researchers participation was highest in the area of engineering and technology.

Table 4.14

THE DISTRIBUTION OF RESEARCHERS (FTE) ACCORDING TO DISCIPLINE

Discipline	R&D Scientists (Full Time Equivalent)			
	Male	Female	Total	Female %
Natural Sciences	436	275	711	38.7
Engineering & Technology	615	141	756	18.7
Medical Sciences	116	110	226	48.7
Agricultural Sciences	384	171	555	30.8
Social Sciences and Humanities	198	131	321	39.9
Other	70	32	101	31.7
Total	**1,819**	**860**	**2,679**	**32.1**

The research intensity by discipline and sex is given in Table 4.15. The research intensity measured as the ratio of FTE to the total number of scientists in the STP work force is 27 per cent. This is a one per cent (1 per cent) increase from 1996 (26 per cent). One third of the R&D scientist population consisted of female scientists. Research intensity was higher for female scientists (33 per cent) compared to their male counterparts (25 per cent).

Table 4.15

RESEARCH INTENSITY BY SEX

	R&D Scientists (Full Time Equivalent)				S&T Scientists				Research Intensity FTE/S&T		
Discipline	M	F	T	F%	M	F	T	F%	M	F	T
Natural Sciences	445	285	730	39	1,170	852	2,022	42	38	33	36
Engineering & Technology	625	148	773	19	3,658	453	4,311	11	17	33	18
Medical Sciences	124	115	239	49	421	363	784	46	29	32	30
Agricultural Sciences	394	180	574	31	885	357	1,242	29	44	50	46
Social Sciences and	167	109	276	40	842	511	1,353	38	19	21	20
Humanities Other	63	24	87	32	161	73	234	31	39	32	37
Total	**1,818**	**861**	**2,679**	**32**	**7,137**	**2,609**	**9,746**	**26**	**25**	**33**	**27**

M = male; F = female; T = total

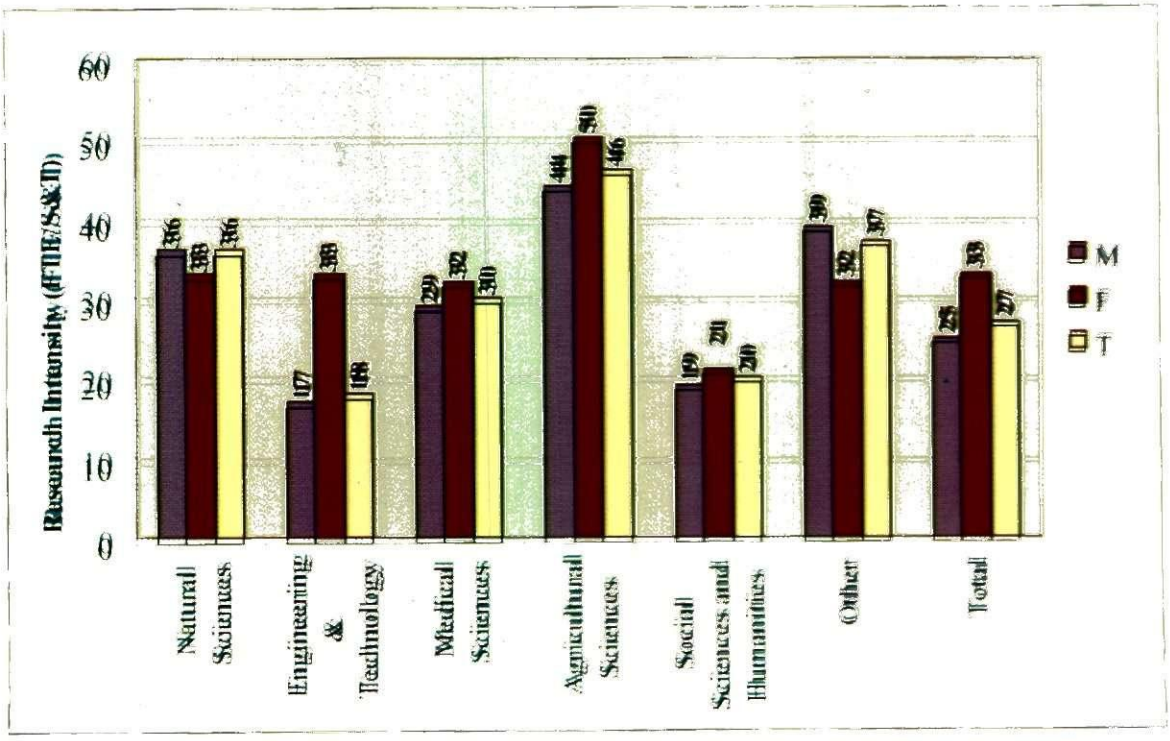

Figure 4.4

RESEARCH INTENSITY BY SEX

The highest intensity of female participation in research (FTE) was seen in the areas of medical sciences (49 per cent) followed by social sciences (40 per cent), natural sciences (39 per cent), and agricultural sciences (31 per cent). Female participation in the engineering and technology sector was comparatively low (19 per cent). However, in the field of natural sciences (37 per cent) male scientists have a higher research intensity compared to other fields (Figure 4.4).

4.10 Migratory Manpower of the country

Brain Drain of the scientific community is identified as the major cause for the low rate of development in the S&T sector in the country. However, there is no valid data to measure the exact annual loss of educated manpower due to the brain drain to developed countries. To remedy this information gap on expatriate scientists, the Science and Technology Policy Research Division (STPRD) of the National Science Foundation, Colombo initiated data collection through a questionnaire to be administrated to expatriates scientists. According to the information collected, USA leads in having the majority of Sri Lankan expatriates followed by Australia and then Canada. The sample also revealed that the majority are married (87 per cent) and are male scientists (80 per cent), and falls in the age group of 40-55 years (52 per cent). More than 60per cent of them have Ph.Ds. The initial study revealed that the main reasons for leaving the country are lack of quality jobs for talented scientists; limited opportunities to conduct research in the areas of their interest; lack of recognition in terms of promotions and/or national rewards and limited opportunities available for participation in the conferences, seminars or training programs at international level.

Table 4.16 indicates the migration statistics of the professional, skilled and unskilled manpower from the country. The highest proportion of labour force migrant workers was in the housemaid category and they are the major source of foreign exchange generation for the country. The other categories of labour force migration for foreign employment in large numbers are the skilled and unskilled labour categories.

Table 4.16

MIGRATION FOR EMPLOYMENT BY MANPOWER LEVEL

Manpower Level	2003	2004
Professional Level	1,543	1,810
Middle Level	7,507	6,509
Clerical & Related	6,779	6,588
Skilled	47,744	45,618
Unskilled	44,264	42,894
House Maid	102,011	110,034

Source: Statistical Abstract 2005, Department of Census & Statistics, Sri Lanka

However, the manpower migrating for employment in skilled, unskilled and housemaid categories are purely on a temporary basis. On the other hand, the professional level workers migrate to the other countries for longer time periods or on a permanent basis and therefore, in comparison to other workers the foreign exchanged received from their employment is very low. Therefore, the migration of educated manpower results in severe economic loss to the country. According to the migratory pattern the level of professional manpower migration has increased from 1,543 in 2003 to 1,810 in 2004 while middle level manpower has decreased from 7,507 in 2003 to 6,509 in 2004 (Table 4.16).

4.11 Auxiliary Personnel in Medical Sciences

The achievements in Sri Lanka's Health Sector are considered highly commendable when compared with other developing countries of comparable per capita income. Sri Lanka recorded life expectancy of 73 years, an infant mortality rate of 11.1 per 1000 live births (2003) and maternal mortality rate of 0.1 per 1,000 live births (2002). These outcomes have been achieved with a relatively low level of expenditure. Total expenditure on the Health sector has increased from Rs. 20,696 million in 2000 to Rs. 34,419 million in 2004, and constitutes only 1.7 per cent of GDP (Table 4.17).

The broad aim of Sri Lankan health policy is to increase life expectancy and to improve the quality of life by controlling preventable diseases through health promotion activities. The Ministry of Healthcare and Nutrition works towards achieving five strategic objectives as follows: to ensure the delivery of comprehensive health services, which reduce the disease burden and promote health, to empower communities to actively participate in maintaining their health development and management, to improve health financing, resources allocation and utilization and to strengthen stewardship and management functions of health system. In attempting to achieve these goals, the government provides health care facilities including specialized and intensive care services through an extensive network of health care institutions free of charge to the entire population, while the Private sector operates a fee-based system.

Provision of health care services in the public sector is the responsibility of the Central Ministry of Healthcare and Nutrition and eight Provincial Ministries of Health that function under the Provincial Councils. The Public sector comprises the Western and the Ayurvedic systems while the Private sector comprises the practitioners of Western, Ayurvedic, Siddha, Unani and Homeopathy systems.

The public hospital network which comprises various categories of facilities from the primary level to tertiary, are well developed and spread throughout the country, reaching the majority of the community. The Medical Officer of Health (MOH) is responsible for managing national facilities and Teaching Hospitals, procuring drugs and supplies, while the Provincial MOHs are responsible for managing provincial /district health facilities.

The service in the State sector is characterized by National, Provincial, General and Base (large town) hospitals and a widely spread network of district hospitals and health care units operating at lower levels of utilization and occupancy. Primary health care is provided throughout the health service and especially in the network of central dispensaries and maternity homes, rural hospitals, peripheral units and district hospitals. In addition to there services, public health services including health promotion and preventive care are provided by health units and include services in maternal and health planning and control of communicable diseases. In addition there is a high level of utilization of private dispensaries and private pharmacies.

Table 4.17

SALIENT FEATURES OF HEALTH SERVICES

	2001	2002	2003	2004
Total Population (in thousands)	**18,732**	**19,007**	**19,252**	**19,502**
Annual Population Growth Rate (%)	**1.2**	**1.2**	**1.3**	**1.3**
Life Expectancy (yrs)	**73**	**73**	**73**	**73**
GNP (Rs. billion)	1,377	1,560	1,777	2,038
GNP Per Capita (Rs.)	**73,528**	**81,341**	**92,287**	**104,838**
Annual State National Health Expenditure				
Per Capita (Rs.)	**1,222**	**1,339**	**1,417**	**1,764**
Total Health Expenditure as % of GNP	1.6	1.9	1.5	1.7
% of Public Spending on Health (%)	4.9	4.6	4.1	
No. of Hospitals	**729**	**736**	**779**	**791**
No. Public Hospitals	569	576	607	617
No. Private Hospitals	160	160	172	174
% Public Hospitals			78	78
Total Beds	**57,946**	**59,144**	**67,746**	**68,978**
No. in Public Hospitals	57,946	59,144	59,246	60,328
No. in Private Hospitals			8,500	8,650
Primary Care Units	**1,006**	**1,012**	**1,043**	**1,094**
Public (First contact treatment centers)				
(PU+RH+CDMH+CD)	741	751	761	777
Private (Clinics)	n.a.	n.a.	21	21
Preventive care (Health) Centers (MOH)	265	261	261	296
Pharmacies (private out-patient)	468	520	599	692

Source: Ministry of Healthcare and Nutrition; Department of Ayurveda

In the area of Human Resources of Health (HRH), the numbers of health-care workers in most categories have increased over time. Even though the numbers of nurses and para-medical staff have increased steadily, the system is experiencing a considerable shortage of qualified nurses and para-medical staff in almost all the medical institutions across geographic boundaries. The main reason envisaged for this is the imbalance in production of HRH caused by virtually decreasing level of production of nurses and paramedics and increasing level in production of doctors.

Table 4.18

DISTRIBUTION OF MANPOWER IN HEALTH SECTOR

Item	2004
Western medical system	
Total No. of Administration staff	424
Total No. of Administration Supporting staff	4,495
Total No. of Specialists	730
Total No. of Consultants	79
Total No. of Medical Officers	8,749
Total No. of Assistant Medical Practitioners	1,276
Total No. of Dental Surgeons	805
Total No. of Nurses	27,138
Total No. of Midwives	8,861
Total No. of Statisticians	50
Total No of Attendants	6,696
otal No. of Other Supporting Staff	31,311
Total No. of Technical Staff	3,244
Total No. of Health Education Officers	49
Total No. of Public Health Inspectors	1,579
Total No. of Pharmacists	980
Total No. of Dispensers	886
Ayurvedic Medical System:	
Teaching Hospitals	03
Central Dispensaries	124
Provincial Hospitals	47
Local Dispensaries	231
Research Institutes	1
National Institute of Traditional Medicine	1
Herbal Gardens	5
Total Number of Ayurvedic Physicians	17,038

Source: Ministry of Healthcare and Nutrition and Department of Ayurveda

The total manpower of Health Physicians in 2004 comprised 8,749 doctors, 1,279 Assistant Medical Practitioners and 17,038 Ayurvedic Physicians. The other human resources in health comprised 27,138 Nurses and midwives; 3,244 of Technical Officers; 1,579 Public Health Inspectors (PHI); 980 Pharmacists; 886 Dispensers; 6,696 Attendants; 31,311 other supporting staff (Table 4.18).

The Postgraduate Institute of Medicine provides postgraduate training locally while scholarships are also granted for training at specialized institutions abroad. The National Institute of Health Science (NIHS) is the national focal point for health systems research training and continuing education.

Chapter 5

R&D OUTPUT

An important outcome of scientific research is the generation of new information. The components of this information flow are systemized and embodied in scientific papers and patents which are thus recognized as products of research. Over the past few decades, counts of these output components have been used not only for measurements of productivity, but also to compare the research performance of different countries. Other measurements of research output include counts of citations, patents, inventions and innovations.

This chapter summarizes the research output in the country in 2004 with comparisons of previous records and international data.

5.1 Patents Output

Patent data have long been used as a measure of innovative activity and technology development. Particularly, its use as international comparisons of technology growth. Since the patents are meant for protecting inventions developed by firms, institutions or individuals, it can be interpreted as indicators of inventions. The number of patent applications lodged or patents granted can provide a proxy measure for the output of inventive activity. Patents also provide insight into how the research is protected or commercially pursued. They can also be used to monitor technological activity as well as internationalization.

In table 5.1 the patent output in Sri Lanka from 1995-2004 is presented. The number of patents granted by Sri Lanka for resident as well as non-resident applicants increased marginally over the years. The proportion of patents granted for residents and non-residents was approximately 1:1 in the surveyed years except in 1998 where the number of patents granted for non-residents was double the number issued to residents. However, the patents granted for local scientists have increased gradually over the years and it is a positive indication of increasing awareness of the local scientists of intellectual property rights.

Table 5.1

NUMBER OF PATENTS REGISTERED LOCALLY DURING 1995-2004

Year	Resident	Non-resident	Total
1995	64	95	159
1996	98	107	205
1997	65	96	161
1998	44	97	141
1999	78	101	179
2000	59	69	128
2001	71	104	175
2002	62	56	118
2003	59	53	112
2004	99	91	190

Source: R&D survey Report, NSF 2000

The detailed analysis of patents granted for local grantees is presented in Table 5.2. Accordingly, it can be seen that the highest proportion of patents were received by the inventors in the Private sector organizations and individual inventors. The patents received by the State sector were very low.

Table 5.2

LIST OF PATENTS REGISTERED LOCALLY DURING THE PERIOD OF 2001-2004

Organization Types	2001	2002	2003	2004
S&T Institute	5	5	8	5
Higher Education	1	1	4	4
Private	4	7	8	13
Individual	64	49	41	75
Total	**74**	**62**	**61**	**97**

When considering the proportion of patents registered by each sector, the highest number of patents was registered by the individual inventors. This amounted to 78 per cent of the total patents registered in 2004. The number of patents received by S&T institutes was only 5 per cent, Private sector 17 per cent and the Higher Education sector 4 per cent in 2004.

Table 5.3

DISTRIBUTION OF PATENTS ACCORDING TO CLASSIFICATION

	Year				
Classification	2001	2002	2003	2004	Total
Dryers/Dehydration Technology	3	0	1	1	5
Food and Beverage Process Technology	2	2	4	5	13
Rubber Production and Processing Technology	1	3	0	2	6
Agricultural Systems and Development Technology	7	5	5	7	24
Construction Technology and Materials	3	1	3	4	11
Packaging and Packing Materials	3	1	1	7	12
Energy Saving/ Generating Devices	10	9	3	5	27
Process Technology - Manufacturing Sector	5	2	4	5	16
Process Technology - Miscellaneous	3	3	6	5	17
Innovations in Domestic Appliances/ Utilities	7	19	9	11	46
Innovations - Miscellaneous	23	7	11	19	60
Product Development	7	10	14	26	57
Total	**74**	**62**	**61**	**97**	**294**

Tables 5.3 and 5.4 give a detailed analysis of the type of patents registered by the local inventors. Accordingly, most of the patents registered by local inventors are of various kinds pertaining to domestic appliances or product development but fall mostly into the miscellaneous category. The patents related to energy saving devices/generating devices and agriculture innovations were slightly higher than the other type of inventions. However, the innovations in the area of energy saving/ generating devices have gradually declined over the years.

The international data on patent statistics enumerate disparities that exist in the world. The developing countries account for 22 per cent of the world GERD (Chapter 3, Table 3.3) and they represent just over 7 per cent of all patents granted by the United States Patent Office (USPTO) (Table 5.5).

Table 5.4

LIST OF PATENTS GRANTED TO RESEARCH INSTITUTIONS DURING 2001 – 2004

R&D Institute	Title
HORDI	• Formulation of protein Bait useful as Fruit fly attraction
IFS	• Dye - sensitized photoelectron chemical cell made from a film of Magnesium Oxide coated Tin (iv) Oxide.
	• Method for manufacture of natural fiber/polymer composite from rice husk
	• Process for the Manufacture of Shark Silage
	• Process for the Manufacture of Instant soup powder from Tuna waste
	• Process for the Manufacture of Herbal Sausages from Tilapia & Tuna
ITI	• Process for the Manufacture of Pickle from Tilapia
	• Methods of Manufacture of Ligno Plastic wood
	• Process for the Manufacture of Osmotically Dehydrated Tilapia
	• Noise guard to be used to prevent noise pollution caused by high power sound system
	• A process for manufacturing of natural fiber polymer composite from coir fiber and unsaturated polyester resin
NERDC	• Pelting Process for the manufacture of fuel pellets out of kitchen waste, saw dust/paddy husk
	• Domestic- Kitchen waste Anaerobic Digester
	• Method for the manufacture of natural fiber/polymer composite from rice husk
RRI	• Manufacture of Porous Polymer Profile (Tubular, Square, ETC) by Extrusion - Sintering Process
	• Ideal flowers based on natural rubber latex for floral décor.
TRI	• Discovery of Antifungal activity of eatechins and theaflasings (Black tea components) against *Candida aibicans, Candida parapsilosis, Candida tropicalis, Candida Krusei and Candida glabrat* Collapsible (folding) tea plucking basket.
	• Hand Pruner

This is indicative of a strong, mature business environment in the developed countries. For example, the USA offers attractive incentives for innovation. However, this type of business environment is still in its infancy and has a hard time surviving in many developing countries (UNESCO Science Report, 2005).

Table 5.5

PATENTS GRANTED AT USPTO, 1991 AND 2001

	Total		% World	
	1991	2001	1991	2001
World	96,268	166,012	100.0	100.0
Developed Countries	94,285	154,999	97.9	93.4
Developing Countries	2,215	12,128	2.3	7.3
Less-Developed countries		8		0.0
European Union	18,504	29,124	19.2	17.5
Asia	23,028	45,163	23.9	27.2
Comm. Of Ind. States in Asia		9		0.0
Newly Indust. in Asia	1,436	9,811	1.5	5.9
Arab States in Asia	10	37	0.0	0.0
Other in Asia	17	58	0.0	0.0
OECD	94,667	158,317	98.3	95.4
Brazil	66	149	0.1	0.1
China	63	298	0.1	0.2
France	3,154	4,516	3.3	2.7
Germany	7,914	12,122	8.2	7.3
India	31	231	0.0	0.1
Israel	336	1,098	0.3	0.7
Japan	21,144	33,721	22.0	20.3
South Africa	115	132	0.1	0.1
United Kingdom	2,969	4,622	3.1	2.8
United States of America	51,703	89,565	53.7	54.0

Source: UNESCO Science Report, 2005

Sri Lanka had only one application for patenting at USPTO in 2001. When comparing the data across different countries, there is a need to take into account several factors such as: patent legislation and domestic patenting activities vary from country to country; patent costs also vary with consequent significant effects on observed trends; all the patents do not necessarily have the same commercial value; not all inventions are patented; and the prosperity of patents varies between industries and across different economic conditions. When considering all the above aspects, the number of inventors also applying for patents would naturally be very low in countries like Sri Lanka because of the high

cost and cumbersome procedures to follow in the application. Many inventors and/or scientists in the country are not well aware of the procedure for application and hence all the local inventions are not patented. Due to this reason, the patent data alone is not a good indicator in measuring R&D in Sri Lanka. Further, the nature of industries in different countries should be taken into consideration when drawing comparisons between countries. Countries based on industries of high technological nature tend to produce more patents than the countries based on industries of manufacturing nature like Sri Lanka. Most of the industries in Sri Lanka are not fully involved in inventions but in technology development and adaptation activities.

Table 5.6 gives information on the technologies developed and adapted by R&D sector in the country in the years 2000-2004. According to the information collected by the survey on technological innovations developed, an increasing trend has been observed.

Table 5.6

SUMMARY OF TECHNOLOGICAL WORKS CARRIED OUT BY R&D INSTITUTIONS IN 2001-2004

Type	2001-2002	2003-2004
Technological innovations	39	70
New process developed	22	45
High technology products produced	24	44
Technology transferred activities	1,572	2,324

5.2 Bibiliometric indicators

Bibiliometric indicators measure the quantity and impact of scientific publications as a proxy for the overall output of scientific research and are based on the count of scientific papers and the citations they received. It can be used as an indicator for the creation and diffusion of knowledge. However, most of the publications are generated in the academic sector. Therefore, the R&D work carried out in the country which directly addresses the local problems and many research of applied nature are not fully accounted. Together with patent indicators, bibiliometric indicators are increasingly used in the evaluation process of R&D in the universities and S&T institutions, or in the country as a whole.

5.2.1 Coverage of ISI database

The use of ISI databases of bibilometric analysis as a tool for evaluating research performance in the international context is a well known practice though there are some deficiencies in such databases. For example, it cannot be universally applied across all fields (Bourke et al., 1996), since it does not comprehensively cover the output of most fields in the social sciences and humanities, engineering, information and other fields of applied sciences while it gives a good coverage of the fields of medical sciences, chemical sciences etc..

Table 5.7

DISTRIBUTION OF NUMBER OF ARTICLES BY SUBJECT FIELD IN SCI FOR THE YEAR 2000 AND 2004

Subject field	2000	%	2004	%
Agriculture	17	9.8	12	5.2
Biological sciences	24	13.8	31	13.5
Biotechnology	8	4.6	7	3.1
Chemical sciences	20	11.5	25	10.9
Earth sciences	0	0	7	3.1
Social Sciences	2	1.2	2	0.9
Engineering & Technology	9	5.2	8	3.4
Environmental sciences	2	1.2	8	3.5
Food science	2	1.2	8	3.5
Mathematics	3	1.7	0	0.0
Health sciences	65	37.6	70	30.6
Natural resources	0	0	11	4.8
Physics	14	8.1	26	11.4
Veterinary science	5	2.9	8	3.5
Forestry	2	1.2	5	2.2
Industries/trade	0	0	1	0.4
Total publications	**173**	**100**	**229**	**100.0**

According to the Science Citation Index (SCI) data base there were 229 articles published in reputed international journals by local scientists in 2004. The total number of articles recorded in 2004 (229) and was higher than the number of articles recorded in 2000 (173) (Table 5.7).

When categorized into different disciplines, the highest number of publications were found in the area of health sciences (31 per cent) followed by biological sciences (14 per cent), physical sciences (11 per cent), chemical sciences (11 per cent), agriculture (5 per cent), natural resources (5 per cent), environment sciences (4 per cent), food sciences (4 per cent), veterinary sciences (4 per cent), engineering & technology (3 per cent), earth sciences (3 per cent) in 2004 (Table 5). A similar pattern had been observed in the data collected in 2000 (Figure 5.1).

Table 5.8 analyzes the authorship pattern of the SCI journals published in 2004 in indicated in Table 5.7. The authorship pattern was categorized as fully authored by Sri Lankan authors and papers with foreign authors. The collaboration ratio was calculated by dividing number of papers in each discipline having foreign co-authorship with number of papers fully authored by Sri Lankan authors in same discipline. Accordingly, it was observed that the collaboration ratio was very high in the areas of natural resources (10), earth sciences (6) and chemical sciences (3). The lowest degree of dependency was seen in the areas of engineering technology (0), energy (0.3) and agricultural sciences (0.5). (Table 5.8)

Table 5.8

AUTHORSHIP PATTERN OF SRI LANKAN PAPERS IN SCI ACCORDING TO MAIN FIELDS FOR THE YEAR 2004

	Sri Lankan only	%	With foreign co-authrship	%	Total	Collaboration rate %
Agriculture Science	8	66.7	4	33.3	12	0.5
Biological Sciences	11	37.9	18	62.1	29	1.6
Biotechnology	3	42.9	4	57.1	7	1.3
Chemical Sciences	7	28.0	18	72.0	25	2.6
Computer Science & ICT	0	-	0	-	0	-
Earth Sciences	1	14.3	6	85.7	7	6.0
Education	0	-	0	-	0	
Energy	3	75.0	1	25.0	4	0.3
Engineering & Technology	4	100.0	0	0.0	4	0.0
Environmental	3	37.5	5	62.5	8	1.7
Fisheries/ Aquaculture	0	0.0	2	100.0	2	
Food Science	4	50.0	4	50.0	8	1.0
Forestry	0	0.0	5	100.0	5	-
Industries/Trade	0	0.0	1	100.0	1	-
Mathematics	0	-	0		0	-
Medical and Health Science	37	52.9	33	47.1	70	0.9
Natural Resources	1	9.1	10	90.9	11	10.0
Physics	8	30.8	18	69.2	26	2.3
Social Science	1	25.0	3	75.0	4	3.0
Veterinary Sciences	1	12.5	7	87.5	8	7.0
Total	**92**	**39.8**	**139**	**60.2**	**231**	**1.5**

When considering the global output of R&D production, the situation is similar to the global pattern of R&D input. Nearly 90 per cent share of publications are from the developed countries. The United States of America has the highest number of publications in comparison to other countries (Table 5.9).

Since Sri Lanka is a developing country, most of the research carried out are of applied nature addressing local needs yielding the publications that have mostly a local interest. Therefore the number of articles generated for international publications are relatively low in comparison to the developed countries. For this reason the number of international publications alone does not give an actual picture of the R&D output in the country. Hence publications which appear in local sources should also be considered when measuring the actual R&D output in the country.

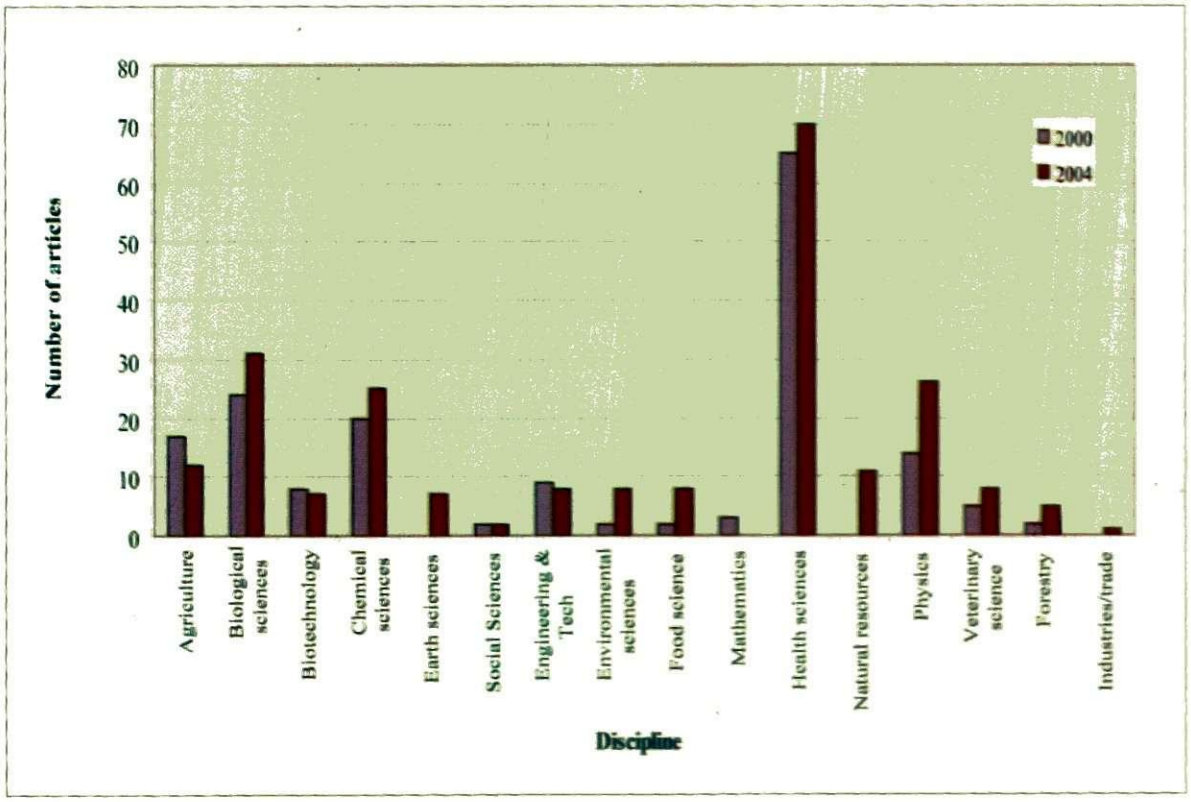

Figure 5.1

NUMBER OF ARTICLES PUBLISHED IN DIFFERENT DISCIPLINES IN 2000 AND 2004

The Annual Proceedings conducted by many leading Scientific Associations in the country contribute immensely in publishing research activities carried out in the country. For example, the Sri Lanka Association of Advancement of Science (SLAAS) has played a leading role in this context in the country over the past five decades.

Table 5.9

WORLD SHARE OF SCIENTIFIC PUBLICATIONS, 2001

	Biology	Biomedical research	Chemistry	Clinical medicine	Earth and space
World	45,482	93,557	77,351	190,400	33,376
Developed countries	40,103	85,646	62,894	173,692	30,415
Developing countries	8,537	11,596	18,177	22,129	5,478
Less-developed countries	350	213	59	694	91
Africa	1,445	973	1,290	2,456	597
Asia	8,012	16,773	23,190	32,799	5,073
Comm. of Ind. States in Asia	33	46	293	48	68
Newly Indust. In Asia	1,372	2,558	3,808	4,915	865
Arab States in Asia	174	168	232	712	114
Other in Asia	454	310	626	942	164
Oceania	3,309	2,919	1,537	6,616	1,914
Other groupings					
Arab states All	447	358	1,151	1,285	295
OECD	40,037	85,392	59,929	176,816	29,890
Selected Countries					
Argentina	569	572	475	932	246
Brazil	954	1,255	1,123	1,985	474
China	982	1,984	5,915	2,897	1,190
Egypt	164	88	573	349	70
France	2,341	6,515	5,145	10,751	2,968
Germany	3,032	8,342	7,388	16,520	3,299
India	841	1,522	2,788	1,789	613
Israel	593	1,163	617	2,527	368
Japan	3,929	9,353	9,686	19,244	1,968
Mexico	639	471	392	821	416
Russian Federation	1,000	2,195	4,903	800	1,602
South Africa	490	442	241	742	285
United Kingdom	4,113	9,399	5,366	19,994	4,131
United States of America	14,045	38,955	16,233	70,796	13,332

Source: UNESCO Science Report, 2005

Note: The sum of the numbers, and percentages, for the various regions exceeds the total number, or 100 per cent, because papers with multiple authors from different regions contribute to the total

5.2.2 The role of Sri Lanka Association for the Advancement of Science (SLAAS)

The Sri Lanka Association for the Advancement of Science was inaugurated on the 29th July of 1944 as Ceylon Association of Science (CAS) and incorporated by Act No. 11 of 1966 as Ceylon Association for the Advancement of Science (CAAS) and renamed in 1975 as the Sri Lanka Association for the Advancement of Science (SLAAS). The main objectives of the Association according to the Act are: to promote the advancement of science (pure and applied): to provide for systematic direction of scientific inquiry in the interests of the community; to promote contact among scientific workers; to hold the Annual Sessions; to disseminate scientific knowledge and to do such things as may be necessary for the advancement of science.

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 up to three different sections according to the extension of their research field. The total number of scientists registered in each section during a year gives an indication of scientists actively engaged in research work during the respective years. Accordingly, the total number of scientists registered has increased over time reaching 3,705 in 2004 (Table 5.10). The total scientists recorded in this survey were 2,679 and this is less than the number of scientists registered in SLAAS in 2004. This disparity may be a result of a shortage of data collection in the R&D survey of scientists who were involved in research on a personal basis especially in the areas of social sciences and medical sciences as well as the student researchers who are not counted as scientists according to the standard used in this survey. Some of the registered scientists may have left the country while others may have registered in more than one field.

Table 5.2 gives the total number of scientists registered in SLAAS during the past four years. Indicating a gradual increase in the total number of scientists. The highest number of scientists was registered in the agriculture science section (696) followed by 682 scientists in life sciences, 556 in social sciences, 492 in chemical science, 426 in medical sciences 309 in physical sciences and 240 in engineering.

Table 5.10

SLAAS MEMBERSHIPS 2000-2004

Section	2000	2001	2002	2003	2004
A (Medical Science)	362	377	391	412	426
B (Agriculture Sciences)	539	570	606	655	696
C (Engineering)	149	167	186	209	240
D (Life Sciences)	559	580	616	645	682
E1 (Physical Sciences)	238	246	263	290	309
E2 (Chemical Sciences)	371	395	427	468	492
F (Social Sciences)	498	509	517	538	556
Total	**2,716**	**2,844**	**3,006**	**3,217**	**3,401**

Source: SLAAS Annual Reports 2000-2004

Table 5.11 presents the number of research papers presented and the number of scientists involved in annual proceedings conducted in 2000-2004. The highest number of paper presentations were recorded in the agriculture section (118) followed by 61 in Life science, 41 in Social Sciences, 28 in engineering, 27 in Physical Sciences, 23 in Chemical Sciences (Figure 5.2). When comparing the SLAAS publications with the ISI index, the fields that represent the highest number of publications shifted from health sciences to agriculture sciences. The reason envisaged here is that in the field of agriculture, most of the research carried out was of applied nature addressing local needs and have more local value than international value as a scientific publication. Agriculture research is not conducted in isolation as it covers many aspects of science. Therefore, agriculture scientists have a long history of drawing on and adapting findings from the basic biological and chemical sciences as well as applied sciences such as biotechnology, food science and technology in furthering their own research. Also the scientific spillover has occurred into other directions as well, increasingly merging the boundaries between agriculture and other sciences. Therefore, when measuring the developments in agriculture sector it is necessary to consider all the ten sectors. Publications in the area of engineering were low both internationally and locally.

Table 5.11

NUMBER OF SLAAS PRESENTATIONS ON ANNUAL PROCEEDINGS AND NUMBER OF SCIENTISTS INVOLVED IN 2000-2004

Section	No. of publications					No. of Scientists involved				
	2000	2001	2002	2003	2004	2000	2001	2002	2003	2004
Medical Sciences	52	25	30	27	36	189	118	87	111	104
Agriculture Sciences	102	85	98	95	118	197	224	49	241	135
Engineering	24	46	59	24	28	31	99	23	70	60
Life Sciences	64	52	89	52	61	129	165	97	114	105
Physical Sciences	43	21	43	24	27	103	48	87	44	71
Chemical Sciences	49	28	57	44	23	127	82	90	95	59
Social Sciences	31	28	34	31	41	34	49	52	65	93
Total	**365**	**285**	**410**	**297**	**334**	**810**	**785**	**485**	**740**	**627**

Source: SLAAS Proceedings 2000-2004

There are other publications such as books or books chapters, papers appearing in local journals and newspaper articles that also disseminate the results of R&D work carried out by the institutions. This type of information was very difficult to collect through printing materials, as they are vastly distributed in the country and no comprehensive database is available locally that records such publications. Therefore, total publications that fall into these categories were collected from individual scientists as well as from the annual reports of the institutions and are presented in the table 5.12. Accordingly, the number of paper articles published locally has increased from 490 (2001-2002) to 545 in the period 2003-2004. The number of international publications also has increased over time. This may be

partly due to the current interest of writing scientific books among the scientific community and also due to the requirement in writing science related books for promotion of the university academic staff. The number of books published locally by the scientists or institutions increased dramatically from 13 in 2001-2002 to 170 in 2003-2004. The number of seminars attended by the scientists as resource persons to disseminate the knowledge locally as well as internationally has also increased over time 2001-2004.

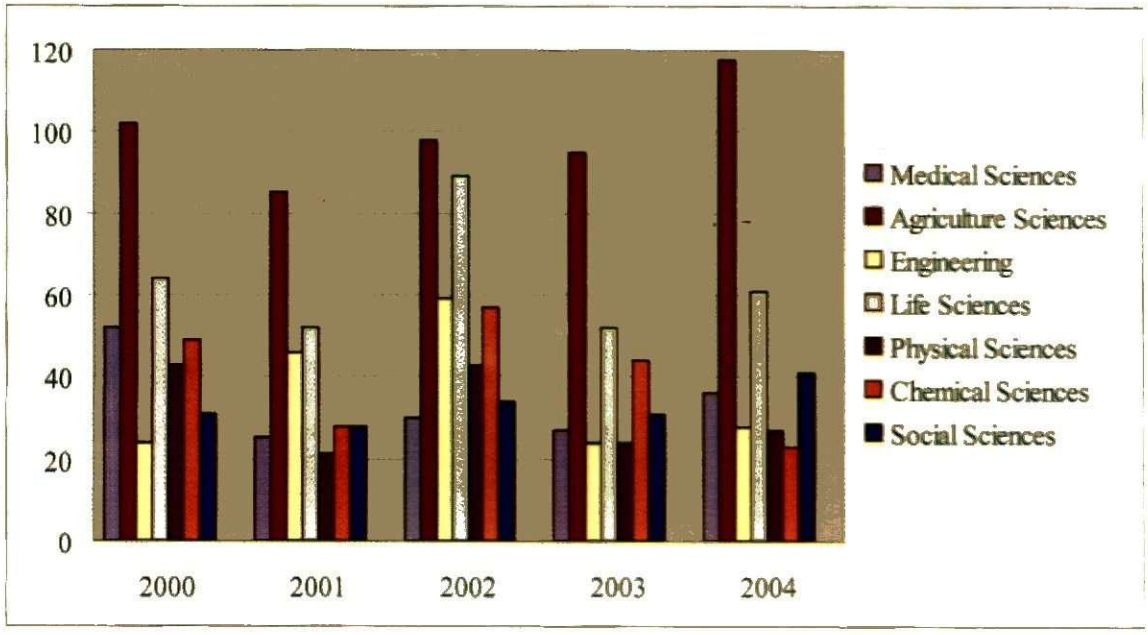

Figure 5.2

THE TREND IN THE PAPER PUBLICATIONS IN SLAAS 2000-2004

The consultancies done by individual scientists also give an indication of knowledge disseminations. This also can be used as an indicator to measure the output in R&D work. The number of such consultancies undertaken by scientists locally and internationally have increased over time.

5.3 Postgraduate Output

The number of postgraduates degrees achieved in the R&D sector is another criterion that can be used to measure the research output in the country. From 2000-2004, there has been a steady growth in postgraduate output in the country. This may be due to the establishment of Postgraduates Institutes in many disciplines during the period.

Table 5.13 gives a detailed description of postgraduate output in 2000 and 2004. Accordingly, the highest number of postgraduate output (315,414) was in the area of medical sciences. However, it is understand that these figures include the few Ph.Ds and number of MDs in the area of medicine. The number of postgraduates in the area of engineering was low but seen to be increasing over time.

Table 5.12

PERFORMANCE OF S&T SECTOR 2001-2004

	National		International	
	2001-2002	2003-2004	2001-2002	2003-2004
Articles (Newspaper, newsletters, web etc.)	490	545	104	142
Books	13	170	40	49
Journal Articles	67	73	22	52
Publications	171	187	64	83
Other Publications	11	2	9	16
Papers presented	892	944	257	312
Seminars attended	759	1,000	174	225
Workshops participated	840	1,227	294	192
Meeting attended	618	819	146	172
Other Meeting	278	279	42	83
No. of consultancies involved	552	870	38	59
Consultancy projects undertaken	124	177	13	19
No. of Special awards	87	83	7	23
Visiting fellowships-In	16	20	20	21
Visiting fellowships-Out	90	51	19	79

Table 5.13

POSTGRADUATE OUTPUT IN 2000-2004

Degree	Year	Medical	Computer	Agriculture	Science	Engineering	Total
PG. Dip.	2000	112	37	1	2	-	152
	2004	167	20	2	5	105	299
MSc./MEng.	2000	101		21	18	-	140
	2004	37	44	130	83	206	500
M.Phil.	2000	0		9		-	9
	2004	5		11	8	18	42
Ph.D.	2000	102*		3		-	105
	2004	205*		1	4	2	212
Total	**2000**	**315**	**37**	**34**	**20**	**-**	**406**
	2004	**414**	**64**	**144**	**100.0**	**331**	**1,053**

Source: UGC Statistics 2005

*Include MDs

5.4 Outcomes of Research Funded by National Science Foundation, Sri Lanka

The National Science Foundation (NSF) was established in 1998 (by act No. 1994) as the successor to the Natural Resources Energy and Science Authority of Sri Lanka (NARESA) established in 1981 and the National Science Council set up in 1968. The main objectives of the NSF is to initiate, facilitate and support basic and applied scientific research by universities, science and technology institutions and scientists, with a view to strengthen scientific research potential including research in the social sciences: developing scientific education programmes; developing the natural resources of Sri Lanka; promoting the welfare of the people of Sri Lanka and training research personnel in science and technology.

One of the main activities of NSF is the awarding of Research Grants. These grants are intended to provide assistance in supplementing the financial, physical and manpower resources of the institutions which scientists are attached to. The grants scheme of NSF administers local grants to individual scientists as well as negotiates foreign grants for scientists in universities and research institutes. Performance of the research grant scheme from 1996-2004 is presented in Table 5.14.

Table 5.14

PERFORMANCE OF NSF RESEARCH GRANTS SCHEME (2000-2004)

	Performance of NSF Research Grants Scheme (2000-2004) by Discipline					
Discipline	Natural Sciences	Agriculture	Engineering	Medical Sciences	Social Sciences	Total
Completed Grants	85	15	41	9	7	157
Total Expenditure	40,231,676	6,123,853	29,838,969	26,984,895	612,789	103,792,182
Masters & Doctoral Degrees	13	3	8	9	2	35
Publications (Foreign & Local)	165	21	56	41	20	303

Source: NSF Annual Reports 2000-2004

The NSF has released an annual allocation of Rs. 25,495,079 for R&D in the year 2004. The funds are awarded to researchers after evaluation of the research proposals by specialist panels. The university sector which has a very small research budget is the major recipient of NSF grants consuming over 75 per cent of the total allocation of research funds. The research grants awarded has yielded 306 international and local publications and other communications during the period 2000-2004. The highest number of grants were awarded in the discipline of natural sciences (Rs. million 40.23) followed by engineering (Rs. million 29.84), medical sciences (Rs. million 26.98), agricultural sciences (Rs. million 6.12) and social sciences (Rs. million 0.6).

In addition to many research publications based on the findings of the research studies, the enhancement of the potential to carry out research, though training personnel under M.Sc., M.Phil, or Ph.D. programme, is a significant achievement of the NSF research grants programme. An average of 6 postgraduate degrees has been awarded annually to scientists working under NSF research grants.

Chapter 6

DEVELOPMENT OF EDUCATION SECTOR IN THE COUNTRY

6.1 Historical Overview of Education System in Sri Lanka

The ancient history of Sri Lanka from the sixth century BC is documented in the Mahawansa, Deepawansa and Chulawansa chronicles. With the introduction of Buddhism to Sri Lanka, a monastic education system flourished in Sri Lanka and was chiefly responsible for the spread of education in the country during the period 200 BC-1500 AD. While the monasteries or temples became the primary education institutions in the villages, the Pirivenas set up for the education of the Buddhist monks became the secondary education institutes for the clergy as well as for lay students. The Mahavihara with learned staff and facilities for research formed the tertiary education centres.

During the period 1232-1271 AD the education system consisted of 1500 Pirivenas. Some of these Pirivenas had curricula covering a broad range of subjects such as weaving, metal work, architecture, town planning, construction of irrigation systems, art and painting. The great dagobas in Sri Lanka, large irrigation tanks (reservoirs) and Sigiri frescoes could be cited as testimony to the high level of education, art, engineering and technical skills that existed during that period.

With the invasion of the country by Portuguese, Dutch (1500-1796 AD) and then British (1796-1948) economic and religious considerations influenced developments in education. Denominational schools set up by the Christian missionaries provided an education in English which was at a premium for securing government jobs, while the government schools mainly provided a vernacular education. During the period 1880 to 1900, to redress this imbalance, a large number of Buddhist, and some Hindu and Muslim schools were set up with the help of philanthropists, religious societies like the Buddhist Theosophical Society and the respective clergy.

Under the British government during the last quarter of the19th century the following tertiary education institutions were started by the government: the Medical College (1870), the Law College (1895), the School of Agriculture (1909) and Technical College and University College (1893)

Since gaining independence from colonial rule in 1948, the government has given highest priority for education. The education in the school system comprises: primary level (5 years: Grade 1-5); secondary level (6 years Grade 6-11); and collegiate level (2 years-Grade 12-13). The higher education system consists of universities and technical colleges. A major reform programme was initiated in 1998 in the education sector. The key objectives of the reforms in the general education sector were to promote access and equity and improve the quality of education. The infrastructure facilities of schools in rural and semi-urban areas have been upgraded by introducing the Navodaya schools programme, with emphasis on activity-based learning approaches and inclusion of ICT education in the curriculum.

Under the economic liberalization policy pursued by successive governments since 1977, private schools and institutions offering education up to degree level started appearing in the country at a rapid rate. These institutions have been set up under the Board of Investment and therefore do not come under the purview of the Ministry of Education. Hence there is no monitoring system to validate the quality and level of education in these institutions. This is a serious deficiency which could result in lowering the standard in education.

The total expenditure on education has increased gradually from Rs. 26.1 million in 2000 to Rs. 38.4 million in 2004. Though the expenditure on education has increased over time in absolute terms when the proportion of GNP is considered there is a substantial decrease from 10.1 per cent in 2000 to 8.7 per cent in 2004.

Table 6.1

SUMMARY INDICATORS OF GOVERNMENT EXPENDITURE ON EDUCATION

Year		2000	2001	2002	2003	2004
GNP at current factor cost		1,102,177	1,221,768	1,378,151	1,541,985	1,777,253
Government expenditure	Recurrent	254,279	303,362	330,847	334,693	389,678
in Rs. '000	Capital	67,769	67,902	58,595	75,089	83,807
	Total	322,048	371,264	389,442	409,782	473,485
Expenditure on Education	Recurrent	26,084	32,044	35,239	35,616	38,423
in Rs. '000	*	(15,426)	(18,541)	(21,282)	(21,320)	(23,862)
	Capital	6,296	5,531	4,606	4,615	2,950
	*	(578)	(554)	(764)	(657)	(799)
	Total	32,380	37,575	39,845	40,231	41,373
	*	(16,004)	(19,095)	(22,046)	(21,977)	(24,661)
Expenditure on Higher	Recurrent	3,947	4,945	5,214	5,538	6,238
Education in Rs. '000	Capital	1,464	1,439	1,098	1,173	1,384
	Total	5,411	6,384	6,312	6,711	7,622
Expenditure on University	Recurrent	3,832	4,729	5,071	5,405	6,124
Education in Rs. '000	Capital	1,279	1,432	1,037	1,092	1,319
	Total	5,111	6,161	6,108	6,497	7,443
Expenditure on Education as	Recurrent	2.37	2.62	2.56	2.31	2.49
percentage of GNP	Capital	0.57	0.45	0.33	0.30	0.19
	Total	2.94	3.08	2.89	2.61	2.68
Expenditure on Higher	Recurrent	0.36	0.40	0.38	0.36	0.39
Education as a percentage of	Capital	0.13	0.12	0.08	0.08	0.09
GNP	Total	0.49	0.52	0.46	0.44	0.49
Expenditure on University	Recurrent	0.35	0.39	0.37	0.35	0.39
education as a percentage of	Capital	0.12	0.12	0.08	0.07	0.08
GNP	Total	0.46	0.50	0.44	0.42	0.48
Expenditure on Education as	Recurrent	10.26	10.56	10.65	10.64	9.86
a percentage of Total	Capital	9.29	8.15	7.86	6.15	3.52
government expenditure	Total	10.05	10.12	10.23	9.82	8.73
Expenditure on Higher	Recurrent	15.13	15.43	14.80	15.55	16.2
Education as a percentage of	Capital	23.25	26.02	23.84	25.42	46.90
Education	Total	16.71	16.99	15.84	16.68	18.42
Expenditure on University	Recurrent	14.69	14.76	14.39	15.18	15.9
education as percentage of	Capital	20.31	25.89	22.51	23.66	20.75
Education	Total	15.78	16.40	15.33	16.15	17.9
Expenditure on University	Recurrent	97.09	95.63	97.26	97.60	99.6
Education as a percentage of	Capital	87.36	99.51	94.44	93.09	95.3
Higher Education	Total	94.46	96.51	96.77	96.81	97.6

Source: University Statistics 2005, UGC, Sri Lanka

Notes : 1. * indicate the expenditure allocated under Provincial Councils

2. The "total expenditure on Higher Education" includes University Education, Advanced Technical Education and Ministerial expenditures while "Total expenditure on education" includes general Education, Teachers Training, Advanced Technical education, University Education and Ministerial Expenditure

6.2 Statistics on Secondary Education

The total number of schools has decreased from 10,615 in 2000 to 10,475 in 2003. This decrease occurred due to concentration of students into popular schools in urban areas and consequent reduction of number of students enrolling in rural schools. This led to the closing down of many schools in rural areas. The number of schools with classes up to A/L has decreased marginally from 2,360 in 2000 to 2,358 in 2003 (Table 6.2).

Table 6.2

STATISTICS ON SECONDARY EDUCATION

Indicator	2000	2001	2002	2003
Total No. of schools	10,615	10,552	10,508	10,475
No. of schools with classes up to A/L	2,360	2,367	2,347	2,358
No. of schools with science up to A/L	575	600	602	606
Percent of A/L schools with science	**24.4%**	**25.3%**	**25.6%**	**25.7%**
Total No. of students	4,340,447	4,337,314	4,179,217	4,096,886
Total No. of teachers	194,718	198,410	196,407	194,931
Student/teacher ratio	**22.3%**	**21.9%**	**21.3%**	**21.0%**
Total No. of graduate teachers (1)	45,454	47,426	47,436	48,009
Graduate teachers/ total teachers	**23.3%**	**23.9%**	**24.2%**	**24.6%**
No of science Graduate teachers	5,638	6,229	6,294	6,594
Science Graduate/Total Graduate	**12.4%**	**13.1%**	**13.3%**	**13.7%**
Certificated science/Math teachers(2)	22,350	23,669	23,526	24,498
Uncertificated science teachers (3)		1,227	753	1,126
All science teachers(1),(2) & (3)	**27,988**	**31,125**	**30,573**	**32,218**

Source: Statistical Abstract 2005, Department of Census and Statistics, Sri Lanka

However, it is encouraging that the total number of schools with science up to A/L has increased gradually from 575 (24.4 per cent) in 2000 to 606 (25.7 per cent) in 2004. The number of certified Science and Math teachers has also increased from 22,350 to 24,498 in 2004. The total number of science teachers including S&T graduate teachers, certificated science/math teachers and uncertificated science teachers amounted to 32,218 in 2003 compared to 27,988 in 2000 (Table 6.2). They are an important category of auxiliary personnel who have not been included in STP definition but make a significant contribution to the development of S&T personnel.

Table 6.3

DISTRIBUTION OF THE EDUCATION SYSTEM IN SRI LANKA 2004

A.	General education	2004
a.	Total schools	10,501
	Government schools	9,765
	o/w National schools	324
	Other schools	736
	Private	85
	Pirivena	651
b.	Students ('000)	4,028
c.	New admissions ('000) (b)	303
d.	Teachers ('000)	198
e.	Student/Teacher ratio (government schools)	21
f.	Total expenditure on education (Rs. billion) (d)	42
	Current	34
	Capital	9
B.	**University education**	
a.	Universities	13
b.	Students (d)	64,801
c.	Lecturers (e)	3,725
d.	Number graduating	10,525(f)
	Arts and Oriental studies	3,366
	Commerce & Management studies	3,091
	Law	166
	Engineering	984
	Medicine	964
	Science	1,323
	Other	631
e.	New admissions for first degrees	13,396

Sources: Annual Report 2005, Central Bank of Sri Lanka.

(a) Provisional

(b) Government schools only

(c) This include 1,935 teachers paid by other than the government

(d) In all Universities, excluding the Open University of Sri Lanka

(f) Includes government expenditure on higher education

It is evident from these statistics that the number of science teachers working in the educational system is not adequate to accelerate the growth in knowledge of science and technology among school children and thereby create a science culture throughout the country. The inadequacy of available laboratory facilities in many schools and low salaries paid may be the main reasons for the shortage of science teachers in the country.

6.3 Expenditure on Higher Education

The expenditure on the higher education sector has increased steadily from Rs.5.4 million in 2000 to Rs.6.7 million in 2003. However, when considered as a per cent of GNP there is a marginal decrease from 0.49 per cent in 2000 to 0.44 per cent in 2003. There are also several public and private institutions as well as prestigious professional institutions such as the Institute of Chartered Accountants of Sri Lanka (ICAS), Chartered Institute of Management Accountants (CIMA), Sri Lanka Law College, National Institute of Business Management (NIBM) , Sri Lanka Institute of Development Administration (SLIDA), Sri Lanka Institute of Information Technology (SLIIT), Sri Lanka Institute of Marketing (SLIM) and Institute of Bankers of Sri Lanka which provide higher education opportunities in the country.

6.4 Review of University system

The university system in Sri Lanka consisted of 15 universities by the end of the 2007. The first university in Sri Lanka was established in Colombo in 1942 followed by a second campus at Peradeniya in 1949. Two prestigious ancient Pirivanas were given university status in 1958 and re-named Vidyodaya University and Vidyalankara University changing the established concept of a single university in the country. This led to the rapid expansion of science education and eventually 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 Katubedda into five campuses of a single University of Sri Lanka reviving the old model. 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 Postgraduate Institutes and six other institutes including the Postgraduate Institutes of Agriculture (PGIA) and Postgraduate Institutes of Medicine (PGIM) 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 establishment of the University Grants Commission (UGC) in 1978 which functions as the apex body of the University system in Sri Lanka The functions of the UGC are planning and coordination of university education, allocation of funds for higher educational institutions (HEIs), maintenance of academic standards, regulation of the administration of HEIs and regulation of admission of students to HEIs.

The University System in Sri Lanka by 2004 comprises the following institutions:

a. National Universities

At the end of 2004 there were 13 National Universities- viz University of Colombo (1942) Peradeniya (1949), Kelaniya and Jayawardenapura (1959), Moratuwa (1972), Jaffna (1974), Ruhuna (1978), Open

University (1980), Eastern University (1981), South Eastern University (1995), Rajarata University (1995), Sabaragamuwa University (1995), and Wayamba University (1999).

b. Postgraduate Institutes

There were Six Postgraduates Institutes attached to universities at the end of 2004. They are: Postgraduate Institute of Medicine (1974), Postgraduate Institute of Agriculture (1975), Postgraduate Institute of Pali & Buddhist Studies (1975), Postgraduate Institute of Archaeology (1986), Postgraduate Institute of Management (1986) and Postgraduate Institute of Science (1996).

c. Other Institutes affiliated to Universities

There were six institutions attached to universities that offered degrees at the end of 2004. They were: Institute of Aesthetic Studies (1974), Institute of Workers' Education (1975), Institute of Indigenous Medicine(1977), University of Colombo School of Computing (1987), Gampaha Wickramarachchi Ayurveda Institute (1995), National Institute of Library and Information Sciences (1999), Institute of Technology in the University of Moratuwa (2000), Institutes of Biochemistry, Molecular Biology and Biotechnology (2003)

The expenditure on university education has increased from Rs.5.1 million in 2000 to Rs. 6,479 million in 2003, but when considered as a per cent of GNP the contribution to university education has decreased from 0.46 per cent in 2000 to 0.42 per cent in 2003 (Table 6.1).

During the year 2004 a total of 93,286 and 108,357 candidates were eligible to apply for university education for academic year 2003/2004 and 2004/2005. Of these 12,647 and 13,653 were offered admission to Higher Education Institutes under normal provisions for the two academic years respectively.

During the academic year 2003/2004 new courses were introduced to the university education system. They are: Peace and Conflict (University of Kelaniya), Ayurveda and Unani (Institute of Indigenous Medicine), Textile and Clothing Design (University of Moratuwa), Food science and Technology (Universites of Peradeniya and Sri Jayawardenapura), Siddha Medicine (University of Jaffna), Nursing (University of Sri Jayawardenapura) and Information and Communication Technology (University of Colombo, School of Computing) (UGC Annual Report 2004).

d. Establishment of New Universities and Institutes during the year 2004

1. Uva Wellassa University of Sri Lanka. UGC established this University in Uva Province to provide Higher Education in the areas Science and Technology, Management Sciences, Animal Sciences and Export Agriculture. It will initially have Faculties of Science and Technology and a Faculty of Management.

2. University of Visual and Performing Arts: UGC has taken steps to elevate the Institute of Aesthetic Studies which has already been functioning as a fully fledged degree awarding institute for the last thirty years, to the status of an Independent University. The university will consists of three faculties as Faculty of Arts and Sculpture, Faculty of Dance and Drama and Faculty of Music.

3. National Centre for Advanced Studies in Humanities and Social Sciences (NCAS) In order to organize the establishment of the proposed NCAS, a coordinating office was set up in the UGC in May 2004.
4. Institute of English. Action was taken to establish this Institute affiliated to the Open University of Sri Lanka.
5. Swamy Vipulananda Institute of Aesthetic Studies. Action was taken to establish this institute affiliated to the Eastern University, Sri Lanka for purpose of providing, promoting and developing higher education in aesthetic studies.

New Faculties established during the year 2004

1. Faculty of Healthcare Sciences – Eastern University
2. Faculty of Geomatics – University of Sabaragamuwa

New Departments established during the year 2004

1. Department of Family Medicine at Faculty of Medical Sciences, University of Sri Jayawardenapura
2. Department of Kulliyath (Fundamentals in Unani) in the Institute of Indigenous Medicine of the University of Colombo
3. Department of Botany of Faculty of University of Colombo was renamed as the Department of Plant Sciences
4. Departments of OUSL renamed as follows:
   a. Department of Education to Department of Secondary and Tertiary Education
   b. Department of Early Childhood Education to Department of Early Childhood Education and Primary Education
   c. Department of Special Education to Department of Special Needs Education

6.5 Statistics of Higher Education –Funds, Student Enrolment and Staff (2004)

The university system and the higher education sector in the country is expanding continuously to accommodate the ever increasing number of students satisfying the basic qualifications for university entrants (Table 6.4). It is evident from the statistics issued by the UGC over the last four years which are presented in Table 6.4 that only about 13 per cent of those students who qualify for university entry are admitted to the universities every year.

Table 6.4

STATISTICS OF UNIVERSITY ENTRANTS

Academic Year	No of students satisfying minimum entry requirements	No. Selected	Percentage selected
2003/2004	93,442	13,396	14.34
2002/2003 (a)	92,296	13,040	14.13
2002/2003 (b)	98,426	12,431	12.63
2001/2002	91,676	12,144	13.25

Source: University Statistics 2004, UGC, Sri Lanka

Note: In the year 2003, there were two undergraduate intakes 2002/03(a) to the universities. Intake 2002/03 refers to those who qualified at the GCE (A/L) examination held in August 2001 and intake 2002/03 (b) refers to GCE (A/L) examination held in April 2000.

In addition to free primary and secondary education, financial assistance in the form of scholarships are provided by the government to the majority of students who enter the universities and other higher education institutes. These scholarships are provided on the basis of merit at the A/L results and/or on the need based on low household income. As indicated in Table 6.5, the number of students awarded Mahapola Scholarships has increased by 2,442 numbers from 2003 to 2004. Similarly, the government Bursaries also has increased by 60 from 2003 to 2004. Out of the total number of under-graduate students studying in the national university system in year 2004 (n=72,860) 64 per cent had received Scholarships.

Table 6.5

STATISTICS OF FINANCIAL ASSISTANCE TO UNIVERSITY STUDENTS

Type of Assistance	No. of students		
	2003	2004	Increase
Mahapola Scholarship	31,558	34,000	+2442
Government Bursaries	12,540	12,600	+60
Total	**44,098**	**46,600**	**+2502**

Source: University Year Book 2003/2004, UGC, Sri Lanka

The apportionment of recurrent funds among the universities and institutions under the purview of the UGC is given in Table 6.6. It is seen that over 83 per cent of funds were allocated to the universities while 6 per cent was given to higher education institutes that function under the UGC. Of the total expenditure, 9 per cent goes as financial assistance for undergraduates in the form of scholarships.

The distribution of students and staff is also shown in Table 6.6. The average ratio of staff to full-time under-graduate students in the universities is 18 and ratio of non- teaching staff to teaching staff is 2.5.

The total enrolment in 2004 comprised 68,258 undergraduate university students, 4,451 graduates in other higher education institutes and 5,786 postgraduate students. Other than resident graduates attached to universities there are 131,877 students registered in some universities for external degree programes.

6.6 University Undergraduate Admissions for year 2004

The total university admissions in 2003/2004 and 2004/2005 comprised 33 per cent arts and law students, 21 per cent commerce and management students, 19 per cent science students, 11 per cent under-graduates in medicine and allied subjects, 11 per cent engineering, architecture, computer and IT under-graduates and 6 per cent agriculture under-graduates (Table 6.7). The highest per cent of under-graduate enrolment was by the Universities of Peradeniya (14.9 per cent) followed by Colombo (14.5 per cent), Sri Jayawardenapura (14.3 per cent) and Kelaniya (13.6 per cent) (Table 6.7).

Table 6.6

STATISTICS ON HIGHER EDUCATION-FUNDS, STUDENTS ENROLMENT AND STAFF 2004

Institution	Recurrent funds (Rs Million)	Total Enrolment Undergraduate	Total Enrolment Post graduate	Academic staff	Academic support Staff	Admin. Support staff
a) Universities	3,842.7	68,258	5,786	3,525	1,004	7,703
Colombo	440.3	8,784	1,213	431	45	843
Peradeniya	862.8	9,903	258	730	174	2,089
Sri ayawardanapura	384.1	9,376	308	360	110	660
Kelaniya	394.9	8,110	597	410	72	637
Moratuwa	277.4	4,181	183	226	17	522
Jaffna	258	4,640	146	281	101	528
Ruhuna	428.8	6,746	129	392	140	814
Eastern	151.2	1,950	46	166	29	312
South Eastern	103.05	1,154	22	91	26	157
Rajarata	108.2	1,802	98	81	34	158
Sabaragamuwa	130	2,395	48	103	31	251
Wayamba	92.85	1,309	_	75	24	176
Open University	210.3	7,908	2,738	179	145	556
b) Institutes	277.96	4,451	2,838	241	225	224
Post graduate	40.84		2,639	41	161	89
Other	237.12	4,451	199	200	64	135
c)University Grants commission	52.6					
d) Financial Assistance Bursaries & Scholarships8	430					
Total Recurrent funds	**4,602.46**					

Source: University Statistics 2004&2005, UGC

Table 6.7

UNIVERSITY UNDERGRADUATE ADMISSIONS

University	Discipline							
	Arts/Law	Commerce / Management	Science	Med/ Allied	Agriculture	Engineering Architec & IT	Total	%
UOC	825	391	407	197		122	1,942	14.5
UOP	699		398	374	209	320	2,000	14.9
UOSJ	591	815	312	192			1,910	14.3
UOK	785	425	397	160		51	1,818	13.6
UOM						843	843	6.3
UOJ	407	257	186	84	58		992	7.4
UOR	462	305	389	133	176	96	1,561	11.7
EUSL	157	53	51		33		294	2.2
SEUSL	106	74	54				234	1.7
RUSL	146	253	105		103		607	4.5
SUSL	195	166	191		83		635	4.7
WUSL		64	112	70	85		331	2.5
IIM				151			151	1.1
GWAI				78			78	0.6
Total	**4,373**	**2,803**	**2,602**	**1,439**	**747**	**1,432**	**13,396**	**100.0**
%	33	21	19	11	6	11	100	

Source: University Statistics 2005 (UGC)

6.7 Output of University Graduates by Discipline and Sex

The output of graduates in the year 2004 by discipline and sex is presented in Table 6.8. The of graduate output in the arts and commerce streams is 57 per cent while graduate output in the S&T stream (science, agriculture, engineering and medicine and allied) is 43 per cent (Table 6.8).

Table 6.8

OUTPUT OF GRADUATE (INTERNAL) BY DISCIPLINE AND SEX

University	Discipline							
	Arts/Law	Commerce / Mt	Science	Med/ Allied	Agri.	Eng. Arch/IT	Total	%
UOC	582	260	265	192			1,299	13
UOP	506		531	468	175	275	1,955	20
UOSJ	848	753	324	249			2,174	22
UOK	736	311	169	241			1,457	15
UOM						435	435	4
UOJ	316	166	145	158	16		801	8
UOR	161	312	196	100	123		892	9
EUSL	144	86			14		244	2
SEUSL	13	4	13				30	0
RUSL	80	58	31				169	2
SUSL	175	171	40		30		416	4
WUSL	0		12		36		48	0
Total	**3,561**	**2,121**	**1,726**	**1,408**	**394**	**710**	**9,920**	**100%**
%	36	21	17	14	4	7	100	

Source: University Statistics 2005, UGC, Sri Lanka

6.8 Distribution of Academic Staff among Universities and Faculties

The distribution of academic staff among universities and faculties presented in Table 6.9 indicating that the highest percentage is in the arts stream (26 per cent) followed by science (24 per cent) and engineering and architecture (17 per cent).

The distribution of academic staff by category and university is given in Table 6.10. It is seen that 36 per cent of the academic staff comprised lecturers on probation and another 21 per cent was in temporary positions such as demonstrators, instructors and assistant lecturers. Academics staff at senior level constituted only 42 per cent of the total academic staff (Figure 6.1). This lack of senior academics in the university system again may be attributed to the extensive brain drain faced by the country. And the lack of senior academics for teaching in the university system eventually lead to the production of poor quality graduates. This is recognized as one of the reason for low demand for the graduates in the labour market (Tracer Study of graduates, 2004).

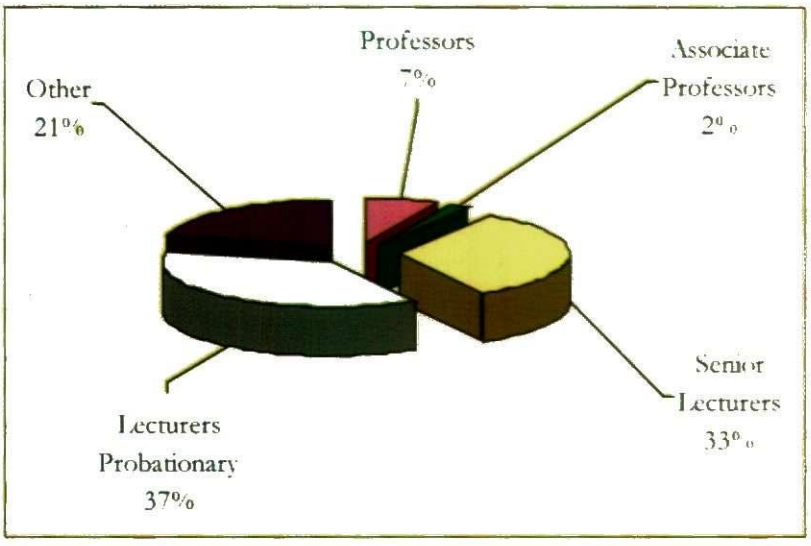

Figure 6.1

DISTRIBUTION OF UNIVERSITY ACADEMIC STAFF BY QUALIFICATION 2004

Table 6.9

DISTRIBUTION OF ACADEMIC STAFF BY FACULTY AND UNIVERSITY

University	Faculty											
	Sc.	Agri.	Eng	Arch	Med	Dent	Vet	Arts	Law	Edu	Com Management	Total
UOC	89				121			160	28	30	48	476
UOP	162	136	159		99	67	40	241				904
UOSJ	77				152			97			144	470
UOK	137				121			168			56	482
UOM			143	50								243
UOJ	81	41			58			157			45	382
UOR	174	81	51		100			100			26	532
EUSL	64	38						54			39	195
SEUSL	44							49			24	117
RUSL	39	26						28			22	115
SUSL	38	26		22				30			18	134
WUSL	30	29					29				11	99
OUSL	144		95					64		21		324
Total	**1,079**	**377**	**498**	**72**	**651**	**67**	**69**	**1,148**	**28**	**51**	**433**	**4,473**
%	24	8	11	2	15	1	2	26	1	1	10	100

Source: University Statistics 2005, UGC, Sri Lanka

Table 6.10

DISTRIBUTION OF ACADEMIC STAFF BY CATEGORY AND UNIVERSITY

University	Category						
	Professor	Assoc. Professor	Senior Lecturer	Prob. Lecturer	Other	Total	%
UOC	49	28	206	148	45	476	11%
UOP	104	22	319	285	174	904	20%
UOSJ	37	12	177	134	110	470	11%
UOK	29	19	193	169	72	482	11%
UOM	23	5	124	74	17	243	5%
UOJ	14	10	110	147	101	382	9%
UOR	25	5	137	225	140	532	12%
EUSL	1	2	42	121	29	195	4%
SEUSL	0	1	12	78	26	117	3%
RUSL	6	0	19	56	34	115	3%
SUSL	5	0	21	77	31	134	3%
RUSL	6	1	17	51	24	99	2%
OUSL	10	1	101	67	145	324	7%
Total	**309**	**106**	**1,478**	**1,632**	**948**	**4,473**	**100%**
%	7%	2%	33%	36%	21%	100%	

Source: University Statistics 2005, UGC, Sri Lanka

The highest percentage of academic staff is present in the University of Peradeniya (20 per cent) followed by University of Ruhuna (12 per cent), University of Colombo (11 per cent), University of Sri Jayawardenapura (11 per cent) and University of Kelaniya (11 per cent) respectively. This shares a marked disparity when compared to the fledgeling universities such as University of South Eastern (3 per cent) Universities of Sabaragamuwa (3 per cent) and Rajarata (2 per cent) which have an exceedingly low number of academic personnel (Figure 6.2).

Sri Lanka has a rich historical tradition of technological competency and unrivalled excellence in the field 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 colonial rule which fostered an export-import economy based on plantation agriculture and devalued traditional technical skills.

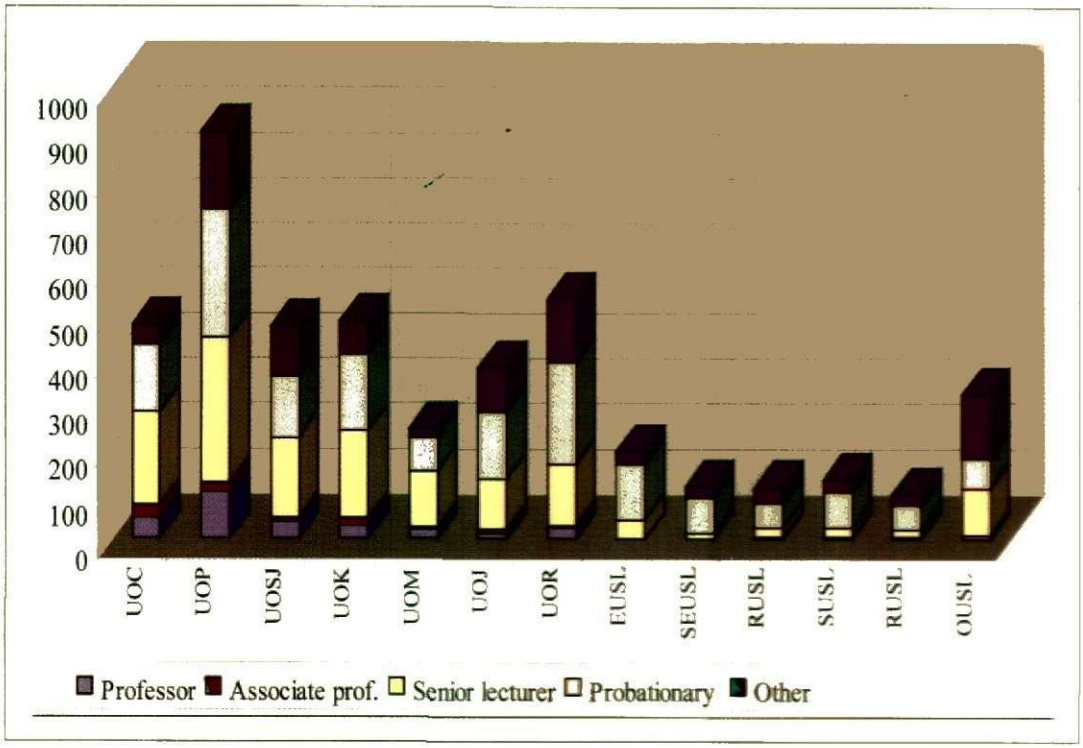

Figure 6.2

DISTRIBUTION OF ACADEMIC STAFF BY CATEGORY AND UNIVERSITY

6.9 Technical and Vocational Education

The Ceylon Technical College established in 1894 was later upgraded and absorbed into the university system. Today there is a large number of public and private institutes that are involved in technical and vocational education and training. The Tertiary and Vocational Education Commission (TVET) as the central planning, development and coordinating body for this sector, and the Ministry of Vocational and Technical Training implement competency-based training (CBT) through a number of public and private institutions. These public institutions include the Department of Technical Education and Training (DTET), Vocational Training Authority of Sri Lanka (VTA), and National Apprenticeship and Industrial Training Authority (NAITA). There are 365 CBT courses identified to be provided through these institutions (Central Bank Annual Report, 2005).

Table 6.11

STATISTICS ON TECHNICAL TRAINING

Item	2001	2002	2003	2004
Total No. of Technical Colleges	**36**	**37**	**36**	**36**
Grade 1 Technical colleges	36	37	36	36
Number of Staff	**1,675**	**1,675**	**1,817**	**1,692**
Teaching Staff	574	538	542	515
Others	1,101	1,137	1,275	1,177
New Admissions	**11,377**	**13,197**	**12,918**	**11,866**
Total enrolment by level of courses	16,263	17,850	18,074	17,200
National Diploma (ND)	170	157	186	108
National Certificate	11,182	12,040	12,570	7,750
National Craft (Trade)	3,980	4,418	4,476	3,025
Others	931	1,235	842	983
Total Expenditure on technical education (Rs. million)	**413**	**443.8**	**410.1**	**515**
Recurrent Expenditure (Rs. million)	309.4	318.9	329.7	394.4
Capital Expenditure (Rs. million)	103.6	124.9	80.4	120.6

Source: Statistical Abstract 2005, Department of Census and Statistics, Sri Lanka

Note: All ND courses (except Diploma in Jewellery Design) were taken over by SLIATE (Sri Lanka Institute of Advanced Technical Education)

The specific objectives of these institutes are to provide vocational and technical education and skills development programmes for school leaving youth in order to find them suitable employment opportunities: to provide vocational training and technical education from the craft level leading to Certificate, Diploma and Degree, to establish an efficient and effective management system in the Ministry and Institutions coming under its purview; to review and re-structure current skills development and vocational and technical education programs to minimize duplication, overlaps, gaps and waste, to enable optimum utilization of resources; to promote and facilitate the private sector and NGOs for identification and provision of demand driven programmes; to expand skills development training opportunities to the rural areas to ensure greater access to quality training for youth and to rationalize the existing institutional infrastructure and resources to ensure optimum utilization in TVET.

Table 6.11 gives the statistics on technical training in 2001-2004 in the country. The national expenditure on Technical education has increased from Rs. million 80 in 2003 to Rs. million 120 in 2004.

6.10 Computer Education in Sri Lanka

The Government of Sri Lanka has developed the following vision to leverage ICT for development of the Government sector: "To adopt ICT in its all aspects to make the Government more efficient and effective, improve access to Government service and create a more citizen centric Government "

The government first recognized the need for the development of ICT through the National Computer Policy of 1983 (COMPOL). This first attempt was taken by the National Resource Energy and Science Authority of Sri Lanka (NARESA predecessor of NSF) on the instructions of the then President of the government of Sri Lanka. A committee appointed by NARESA produced the National Computer Policy Report.

The acceptance of the COMPOL report by the Government gave rise to the establishment of CINTEC by Act No. 10 of 1984 as the "Computer and Information Technology Council of Sri Lanka" (later termed the Council for Information Technology) to function directly under the then President.

In November, 2002, the GOSL launched the e-Sri Lanka initiative with the objective of using ICT in all its aspects for the benefit of the people of Sri Lanka and to further the socio-economic development of the nation. The Information and Communication Technology Agency (ICT) of Sri Lanka has been vested with authority under the Information and Communication Technology Act, No. 27 of 2003.

TABLE 6.12

SOME KEY STATISTICS ON COMPUTER LITERACY, USE OF HOME COMPUTERS, E-MAIL AND INTERNET SERVICES IN SRI LANKA 2004.

No	Indicator	%
1	Computer literacy (Percentage of Household population in the age group of 5-69 who can use computers	9.7
2	Households having computers(national)	3.8
3	Households having computers (Urban sector)	10.5
4	Households having computers (Rural sector)	3.1
5	Households having computers (Estate sector)	0.3
6	Households having e-mail facility	0.9
7	Households having internet facility	0.7
8	Households having computers which had been bought within the 24 month prior to the survey	44.2
9	Households having computers and using them for less than 10 hours per day	53.3
10	Households having computers and experiencing faults during the three months prior to the survey	26.6
11	Households without computers and strongly feeling the need to have one	36.1
12	Household population in the age group of 5-69 years, who are aware about computers and their applications	18.2
13	Household population in the age group of 5-69 years who can use e-mail on their own	2.8
14	Household population in the age group of 5-69 years who can use internet on their own	2.6

Source: Department of Census and Statistics Sri Lanka

Sri Lanka initiated computer education programs at the school and university level in 1983. The Institute of Computer Technology was established at the University of Colombo in 1987. However, integration of IT or Computer Education at school level with the formal curriculum has not been achieved as yet but steps have been taken to train students on basic knowledge of IT and computer handling. With the objective of popularizing computer education in schools, the government has put up 1200 computer laboratories in schools distributed in 8 provincial councils. These units will function for the use of the school community during school hours, after hours and on week-ends also will provide training to school leavers. Other than the above, to promote computer usage among students, all school principals in such schools have been provided with one additional computer with the neccessary management software and teachers were provided one common computer for their use while the school career guidance unit also was given computer facilities for their work. The government is constantly providing software and CDs for schools on subject matters as well as other learning materials.

The university system in Sri Lanka has included IT education and Computer Technology and offers degrees in various related categories. Other than the public education system there are a large number of local and international institutions providing IT education in the country from diploma level to postgraduate level and a large number of students of various age categories are enrolled in these institutions.

A sample survey done by the Department of Census and Statistics in 2004 indicated that computer literacy of the population in the 5-69 age group was 9.7 per cent. The households with computers amounted to only 3.8 per cent of the total households in the country. The households having e-mail facilities was 0.9 per cent and the households having internet facilities was 0.7 per cent (Table 6.12). 18 per cent of the population is aware of computer usage though they do not possess computers in their homes.

Chapter 7

ROLE OF S&T IN ECONOMIC DEVELOPMENT

7.1 Economic Indicators

The Science and Technology sector plays a pivotal role in achieving the ultimate goal of economic and social development in the context of a globalized economy. Even though the primary output of Research and Development is knowledge which is intangible, it has a direct impact on the production and value addition to goods and services by innovations which enhance productivity, quality, efficiency and competitiveness in the global market. If R & D is treated as a mere luxury and not valued as an intangible asset and investment, it would lead to under estimation of national production capability and inadequate funding resulting in economic stagnation.

While the input indicators analyzed in the chapters 3 and 4 measure the quantity and the output indicators discussed in chapter 5 measure the performance and quality, some relevant proxy impact indicators discussed in this chapter will measure outcomes of S&T in the form of improved economic performance, more equitable distribution of income and better quality of life for the people.

7.2 Historical Perspective

When Sri Lanka gained political independence as a sovereign nation in 1948, it inherited a classic export economy which was predominantly agriculture based. It had a dual structure with a modernized export oriented commercial plantation sector comprising tea, rubber and coconut and a traditional peasant agriculture sector mainly paddy, small-scale fishing, cottage industries and informal services. The modernized sector which enjoyed favourable market conditions at the time generated foreign exchange and provided funds for an incipient welfare state while the traditional sector remained at subsistence level and there was minimal interaction between the two sectors.

With the gradual deterioration of the terms of trade there was a shift in the 1960s from the export economy to an import substitution economy, with import controls, price regulation, etc. In 1977 fundamental policy reforms facilitated Sri Lanka's entry into the global market as an exporter of labour-intensive low-technology industries, mainly garments. Consequently there was an increase in Foreign Direct Investment (FDI) and a rejuvenation of the private sector.

However, the economic dynamism was not matched by any significant decline in the incidence of poverty, while the economic liberalization led to a substantial concentration of wealth in the hands of a few and exacerbated inequalities in income distribution with devastating social impact.

The percentage share of Household Income by Income decile is shown in Table 7.1. It is evident that the richest 20 per cent of households received 52.8 per cent of household income while the poorest 20 per cent received only 4.8 per cent of household income. According to the Household Income Survey 2002 the median monthly income in 2002 was Rs. 8,482/- which means that 50 per cent of households received an income of les than Rs. 8,482/- The proportion of population whose income is less than the poverty line is estimated at 20 per cent.

Table 7.1

MEAN INCOME AND SHARE OF INCOME BY HOUSEHOLD INCOME DECILE SRI LANKA -2002

House hold income decile per month (Rs.)		Mean income the group	% shared by
All deciles		13,038	100
1	Less than 3301	2,237	1.7
2	3301-4660	4,026	3.1
3	4661-5823	5,242	4.0
4	5824-7000	6,447	5.0
5	7001-8387	7,643	5.8
6	8388-10000	9,219	7.1
7	10001-12688	11,242	8.6
8	12689-16390	14,265	10.9
9	16391-24225	19,670	15.1
10	More than 24225	50,490	38.6

Source: House Hold Income and Expenditure Survey 2002 , Department of Census and Statistics, Sri Lanka

7.3 Structure of Economy

With the economic transformation, there were structural changes in the economy to meet the emerging needs. The share of the agriculture sector in terms of both output and employment declined, while the contribution of the industry and services sectors increased gradually as indicated in Table 7.2.

Table 7.2

STRUCTURE OF ECONOMY IN SRI LANKA

Period	Agriculture (%)	Industry (%)	Services (%)
1951-1960	42	17	40
1961-1970	35	18	47
1971-1980	29	27	44
1981-1990	27	27	46
1991-2000	23	27	50
2001-2003	20	26	54

Source: Annual Report 2003, Central Bank, Sri Lanka

At independence and in the early stages of development, Sri Lanka was heavily dependant on the agriculture sector mainly of three export commodities, tea, rubber, and coconut. The Agriculture sector contributed to nearly half of the GDP and employed more than 40 per cent of the labour force in the country within the period 1951-1960s (Table 7.2). The share of Industry sector was less than 20 per cent and it was

mainly involved in processing of the major agriculture crops and a few medium sized industries producing domestic requirements such as cement, soap, textiles and traditional handicrafts, construction materials etc.. The Services sector contributed to around 40 per cent of GDP.

7.4 Sectoral composition of GDP

The sectoral composition of GDP in 2004 is presented in Table 7.3. The contribution of the Agricultural sector to GDP has shown a decline from 18.4 per cent in 1996 to 17.9 per cent in 2004. The agriculture sector faced a setback due to adverse weather conditions with a drop in

Table 7.3

COMPOSITION OF GROSS DOMESTIC PRODUCT

(Rs. million)

Sector	Current Price			Constant(1996)					
	2002	2003	2004	2002	%	2003	%	2004	%
Agriculture, Forestry and Fishing	287,840	297,342	320,201	173,623	20	176,450	19	175,852	18
Mining and Quarrying	25,821	27,489	35,965	14,858	2	15,699	2	16,946	2
Manufacturing	221,970	243,596	275,630	145,864	17	151,951	16	159,721	16
Electricity and Water	20,314	28,405	27,668	12,044	1	14,651	2	14,287	1
Construction	100,590	113,284	142,430	60,796	7	64,115	7	68,332	7
Industry Sector	368,695	412,774	481,693	233,562	27	246,417	26	259,286	26
Wholesale and Retail trade and Hotels and restaurants	295,485	323,285	380,975	191,505	22	206,507	22	219,041	22
Transport, storage and Communication	175,711	216,059	257,893	113,525	13	125,538	13	142,727	15
Financial Services, Real estate and Business services	158,054	192,688	217,609	99,820	11	108,590	12	114,661	12
Public Administration, defense and other services	117,500	120,588	139,570	65,213	7	66,556	7	69,153	7
Services Sector	746,751	852,621	996,047	470,063	53	507,191	55	545,582	56
Gross Domestic Product	1,403,286	1,562,737	1,797,941	877,248	100	930,057	100	980,720	100

Sources: Annual Report 2005, Central Bank, Sri Lanka

paddy and coconut production during the year caused by the prolonged drought. The industry sector registered 5.2 per cent growth rate in 2004 with all sub-sectors, except electricity and water contributing

to its high performance. However, the contribution of the industrial sector to GDP has also declined from 31.9 per cent in 1996 to 26.5 per cent in 2004.

The Services sector is the fastest growing sector of the global economy and accounts for two thirds of global output, one third of global employment and nearly 20 per cent of global trade. In keeping with global trends, in Sri Lanka too the Services sector has recorded a substantial increase from 49.8 per cent in 1996 to 56 per cent in 2004. With economic development and diversification, there was a need for a fast growing more dynamic Services sector that could provide modern efficient and convenient links between production and consumption. Telecommunications, import trade, and financial services contributed most to overall growth in the services sector, while tourist related services, cargo handling and export trade also performed satisfactorily according to analysts of the Central Bank of Sri Lanka. The growth of sub-sector of telecommunication was driven by the upward trend in mobile phone usage, which increased over 50 per cent over the first half of 2003.

Table 7. 4

TRENDS IN ECONOMIC ACTIVITY IN SOUTH ASIA, 1980-2002

Sectoral composition of production (% GDP)							Sectoral share of labour force (% of total)					
	Agriculture		Industry		Services		Agriculture		Industry		Services	
	1980	1995-2002	1980	1995-2002	1980	1995-2002	1985-1986	2002	1985-1986	2002	1985-1986	2002
Bangladesh	49.4	17.6	14.8	27.9	35.8	54.6	56.5	62.0	11.5	10.0	33.7	24.0
Bhutan	56.7	30.3	12.2	39.2	31.1	33.6	-	94.0	-	1.0	-	5
India	38.1	23.4	25.9	23.8	36.0	54.9	65.0	67.0	10.0	13.0	26.6	20.0
Iran	18.0	12.0[2]	32.0	39.0[2]	50.0	49.0[2]	36.4	23.0[3]	32.8	32.0	30.8	45.0
Maldives	31.0	7.2	6.0	20.8	63.0	72.0	-	22.0[4]	-	18.0	-	60
Mongolia	15.0	33.0[1]	33.0	28.0[1]	52.0	-	39.8	32.0[1]	21.0	23.0[1]	39.2	45.0[1]
Myanmar	47.0	59.0[1]	13.0	10.0[1]	40.0	-	-	63.0	-	21.0	-	16
Nepal	61.8	39.2	11.9	20.8	26.3	43.9	93.0	81.0[5]	0.6	3.0[5]	6.4	6.0[5]
Pakistan	30.6	22.3	25.6	21.2	43.8	56.4	49.6	48.0	12.4	18.0	38.0	34.0
Sri Lanka	26.6	21.4	27.2	24.7	46.2	54.0	49.8	42.0	18.8	23.0	32.2	35.0
South Asia	37.8	24.6[1]	25.0	30.2[1]	37.2	55.2[1]	62.8	64.6[1]	10.6	14.8[1]	27.2	18.6[1]

Sources: UNESCO (1998) World Science Report,2005

Notes: 1. Data for 1997.
2. Data for 2002 from Encarta.msn.com/encyclopedia-761567300_3/Iran.html
3. Data for 1996.
4. www.mapquest/com/atlas/main.adp?/region=maldives
5. Data for 1999, source as 4 above.

The changes in the sectoral composition of GDP over the years in Sri Lanka, is comparable to that of other countries in the region. India, with a more diversified resource base and a large domestic market also recorded the same trend in declining share of Agriculture and increasing share of GDP in

Services and Industrial Sectors. In the seven–nation South Asian Association of the Regional Cooperation (SAARC), the share of Agriculture in GDP declined between 1980 and 2002, and there was a corresponding increase in the share of Industry and Services (Table 7.4). The industry and service sectors of the SAARC region witnessed steady growth from 1981 to 1999 whereas agriculture sector grew at an average rate of 2.3 per cent over the period (Table 7.4). Even though, the share of the services sector in GDP increased considerably during 1986-2002, its share of the labour force registered a decline in the SAARC region. However, in Sri Lanka, the share of the labour force in Industry and Services sectors has shown an increase within the period of 1985-2002 while the share of the labor force in the agriculture sector showed a decline (Table 7.4).

7.5 Industrial Production by Sub-sector

The production structure of the manufacturing sector has changed substantially as shown in Table 7.5 below.

Factory industry, which is the largest sub-sector in the manufacturing sector expanded by 6.1 per cent in 2004. It is evident from Table 7.6 that the major contribution to the growth in factory industry in 2004 (viz:86 per cent) came from three main industrial categories; Textiles, wearing apparel and leather products (47 per cent); Food, beverages and tobacco products (23 per cent); Petroleum, chemicals, rubber and plastic products (16 per cent).

Table 7.5

STRUCTURE OF MANUFACTURING SECTOR

Structure	Period				
	1976-1980	1981-1985	1986-1990	1991-1995	2004
Manufacturing	100.0	100.0	100.0	100.0	100.0
Export Processing (mainly tea,rubber,coconut)	41.4	35.9	28.4	20.5	15.0
Factory Industries	47.6	54.4	63.6	72.5	77.8
Cottage Industries	11.0	9.7	8.0	7.0	7.2

Source: Statistical Abstract 2005, Department of Census & Statistics, Sri Lanka

Export market oriented industries as well as domestic market oriented Industries contributed to the growth of the manufacturing sector. Of the export market oriented industries, the textile, wearing apparel and leather products category grew by 4.3 per cent (Table 7.6). In addition to the textile sector, other export oriented industries such as rubber products, ceramics and processed diamonds also performed well during the period. The domestic market oriented industries such as food and beverage, plastic and PVC products, pharmaceuticals and detergents, and cement and other building construction materials also performed well in response to domestic demand.

Table 7.6

INDUSTRIAL PRODUCTION BY SUB SECTORS

Sub sector	Value of Industrial Production (Rs. million)				Value Added in Industry (Rs. million)				Capacity utilization
	2000	%	2004	%	2000	%	2004	%	2004
Food Beverages and Tobacco products	105,671	23	172,424	25	49,031	29	72,636	31	91
Textile, Wearing apparel and leather products	215,686	47	295,379	42	69,451	41	91,308	39	88
Wood and wood products	3,084	1	4,277	1	1,554	1	2,007	1	74
Paper and paper products	6,516	1	9,869	1	2,808	2	3,374	1	86
Chemical, petroleum, rubber and plastic products	74,670	16	123,491	18	17,771	11	26,179	11	76
Non metallic Mineral products	28,198	6	47,231	7	14,240	9	19,881	8	87
Basic metal products	3,378	1	5,366	1	959	1	1,593	1	59
Fabricated metal products etc.machinery and transport equipment	15,678	3	24,964	4	7,714	5	11,679	5	89
Manufactured products	9,839	2	14,088	2	3,965	2	5,425	2	89
Total	**462,720**	**100**	**697,089**	**100**	**167,493**	**100**	**23,082**	**100**	

Sources: Annual Report 2004, Central Bank, Sri Lanka

The manufacturing sector is projected to grow by 4.8 per cent and the factory industry sub-sector, which covers large and medium scale industries, is projected to grow by 5.2 per cent. However, the rising inflation and escalation in prices of oil and utilities such as gas will be a deterrent to the expected performance, as the increase in the cost of inputs will reduce the value added as well as the export competitiveness of factory industries (Central Bank Recent Economic Developments Highlights of 2004 and Prospects for 2005).

7.6 Exports and Imports

There was an expansion in external trade in 2004 with increases in both exports and imports. Total export earnings increased by 12 per cent to US$ 5,707 million in 2004 from US$ 5,133 million in 2003.

Agriculture exports grew by 10 per cent in 2004 reflecting the higher performance of the three major crops; tea, rubber and coconut, and accounted for 19 per cent of total exports Minor agriculture exports increased by 8 per cent in 2004, mainly supported by higher export of cloves, vegetables, cinnamon and unprocessed tobacco. (Table 7.7).

However, Industrial Exports which accounted for 78 per cent of total exports continued to be the main contributor to export earnings reflecting the impact of the economic expansion. The growth of 13 per cent shown by industrial exports was due mainly to a healthy performance by Textile and garment exports in the face of strong challenges arising from the phasing out of the Multi Fibre Agreement. Textile and garment exports increased by 9 per cent in 2004 and accounted for 62 per cent of industrial exports and 49 per cent of total exports. Earnings from mineral exports increased by 43 per cent mainly due to a preponderance of gem and jewellery exports, which accounted for 90 per cent of mineral exports.

Table 7.7

COMPOSITION OF EXPORTS, 1999-2003

(Rs. million)

Category	2003		2004(a)		Change in Value a:	Growth rate (a)	Contribution to growth a:
	Value	Share	Value	Share			
Agricultural exports	**965**	**19**	**1,065**	**19**	**100**	**10.4**	**16.0**
Tea	683	13	739	13	56	8.2	8.9
Rubber	39	1	51	1	12	30.8	1.9
Coconut	93	2	113	2	20	21.5	3.2
Kernel products	48	1	59	1	11	22.9	1.8
Other	45	1	54	1	9	20.0	1.4
Minor agricultural products	150	3	162	3	12	8.0	1.9
Industrial exports	**3,977**	**77**	**4,506**	**78**	**529**	**13.3**	**84.8**
Food, beverages and tobacco	145	3	175	3	30	20.7	4.8
Textiles and garments	2,575	50	2,809	49	234	9.1	37.5
Petroleum products	65	1	100	1	35	53.8	5.6
Rubber products	231	5	283	5	52	22.5	8.3
Ceramic products	42	1	47	1	5	11.9	0.8
Leather, travel goods and footwear	58	1	43	0	-15	-25.9	-2.4
Machinery and equipment	290	6	386	7	96	33.1	15.4
Diamond and jewellery (b)	233	5	265	5	33	13.7	5.1
Other Industrial exports	337	7	398	7	61	18.1	9.6
Mineral exports	**84**	**2**	**120**	**2**	**36**	**42.9**	**5.8**
Gems	79	2	109	2	30	38.0	4.8
Other mineral exports	5	0	11	0	6	120.0	1.0
Unclassified (c)	**108**	**2**	**66**	**1**	**-42**	**-38.9**	**-6.7**
Total exports (d)	**5,133**	**100**	**5,757**	**100**	**624**	**12.2**	**100.0**
Annual average exchange rate	**96.52**		**101.19**				

Sources: Annual Report 2004, Central Bank, Sri Lanka

Expenditure on imports increased by 21 per cent from US$ 3,078 million in the first half of 2004. The expenditure on imports consisted of intermediate goods (57 per cent), investment goods (22 per cent) and consumer goods (20 per cent) in the first half of 2004. Intermediate goods and investment goods imports accounted for 53 per cent and 41 per cent respectively to overall growth of imports in the first half of 2004. The imports of food and beverages increased by 5 per cent in 2004 as compared with the 0.2 per cent growth registered in 2003 (Table 7.8)

Table 7.8

COMPOSITION OF IMPORTS

(Rs. million)

Item	1999	2000	2001	2002	2003	2004
Food and beverages	58,712	64,188	70,182	83,119	86,437	98,340
Mineral products	27,495	51,394	52,698	87,965	80,770	125,017
Chemical and resins	40,856	50,437	54,245	62,116	69,986	88,434
Leather, wood and paper	15,435	19,502	20,277	21,706	23,981	28,068
Textiles	99,858	121,659	132,662	136,742	142,974	165,815
Precious stones	13,947	20,432	21,312	25,597	30,636	38,278
Base metals	19,000	22,453	22,083	33,802	41,452	60,724
Machinery and equipment	58,459	72,958	66,304	74,283	83,228	108,572
Transport equipment	29,157	33,598	22,871	31,661	48,676	55,412
Other	15,589	20,868	21,028	21,310	21,743	27,739
Total	**378,508**	**477,489**	**483,662**	**578,301**	**629,883**	**796,399**

Source: Statistical Abstract 2005, Department of Census and Statistics, Sri Lanka

7.7 Foreign Investment

Foreign Direct Investment (FDI) has benefited many Asian countries in acquiring high technology from other countries in addition to finding a solution to the increasing unemployment and poverty in the country. The presence of FDI agencies inevitably brings in technology transfer and also enhancement of the skills of the labour force. The foreign direct investments has reached US$ 190 million during 2004 with the implementation of a large number of agreements signed with the Board of Investment in Sri Lanka (BOI) during 2003. The Board of Investment (BOI) is the facilitator in Sri Lanka in creating a platform for internationally competitive value addition.

Table 7.9

REALISED INVESTMENTS IN BOI PROJECTS IN 2003-2004

Categories	No. of Enterprises		Foreign Investment (Rs. million)		Total investment potential (Rs. million)	
	2003	2004	2003	2004	2003	2004
Food beverages and Tobacco products	148	155	9,773	12,493	15,774	21,184
Textile, wearing apparel and leather products	500	518	26,806	26,313	40,110	42,700
Wood and wood products	24	27	3,680	5,218	3,916	5,458
Paper and paper products	25	27	497	504	1,638	1,644
Chemical, petroleum, rubber and plastic products	138	140	15,058	14,660	29,640	21,259
Non metallic mineral products	66	65	5,217	9,703	12,486	17,669
Basic metal products	-	-	-	-	-	-
Fabricated metal products, machinery and transport equipment	75	88	6,390	7,189	8,088	9,454
Manufactured products	166	163	6,763	8,176	9,907	10,703
Services	624	684	112,598	124,440	165,921	189,394

Source: Annual report 2005, Central Bank, Sri Lanka

In 2004, there were 1,760 companies operating under the BOI regime, of which 49 per cent are locally owned Sri Lankan investment projects while 24 per cent are foreign owned. Jointly owned projects (Sri Lankan and Foreign) amounted to 27 per cent. The details of these projects are indicated in Table 7.9.

The textile and leather products sector has attracted the largest number of companies (518) and the highest foreign investment (Rs. 26,313 m), followed by the food and beverages sector with 155 companies and Rs. 12,493m foreign investment and the chemical products sector with 140 companies and foreign investment of Rs. 9,703m. It is seen from Table 7.7 that these three sectors are mainly responsible for employment generation and value addition.

The estimated foreign investment by the top ten investing countries in 2004 are Singapore (Rs. 21,634m), India (Rs. 13,880m), USA (Rs. 11,090m), UK (Rs. 7,735m), Korea (Rs. 2,072m), Malaysia (Rs. 1,964m), Italy (Rs. 1,442m), Netherlands (Rs. 703m), China (Rs. 631m) and Maldives (Rs. 530m).

7.8 Employment

The principal indicators of industrial activity classified by the type of industry according to the Annual Survey of Industries 2002 are shown in Table 7.10. The textile, wearing apparel and leather category (45 per cent) leads in employment creation followed by the food, beverages & tobacco sector (20 per cent) and the chemicals, petroleum, rubber and plastic sector (9 per cent). The major contributions to value addition come from the food & beverages sector (33 per cent) followed by the textile sector (29 per cent) and chemicals sector (14 per cent).

The growth in economic activities has resulted in increased creation of employment with unemployment rate decreasing from 9.0 per cent in the first quarter of 2003 to 8 per cent in the first quarter of 2004 (excluding the northern Province), as shown by the Quarterly Labour Force Survey of the Census and Statistics Department, decreasing from 9.0 per cent in the first quarter of 2003 to 8 per cent in the first quarter of 2004. Workers taking up foreign employment rose by about 10 per cent in the first half of 2004. The employment rate of graduates in the Science and Technology field also has increased from 61 per cent in 2003 to 91 per cent in the beginning of 2005, according to a NSF Survey (Dilrukshi and Wickremasinghe, 2006).

Table 7.10

PRINCIPAL INDICATORS OF INDUSTRIAL ACTIVITY CLASSIFIED BY INDUSTRY DIVISION – 2001*

Industry division	No. of establishments (No)	Persons engaged (No)	Employees (No)	Salaries & Wages (Rs.million)	Value of output (Rs.million)	Value of input (Rs.million)	Value added (Rs.million)
Other Mining	1,656	13,879	12,831	232	780	214	566
Food, Beverages & Tobacco	3,865	45,433	28,881	656	9,215	5,608	3,607
Textile, Wearing Apparel & Leather	2,112	25,114	23,066	796	3,624	2,157	1,467
Wood, Wood Products & Furniture	902	8,561	7,491	188	701	226	475
Paper Products, Printing & Publishing	264	1,870	1,498	50	2,896	1,985	911
Chemicals, Petroleum, Rubber & Plastic	656	7,963	7,312	202	1,528	916	611
Non-metallic Mineral Products	1,599	16,712	14,857	344	722	308	414
Metal Products, Machinery & Equipment	475	2,927	2,422	98	484	175	308
Other Manufacturing Industries	225	1,681	1,219	40	732	241	490
Total	**11,754**	**124,140**	**99,577**	**2,606**	**20,682**	**11,830**	**8,849**

Source: Department of Census and Statistics

*Establishments with 5 or more persons engaged

7.9 General Trends

The Sri Lanka economy registered an annual growth of 5.4 per cent in real Gross Domestic Product (GDP) in 2004. The growth of over 5 per cent is a reflection of the economy's resilience to the many adverse shocks the country had to face during the year such as surge in international oil prices, a severe drought in the early part followed by floods later and at the end of the year the Tsunami disaster (Central Bank Annual Report, 2004).

The growth momentum of the Industrial sector has to be maintained by nurturing technological innovation and creating the climate for investment promotion in a globally competitive environment. In order to enhance quality, productivity and competitiveness several thrust areas have been identified in the selected industrial sub-sectors based on their export potential, high value addition and employment generation capability and prospects for domestic resource utilization. The thrust areas include textiles and apparel, footwear and leather products, ceramics, rubber and wood based products, gems & jewellery and the IT industry.

Speed, flexibility and quality are the essence of the apparel industry which earns over Rs. 2.6 billion and provides employment to over one million persons. R&D can play a critical role in enhancing these attributes. The ceramics industry earns over Rs. 4 billion in Foreign exchange and provides employment approximately to 20,000 persons (http://www.competitiveness.lk). Sri Lankan ceramics are of a very high quality but absence of an internationally accepted certification system and lack of R&D inputs have been identified as restricting growth. There is potential for further expansion of the jewellery sector with the introduction of innovative designs and modern skills. Significantly, IT exports increased by 11 per cent to US$ 72 million in 2004 indicating enormous potential for foreign exchange earnings with continuation of R&D and skills development, and further improvements in telecommunication infrastructure to ensure reliable connectivity and speedy transmission to maintain global competitiveness.

The national economic policy is formulated by positive attributes of a free market economy, to ensure a modern and balanced approach, with the complementary participation of a socially responsible private sector and a strong revitalized public sector. New initiatives are imperative for synergistic collaboration through a triangular linkage strengthening the bonds between government, industry and universities through Intermediary institutions, which have been harnessed successfully in countries such as Korea, Taiwan and Malaysia to bridge the gap between S&T in academia and innovation and commercialization in industry.

They would provide avenues for younger scientists and engineers to be exposed to the entrepreneurial culture at an early stage in their university career and motivate those with a propensity for entrepreneurship to join spin-off companies resulting from such collaboration. The Intermediary institutions would serve as an inexpensive mechanism for the smooth transition of S& T resources from academia to industry which is vital for the development of these thrust areas.

Chapter 8

DISCUSSION

The survey indicates that there has been a slight growth of R&D expenditure both in the absolute and the real terms during the past decade (1993-2004). However, the national co-efficient of R&D still remains at a very low level (0.21 per cent). There were no significant changes in the growth pattern of expenditure with respect to the categories such as activities of work, human resources, sector of performance, fields of science and other objectives.

The national economy basically depends on three sectors such as agriculture, industry and services. When compared with the last 50 years it is evident that the contribution of the agriculture sector in the country is declining. Within the sector of agriculture, the plantation industry was the highest foreign exchange earner until mid-eighties. However, the position of agriculture was taken over afterwards by the foreign employment, garment industry and tourism. Similarly, the R&D activities carried out in the areas of agriculture sciences have also declined and this may have had a direct impact on the economy in the country. Since the food requirement in the country depends on agriculture, it is vital that the agriculture sector should develop in such a way to become an independent and self-sufficient nation.

The decrease of the R&D funding in the area of agriculture in the country may have a direct impact on the economy in the country. The low income gain in the agriculture sector may be due to the high cost of production. This is one of the major problems faced by the farmers as well as the consumers in the local market. The high cost of agricultural goods in the local market mainly arises due to the high cost of inputs fertilizers, insecticides etc. and also due to the poor post harvest management. The defects in the cultivation and collection of fruits, vegetables and other products, losses and damages in storage and transport, ineffective techniques of processing are the major constraints in the country. A high wastage has been recorded during the chain of processing when the farm products are delivered into the consumer as well as in the period when there is a high yield or during harvesting time. These problems can be overcome by development of techniques such as processing excessive products for future usage; reduce losses during marketing process or storage etc. that should be worked out by extensive R&D activities. In some Research Institutions i.e. ITI, IPHT etc., and at the university level, this type of research work is being carried out, but no proper channels have been formed to introduce these techniques at industrial level or to the farmers and retailers. The lack of funds for scaling up these research findings to the market level and the lack of communication between the Scientists and the Industry and/or the responsible parties in the policy planning bodies in the country are the major problems envisaged in developing these activities.

The contribution of the Industry sector to the country's economy was 26 per cent in the year 2004 and compared with the previous records, this sector shows no improvement within the last 30 years. The highest proportion of contribution in the Industry sector comes by manufacturing. Despite the improvements of the manufacturing sector, the technological base of Sri Lanka is still weak and depends to a large extent on foreign inputs. During this survey it is seen that most of the industries depend to a large extent on foreign enterprises for advice and techniques due to lack of expertise in the country. However, it may probably be not due to lack of expertise but lack of communication between the scientists working in the local research institutions and the universities.

It was seen during this survey, that some Research Institutions and/or the Industry based public organizations in the country have deviated from their research activities and currently, most of their

efforts are put into providing services to overcome financial constraints faced by the institutions. This has led to spending less time and effort on R&D. These financial constraints in the R&D institutions reduce productive research and also create unhappiness among scientists. The main cause for the extensive Brain Drain of scientists is the lack of recognition for the Science and Technology work in the country. The majority of the institutions which took part in this survey expressed their grievances on this matter. When compared with the other workers in the country, the highly qualified research scientists draw low salaries and receive fewer benefits in spite of their qualifications. This cause extensive external Brain Drain to the countries that value their contributions to the S&T and the few who remain in the country tend to move in to the private sector and other areas that pay well i.e. administration, banking etc. But the concern here is that scientists do not use their S&T skills but only their managerial skills. The recently passed out graduates show reluctance to be employed as scientists due to low salaries offered in the sector and even when employed, most of the institution authorities have experienced that it is very difficult to keep the young S&T graduates for a long time when they get opportunities to join other sectors with higher salaries and benefits. This situation could be one of the main reasons for the declining trend seen in the number of scientists within the period 1996-2004.

To overcome these issues, the policy planning bodies and the financial authorities in Sri Lanka, like other developed countries, should recognize the importance of S&T for the development of the country and take necessary steps to improve the infrastructure in the research institutions and the S&T institutions for better working environment and recognize the contribution of the scientists to the country's economy.

The number of postgraduates, especially the Ph.D. qualified scientists produced in the local universities is low. When we looking at the number of scientists with Ph.D. in Sri Lanka, it is also low compared to some of the developing countries in the region. This may probably be due to the lack of research conducted in the higher education sector in the country.

8.1 Problems and Constraints faced in conducting the R&D Surveys

Though Sri Lanka has a legalized system for data compilation on the S&T system since 1967, it does not function satisfactorily due to the poor attention paid to the importance of measuring S&T capability in the country. The most significant reason for this is the absence of proper awareness in the country on the importance of S&T indicators. Due to this reason, there is only a very limited amount of funds and human resources are devoted for compilation of S&T information in Sri Lanka. Thus, conducting the regular surveys on S&T system is an arduous task. Poor knowledge on S&T indicators and inadequate usage of same by the policy planners and administrative bodies in the country is another disadvantage. There is no proper planning yet developed to incorporate S&T indicators with economic indicators in the country.

The other drawback found when conducting the survey was the absence of institutional support to gather accurate and timely S&T information relevant to the institution. Absence of institutional commitment to maintain or periodically update the S&T statistics may be the main reason for this situation. Especially, the absence of cooperation from the industrial and private sector organizations hinders the proper assessment of the S&T system in the country. Many such organizations or authorities have no confidence that there will be fruitful results through application of S&T indicators to the

planning process in the country and hence they feel that the time and effort devoted to provide such information is of no use to them. The low response could be attributed also to the lack of understanding of the main purpose of the survey, the definitions and the terms used in the questionnaire.There are very few industries in the country that are engaged in high level R&D activities. Some of the large multinational companies that operate in Sri Lanka have their technology developed or technology transferred from other countries through their parent organizations that operate outside the country. It was learnt that there are also a large number of local firms engaged in technology adaptation or technology development according to their requirements. It was difficult to convince the management of these industries that such activities are also classified under R&D. As a result, they were reluctant to give crucial information on technological innovations which are the precursors to R&D.

8.2 Limitations and Suggestions

It was noted that the paucity of attempts made by institutions to measure the output of S&T activities was attributed to the difficulties in measuring outputs. Patent activities were also not well organized and patronized by the research institutions. Results of research work are generally published locally and hence they are not necessarily reflected in the international citation counts. Hence the efforts of the national surveys relate mainly to the development of input indicators.

The historical S&T information available locally in terms of S&T input and output indicators are also limited and therefore, it was difficult to compare such data with the present survey due to the differences in coverage, concepts used and reliability. However, these previous efforts have no doubt resulted in increasing the awareness of the users of S&T information in planning and managing national S&T activities, as well as increasing the awareness of the need to develop S&T indicators.

Use of verification methods is the general practice in ensuring the accuracy of data in the final reporting of the statistical information collected. These methods include the comparison of previous information submitted by individual institutions, cross checking, telephone inquiries, and re-examination of data that are of questionable nature.

As mentioned elsewhere, the R&D activities of a country depends on the R&D investment and access to resources. Therefore, careful examination of all the S&T data available is essential to arrive at definite conclusions for the formulation of S&T policies and it is therefore very important that these analyses must be done on the solid quantitative data. Since it was difficult to convince the Industrial authorities that technology adaptation and transfer also come under R&D, such information which are precursors to actual R&D may not be comprehensively included. Therefore, it is suggested that these issues should be addressed in a comprehensive Innovations Survey that could be conducted parallel to the R&D survey or incorporated in the Annual survey of Industries conducted by the Department of Census and Statistics of GOSL.

The Central Bank Annual Report states that Foreign Exchange earnings from IT exports increased by 11 per cent which is equivalent to U.S. dollars 7.2 million in 2004. It is predicted that these incipient earnings are only a small fraction of the enormous potential in the global market which can be exploited if attractive incentives are offered within a suitable policy framework. The intensification of skills development, further upgrading of telecommunication infrastructure to ensure reliable and

robust connectivity and speedy transmission are among the factors that have been identified as critical for the future development of IT exports. However, these organizations were very reluctant to reveal software development activities presuming that they would be taxed by the government. Hence it was not possible to incorporate such information into this survey, and it is advisable to conduct a separate survey of the fast developing Information Technology sector, with the full cooperation of ICTA.

The research team of the Science and Technology Policy Research Division (STPRD) of the National Science Foundation expended much effort to capture all the information on the S&T system in the country within the time frame planned for this survey. Therefore, a mechanism should be worked out for constant development of valid and reliable S&T indicators. Good commitment, adequate financial and human resources, institutional backing etc., are the vital factors in this direction. Contributors of the Industrial/Private sector must also be encouraged to provide accurate data with offers such as tax concessions by the government to conduct R&D activities and, etc.

Finally, it is appropriate that the National Science Foundation is granted the legal authority for collection of S&T data from the public and private stakeholders to ensure a comprehensive data coverage in future surveys.

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ANNEX 1

Definitions:
OECD and UNESCO Institute for Statistics 2006
NSF adapted the R&D definition, its inclusion, and exclusions, used by the OECD and UNESCO Institute for Statistics for the purpose of international comparison, namely:

Definition 1: R&D

The Research and experimental Development (R&D) comprised the creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society , and the use of this stock of knowledge to devise new applications.

R&D Activity

Basic Research (Pure, Strategic & Expedient) is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.

Applied Research is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.

Experimental Development is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

The boundaries of R&D

For the survey purposes, R&D must be distinguished from a wider range of related activities with a scientific and technological base. These other activities are very closely linked to R&D both through the flow of information and in terms of operations and personnel, but they should, as far as possible, be excluded when measuring R&D.

R&D includes:

a. design, construction and operation of prototypes where the main objectives is technical testing to make further improvements
b. Construction into operation of pilot plants not operated as commercial units.
c. Research into and original development or substantial modification of computer software such as new programming languages and new operating systems.
d. 'feedback R&D" directed at solving problems occurring.
e. Research work in the biological, physical sciences, and the humanities and Social science research including economics, cultural, educational and sociological research

R&D excludes:

a. Scientific and technical information services
b. Policy related studies, management studies and efficiency studies
c. Consumer survey, advertising, market research
d. Routing quality control and testing
e. Pre-production activities such as demonstration of commercial viability, tooling up and trial production runs
f. Prospecting, exploring or drilling for minerals, petroleum or natural gas
g. Cosmetic modification or style changes to existing products
h. General purpose or routing data collection
i. Routing computer programming, system maintenance or software applications
j. Operations research and mathematical or statistical analysis
k. Commercial, legal and administrative aspects of patenting, copyrighting or licensing
l. Activities associated with standard compliance
m. Specialized routine medical care , for example routine pathological services etc.

R&D ends

a. When the work is no longer experimental and pre-production.
b. If the primary objective is to make further improvements
c. If there is a need to do pre-production planning to get production control system working smoothly for materials, products etc., that is substantially developed and the primary objective now is to develop market.

Definition 2: Sector

Government Sector:
All departments, offices and other bodies which furnish, but normally do not sell to the community, those common services, other than higher education, which cannot otherwise be conveniently and economically provided, as well as those that administered the state and the economic and social policy of the community.
Non-profit institutions controlled and mainly financed by government, not administered by the higher education sector.

Higher Education Sector:
All universities, colleges of technology and other institutions of post-secondary education, whatever their source of finance or legal status. All research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education establishments (e.g. Funds from UGC).

Business Enterprise Sector:
All firms organizations and institutes whose primary activity is the market production of goods or services (other than the higher education sector) for sale to the general public at an economically significant price and the private non-profit instates mainly serving them.

Private and Non-profit Sector:
Non-market, private non-profit institutions serving the households or private individuals

Definition 3: Fields of Science and Technology

(a) NATURAL SCIENCES
Mathematics and computer sciences
Physical sciences
Chemical sciences
Earth and related environmental sciences
Biological sciences

(b) ENGINEERING AND TECHNOLOGY
Civil engineering
Electrical engineering, electronics
Other engineering sciences

(c) MEDICAL SCIENCES
Basic medicine
Clinical medicine
Health sciences

(d) AGRICULTURAL SCIENCES
Agriculture, forestry, fisheries and allied sciences
Veterinary medicine

(e) SOCIAL SCIENCES
Psychology
Economics
Educational sciences
Other social sciences**

(f) HUMANITIES
History
Languages and literature
Other humanities***

Notes:
** Other social sciences include: anthropology and ethnology, demography, geography, town and country planning, management, law, linguistics, political sciences, sociology, organization and methods, miscellaneous social sciences and interdisciplinary.
*** Other humanities include: philosophy, arts, history of art, art criticism, painting, sculpture, musicology, and dramatic art.

Definition 4: Measurement units of S&T personnel

Head Count: data reflect the total number of persons employed in S&T, independently from their dedication. These data allow links to be made with other data series, such as education and employment data, or the results of population censuses. They are also the base for calculating indicators and analyzing the characteristics of the S&T workforce, with respect to age, gender or national origin.

FTE : One full-time equivalent may be thought of as one person-year. Thus, a person who normally spends 30 per cent of his/her time on R&D and the rest on other activities (Such as teaching, university administration and student counseling) should be considered as 0.3 FTE. Similarly, if a full time R&D worker is employed at an R&D unit for only six months, this result is an FTE of 0.5. However, for reporting purposes, the total sum of FTEs should be rounded to the next integer, avoiding the reporting of decimals.

Definition 7: R&D Occupations

Researchers: Professionals engaged in the conception or creation of new knowledge, products, processes, method and systems and also in the management of the projects concerned.
Technical and equivalent staff: Persons who participate in S&T by performing scientific and technical tasks involving the application of concepts and operational methods, normally under the supervision of researchers.
Other Supporting Staff: Skilled and unskilled craftsmen and clerical staff participating in S&T projects or staff directly associated with such projects.

ANNEX 2

Research Institutions

Arthur C Clarke Institute for Modern Technologies (ACCIMT)
Badaranayake Memorial Ayurvedic Research Institute (BMARI)
Central Environmental Authority (CEA)
Ceramic Research Development Centre (CRDC)
Coconut Research Institute (CRI)
Farm Mechanization Research Centre (FMRC)
Field Crop Research & Development Institute (FCRDI)
Fruit Crop Research & Development Centre (FCRDC)
Grain and Legume Research Institute (GLRI)
Gem and Jewellery Research and Training Institute (GJRTI)
Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI)
Horticulture Crop Research & Development Institute (HORDI)
Institute of Fundamental Studies (IFS)
Institute of Policy Studies (IPS)
Institute of Post Harvest Technology (IPHT)
Industrial Technology Institute (ITI)
Medical Research Institute (MRI)
National Aquatic Resources Development & Research Agency (NARA)
National Building Research Organization (NBRO)
National Engineering Research and Development Centre (NERDEC)
Plant Genetic Research Centre (PGRC)
Rice Research & Development Institute (RRDI)
Rubber Research Institute (RRI)
Sugar Cane Research Institute (SRI)
Tea Research Institute (TRI)
Veterinary Research Institute (VRI)

Higher Education Sector

University Grants Commission
University of Colombo
University of Peradeniya
University of Jaffna
University of Kelaniya
University of Morotuwa
University of Sri Jayawardenapura
University of Ruhuna
Eastern University
Sabaragamuwa University
Rajarata University
The Open University
Wayaba University

Southeastern University
National Institute of Business Management (NIBM)
Sri Lanka Institute of Information Technology (SLIIT)
General Sir John Kotalawala Defense Academy
Postgraduate Institute of Agriculture (PGIA)
Postgraduate Institute of Medicine (PGIM)
Postgraduate Institute of Science (PGIS)

Ministries (2004)

Ministry of Agriculture Development
Ministry of Defense
Ministry of Education
Ministry of Environment
Ministry of Fisheries and Aquatic Resources
Ministry of Healthcare and Nutrition and Uva Wellassa Development
Ministry of Highways
Ministry of Housing and Constructions
Ministry of Indigenous Medicine
Ministry of Plantation Industries
Ministry of Ports and Aviation
Ministry of Post, Telecommunication and Udarata Development
Ministry of Social Service and Social Welfare
Ministry of Power and Energy
Ministry of Science and Technology
Ministry of Skill Development Vocational and Technical Education
Ministry of Small and Rural Industries and Self Employment Promotion
Ministry of Urban Development and Water Supply
Ministry of Women Empowerment

Science and Technology Institutions (Government and Semi-government)

Atomic Energy Authority (AEA)
Audio Visual Training Center
Ayurvedic Drug Cooperation
Bank of Ceylon
Central Bank
Central Engineering Consultancy Bureau (CECB)
Central Environmental Authority (CEA)
Central Freight Bureau of Sri Lanka
Ceylon Ceramics Corporation
Ceylon Fisheries Corporation
Ceylon Fishery Harbors Corporation
Ceylon Petroleum Corporation
Clothing Industry Training Institute
Coast Conservation Department

Coconut Cultivation Board
Coconut Development Authority
Department Lotteries Board
Department of Agriculture
Department of Animal Production & Health
Department of Archaeology
Department of Ayurveda
Department of Building
Department of Child Care and Probation
Department of Cultural Affaires
Department of Excise
Department of Export Agriculture
Department of External Resources
Department of Fiscal Policy
Department of Fisheries and Aquatic Resources
Department of Forest
Department of Government Analyst
Department of Government Information
Department of Government Printing
Department of Health Services
Department of Import and Export Control
Department of Meteorology
Department of Motor Traffic
Department of National Archives
Department of National Museum
Department of National Planning
Department of Official Languages
Department of Police
Department of Posts
Department of Public Enterprises
Department of Social Services
Department of Surveyor General
Department of Technical Education
Department of Technical Education & Training
Department of Textile Industries
Department of Valuation
Department of Wildlife Conservation
Department of Censes and Statistics
Department of Examination
Food Commissioner's Department
Geological Survey and Mines Bureau
Institute of Policy Studies
Irrigation Department of Sri Lanka
Lanka Cement Corporation
Mahaweli Authority of Sri Lanka

Mahaweli Venture Capital
Marine Pollution Prevention Authority
Measurement Units, Standards and Services Department
National Apprentice & Industrial Training Authority
National Aquaculture Development Authority
National Chamber of Commerce of Sri Lanka
National Crafts Council
National Dangerous Drugs Control Board
National Film Corporation
National Gem and Jewellery Authority
National Hospitals of Sri Lanka
National Housing Development Authority
National Institute of Education
National Institute of Fisheries & Nautical Engineering
National Institute of Health Sciences (NIHS)
National Institute of Plantation Management
National Institute of Social Development
National Institute of Technical Education
National Intellectual Property Office of Sri Lanka
National Library and Documentation Office
National Livestock Development Board
National Lotteries Board
National Paper Company Ltd.
National Physical Planning Department
National Procurement Agency (NPA)
National Research Council (NRC)
National Saving Bank (NSB)
National Science and Technology Commission (NASTEC)
National Science Foundation (NSF)
National Water Supply and Drainage Board
Naval Research and Development Unit
Peoples Bank
Railway Department
Rajarata Development Bank
Road Development Authority (RDA)
Royal Botanic Gardens
Ruhunu Development Bank
Rural Development Training and Research Institute
Samurdhi Authority of Sri Lanka
Selacine Rupavahini Institute
Sri Lanka Broadcasting Corporation (National Redio)
Sri Lanka Cashew Corporation
Sri Lanka Council for Agricultural Research Policy (CARP)
Sri Lanka Export Development Board (EDB)
Sri Lanka Foundation Institute

Sri Lanka Handicraft Board
Sri Lanka National Child Protection Authority
Sri Lanka National Museum
Sri Lanka Ports Authority
Sri Lanka Rupavahini Corporation
Sri Lanka Standards Institution(SLSI)
Sri Lanka Telecom
Sri Lanka Transport Board
Sri Lankan Airlines Ltd
State Pharmaceutical Corporation
Tea Small Holdings Development Authority
Tertiary and Vocational Education Commission
Urban Development Authority (UDA)
Uva Development Bank
Wayamba Development Bank
Zoological Gardens

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