SRI LANKA
SCIENCE & TECHNOLOGY INDICATORS

PART I

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RESEARCH IS THE FOUNDATION OF KNOWLEDGE

UNESCO

SCIENCE AND TECHNOLOGY INDICATORS IN SRI LANKA

Part I – ORGANIZATIONAL STRUCTURES AND THE STATUS OF NATIONAL EFFORTS IN SCIENCE AND TECHNOLOGY

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FOREWORD

The study of science indicators and statistics was initiated by NARESA to assemble and collate S&T information on the structure, development and status of science and technology in Sri Lanka. It intends to bridge the gaps in the S&T information system in Sri Lanka and develop a firm basis for the collection and development of S&T indicators. The first part of the study has been sponsored by UNESCO and constitutes an analytical review of Structural Changes in Science and Technology in Sri Lanka. This report provides a vivid picture of trends in science in a small third world country. Saddled with financial constraints on one hand, and migration of high calibre manpower on the other hand, Sri Lanka, like most other developing countries is lagging behind in science and technology development and failed to keep pace with the technological advances made by the industrialized countries.

The study provides useful S&T indicators for the development and utilization of science and technology in Sri Lanka using several quantitative measures. Information contained in this report may provide useful guidelines for planners and policy makers to evolve policy options for a planned trajectory in the development of science and technology in Sri Lanka.

Dr. R. P. Jayewardene

Preamble

ORGANIZATIONAL STRUCTURES AND THE STATUS OF NATIONAL EFFORTS IN SCIENCE & TECHNOLOGY IN SRI LANKA

Scientists and science planners from all parts of the world have been investigating and probing the process by which the dynamics of science and technological capabilities in the third world countries could be enhanced. These countries, however, saddled with several economic and social constraints, never had the opportunity, strength or even the foresight to utilize the resources for development of S&T for their economic growth, as witnessed in the industrialized countries. In actual fact, the progress of science in the third world has not been looked at from the point of view of the toils of its scientists. One may note that in some areas, the growth of knowledge has been very impressive. Yet in some directions it was a total failure. A point that is not often appreciated is that, development objectives of third world countries are not directly compatible with those of the industrialized nations, and therefore any attempt to superimpose an ill-conceived western model can have disastrous consequences.

A key feature of this study is to understand the structural, and organizational nature of third world science with special reference to the case of Sri Lanka. One may expect that science as practised in the East and West have more or less similar characteristics (Moravcsik, 1981). Yet science in the third world has subtle differences due to institutional and socio-cultural practises which are specific to these countries. The intention in this study is to examine the foundations of science in Sri Lanka from an evolutionary stand point and review its structure inquiringly, in order to identify its short comings and merits.

A study of this nature is beset with problems because it involves several inter-related factors which can distort and smother the true situation. The elements of the S&T structure that can be easily studied include the organizational structures for S&T, government sponsorship for scientific services, financial resources devoted to research, human resources allocated to S&T, physical S&T infrastructure including instrumentation and advanced technical facilities and legal provisions for conducting S&T. However, these elements will not be completely adequate to describe the true nature of science and technology development efforts. The differences in approaches, knowledge systems and sociological parameters need to be taken into an account in the assessment of S&T systems.

The most serious constraint in S&T indicator studies is the lack of simple measures or yard-sticks to evaluate the national efforts in S&T activities. The variation in the understanding of definitions, the ranges of methodology used and different practices of reporting, the economics of alternative approaches and the effects of personal beliefs and prejudices, and more importantly, marginal S&T effort, makes it difficult to assess and analyse the national

S&T system. Therefore, the reporting system of science and technology needs continuous review and years of data collection in order to achieve the degree of certainty, which would make such studies gainful.

The readers of this report are reminded about the importance of differentiating science and technology activities (STA) into various components such as invention, innovation, research and development etc. The terminology relating to scientific and technological activities used are as defined by UNESCO at its 20th session in Paris in November, 1978. These activities (STA) comprize of,

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

The major concern in this report is the reporting of research and experimental development in relation to economic activities. Whenever it is pertinent, other STET and STS activities are drawn to elucidate the state of national S&T effort. In this study effort has been made to overcome the drawbacks and deficiencies in previous studies. However, some intricate problems are yet to be resolved. Therefore, it is to be noted that the quantitative information presented in this study does not imply any finality. A number of researchers and colleagues have contributed to the success of this report. Their suggestions and ideas have helped us to improve the S&T indicators and statistics. Yet, continuing effort is needed to refine the methodology of constructing S&T indicators.

Chapters one and two describe the historical perspectives in resources studies and the general organizational structure for science and technology in the country. Certain landmarks in S&T development, important policy changes and infrastructure development are discussed in these two chapters. It also provides an insight to the qualitative aspects and sociological dimensions in the science and technological changes in the country.

Chapter three deals with the level of funding for R&D. The national R&D capability in terms of financial resources devoted to S&T development is analysed according to source of funding, types of expenditure and character of R&D activities. A review of science and technology activities according to national, sectoral, scientific field and discipline levels are presented to draw the attention of policy makers to some of the imbalances or deficiencies in R&D funding and spending strategies.

Chapter four describes the state of manpower resource utilzation and depolyment according to various strategies in R&D system. The availability of economically active scientists, engineers and other technical personnel for research and development is considered. The diversity of the workforce, and other salient features pertaining to the S&T workforce are reported in this chapter.

Chapter five attempts to synthesize the connection between the inputs to science and technology development with the economic performance of the country by constructing a series of strategic indicators. The science and technology intensities, performance of S&T in relation to economic indicators, linkages with international S&T activities are discussed in this chapter.

Chapter six summarizes the major findings of this study.

Chapter 1

HISTORICAL PERSPECTIVES AND GLOBAL ISSUES

1.1 RATIONALE

Science and technology have *too* often been regarded as the panacea for under-development. Although this may not be entirely true, it has to be recognized that the impulses of innovation and creativity fostered by science and knowledge, have radically altered the life styles and cultures of the Western societies, leading to what has been commonly referred to as advancement or development.

Science is universal, but technology carries an element of specificity in relation to culture and society. Hence reconciling these conflicting aspects has been a serious hurdle in harnessing science and technology for development in the culturally rich traditional societies of non-European nations. Thus the concept of advancement in the Eastern cultures has to be viewed in this context.

Development is a term which is used widely, but with different connotations. It means different things to different societies, and hence cannot be defined easily. If it is assumed, as is often done, that the technology led transformation so characteristic of the Western societies represent development, then obviously the so-called less developed countries like Sri Lanka will need to find solutions to several vital and soul-searching questions.

(a) What are the aspirations and goals for our people?
(b) Should our societies emulate and follow the Western example, and if so, should they retrace development pathways of the latter ?
(c) If not what are the alternatives and modalities for progress?
(d) What is the quality and type of scientific base desirable to foster and sustain creative advancement?
(e) What is the character and level of sophistication in technology most acceptable for the planned goals of development?
(f) How will science and technology affect the social structure and culture of the nation, and conversely what will be the effects of culture on the development of S&T?

The complex nature of the issues involved leaves little hope for optimism for a consensus on any of these matters. Nevertheless the direct involvement of scientists, technologists, managers, sociologists, economists, philosophers and even politicians, in the search for reconciliatory measures, shows the importance and urgency with which an escape route should be found to trigger-off a socially acceptable development process. And once this is found all the available resources, especially the scientific resources potential of the country will have to be mobilized and utilized optimally to fuel the process of development. This would in brief form the framework for a national policy on science and technology, which in any event should provide guidelines for the organization of the means necessary for the production and ulitization of scientific and technological knowledge and resources, for the social and economic upliftment of the society.

Thus in this situation it is of relevance to determine in our own context whether the scientific resource potential available in this country is of the required quality and quantity to motivate and generate the thrust towards creative progress. This is a basic issue in science planning and has to be systematically evaluated to enable planners and policy-makers to evolve the most desirable policy alternatives.

The present study is an attempt to review, analyse and interpret the scientific and technological resources potential in Sri Lanka, with a view to present the status of these resources, and the trends in their deployment in the country's economy. It is hoped that the updated information will form useful bridges to some, at least, of the crucial grey areas of a future framework for a national science and technology policy.

1.2 HISTORICAL DEVELOPMENT

1.2.1 THE GLOBAL SCENE

It is reported that the earliest measurements of research and development were made by universities and learned societies to monitor their own efforts and make rough estimates about scientific disciplines and fields of research that were of the greatest interest (Freeman, 1982). However, the growth of scientific activity during the 18th and 19th centuries often referred to as the scientific or research revolution, resulted in the demand for statistical measurements of resources devoted to new science and technology. Yet till about the middle of the last century allocation of funds, specially for scientific research was said to be occasional and small, and any that was apportioned had the resemblance of a prestigious award for a cherished art (Freeman, 1970). However, by about the latter part of the century when industrial concerns began to establish research units, evaluation of their levels of R&D effort became vital as a means of comparing performance with competitors. Since then there had been a fairly sharp rise in resources devoted to scientific and technological research, which necessitated industrial organizations in the industrial countries to collect and publish results of surveys of industrial R&D expenditure.

Possibly the earliest official survey on scientific and technological activities was by the Soviet Union, which began collection and publication of data from the early 1930's (Freeman, 1970). In the United States, it was not until the 1940's that the Federal Government began systematic collection of data on the scientific and technical potential. A critical problem during this period was the formulation of standards in respect of terminology and survey procedures, to enable both national and international comparisons. However, following the establishment of the National Science Foundation (NSF) in 1950, regular surveys of R&D began in the United States. These surveys examined the trends in each scientific sector, sub-sector and field of science in the economy of the U.S. The NSF studies have not only influenced the policy-making machinery of the Federal Government, but also provided insights to the trends in academic work, as may be observed from their later work (National Science Foundation, 1986).

Since 1972, the National Science Board of the NSF began publishing biennially the series referred to as Science Indicators, which according to their latest edition" .... describe and analyse our (USA) complex and often elusive system for creating scientific and engineering knowledge and technological products and processes" (National Science Foundation, 1986).

The example set by the Soviet Union and the United States was soon followed by several West European countries and also by Canada and Japan in data collection, until international agencies stepped in to standardize terminology and survey methodology.

1.2.2 ROLE OF INTERNATIONAL AGENCIES

Between 1950 and the early 1960's, influenced by the work of the US National Science Foundation and the pioneering efforts of the United Kingdom, France, Japan, Canada and the Netherlands, most of the industrialized countries of the Organization for Economic Co-operation and Development (OECD) began collecting statistical data on the resources devoted to research and development. However, OECD's interest in this question began in 1957, when the Organization for European Economic Co-operation (OEEC), through its Committee for Applied Research of the European Productivity Agency began discussing with member states on the methodological problems (OECD, Paris, 1974). This Committee appointed an *ad hoc* "Group of Experts" in 1961 to study surveys of R&D expenditure. As a result of this work, a draft document on standardization was drawn up and discussed in 1962, and adopted at a conference of OECD Members held in Frascati, Italy, in June 1963. This document came to be known as the "Frascati Manual". Following the adoption of this Manual, a test study was carried out in seven selected countries, which included the USSR and United States and five West European countries, which had previously carried out surveys on research effort. This study revealed the need for further refinement of the first Frascati Manual. In 1964, the OECD launched the publication of the *International Statistical Year (ISY) on Research and Experimental Development* from the data collected during 1963 – 1964 by its member states, which then later became a regular biennial feature from 1967. But by 1968, in the light of the experience gained, the need for a revision of the Frascati Manual became vital. In 1969, a revised draft prepared by a committee of national experts was examined in Frascati, and by 1970 the Revised Edition of the Frascati Manual was published (OECD, Paris, 1974). Since then, this Manual has been revised twice; once in 1976 (3rd edition) and again in 1981 (4th edition) (Freeman, 1982).

Unfortunately the work of OECD was restricted to a small group of wealthier countries, and therefore its attention was focussed on issues which were of less relevance to the larger fraternity of poor developing countries. It is in this context that the entry of UN agencies into the field becomes significant.

Apart form OECD, other international and regional agencies have programmes for collection, analysis and interpretation of data on scientific and technological activities. These include the European Community's sub-committee for R&D statistics, the Scandinavian Council for Applied Research (NORDFORSK), the Council for Mutual Economic Assistance

(CMEA) on behalf of the East European Socialist nations and the USSR, the organization of American States (OAS), and on a global scale the United Nations Educational, Scientific and Cultural Organization (UNESCO). It is noteworthy that UNESCO at its 13th General Conference in 1964, paid special attention to the Science Statistics Programme, which led to the formation of a Division of Science Statistics in 1965. In 1967, UNESCO launched the first international study on R&D expenditure, using largely the procedures and definitions formulated in the First Frascati Manual. Since then UNESCO has sponsored national surveys, and regularly collected, analysed and published statistical information not only on R&D expenditure, but also on S&T manpower potential (STP), S&T services (STS) and scientific and Technical Information and Documentation (STID). Like OECD, UNESCO also began publishing annually the *Statistical Year book,* commencing with the year 1968. The global comparisons made regularly by UNESCO in its Statistical Yearbook has been a useful guide for identifying broadly, deficiencies in the development of S&T activities in the developing countries. In 1978, at its 20th General Conference, UNESCO adopted the recommendations concerning the international standardization of statistics on science and technology which led to the publication of a Manual in 1980. More recently as a reconciliatory measure, UNESCO published the revised version of the Manaul, in which it compared the UNESCO definitions with those of other prominent agencies such as OECD and CMEA, to further the cause of international standards (UNESCO, 1984). The meeting held in Graz, Austria by the UN Advisory Committee on Science and Technology for Development (United Nations, 1984) was also an important step towards S&T indicators development.

1.2.3. THE POSITION IN SRI LANKA

In most of the developing countries, measurements of scientific resources for the purpose of science planning is of recent origin, and Sri Lanka is no exception. In fact it has been pointed out that although by 1970, many of the organizational structures required to set in motion the planning process for science and technology in Sri Lanka were well established, the enthusiasm necessary for this activity was not visible. It was concluded that the lack of reliable data on scientific resources was at least one of the main reasons for this failure (De Silva, 1986).

The first study on scientific resources was carried out in 1970 by the Ceylon Institute of Scientific and Industrial Research, which surveyed the research and development expenditure for the ten-year period 1955 – 1966. Since this study covered only state sector institutions, and the information obtained was based on actual expenditure recorded under R&D expenditure in Government Estimates, there were many drawbacks, and the findings were therefore of limited value. However, the gross expenditure on R&D was estimated by this survey to be in the region of 0.3% of the GNP during the early 1960's (Cooray, 1970).

The next study was by the Sri Lanka Association for the Advancement of Science (SLAAS), which carried out a survey of S&T manpower in Sri Lanka in 1972. This study was also of limited value, because its scope was restricted to the membership of SLAAS (Pattiarachchi, 1972).

The first comprehensive and systematic survey of scientific and technical manpower was carried out during 1972 – 1973 by the National Science Council of Sri Lanka. This survey attempted to follow strictly the methodology recommended by UNESCO. It bagan with the issue of a questionnaire to secretaries of Ministries requesting lists of S&T institutions within Ministries, and as could be expected the response to this request was 100 per cent. This was followed by a second questionnaire directed to heads of government department calling for a listing of S&T personnel within their respective departments. The response to this was around 80 per cent. In the final phase of the project, a questionnaire was addressed to individuals requesting detailed personal data. The response to this was only 35 per cent, and hence the main outcome of this costly exercise was the preparation of the Directory of Scientific and Technical Personnel. However, in terms of information provided by heads of government departments, Sri Lanka's total stock of economically active scientists and engineers were estimated to be 6845 (National Science Council, 1973).

Learning from previous experience, the National Science Council embarked on its second major study of resources during 1977 – 1978 which included (a) a survey of R&D funding for applied and basic research in the country for the 10-year period 1956 – 1965, and (b) a survey of S&T manpower for the year 1977. With an overall response rate of over 60 per cent, this study provided valuable statistics on S&T resources in the country. Thus the total research funding in the country, according to this study had been gradually increasing in relation to the Gross Domestic Product, from 0.17 per cent in 1966 to 0.21 per cent in 1975 (Liyanage, et al, 1977).

On the other hand the scientific and technical personnel in the country had dropped from 521 per million population in 1973 to 457 per million population in 1977 (Liyanage, and De Silva, 1979).

The most recent study of scientific resources is a commissioned study on inputs into scientific research, carried out by a three-member scientific team for the National Science Policy Co-ordinating Committee of the Ministry of Plan Implementation during October 1984 to January 1985 (Liyanage, De Silva, and Goonetilake, 1985). Among the major findings of this study are the following:

(a) The total economically active scientists and engineers engaged in research was 1702.

(b) The number of economically active natural scientists and engineers had increased from 4569 to 6781 with an annual average growth rate of 4.6 from 1978 to 1984.

(c) The public sector continued to be the biggest employer of S&T personnel, with 92 per cent of the economically active scientists and engineers within its fold. It was also responsible to 95 per cent of the R&D expenditure.

(d) The number of scientists and engineers engaged in R&D activities was 24 per cent of the total economically active scientists and engineers, and only 6 per cent of them were engineers and technologists.

(e) Women comprised of about 13 per cent of scientists and engineers.

(f) At constant 1975 prices, the total R&D expenditure increased gradually from Rs. 45 million in 1975 to Rs. 66 million in 1983.

(g) As a percentage of GDP, R&D expenditure had declined from 0.2 per cent in 1975 to 0.19 per cent in 1983.

It may also be relevant to mention that a study was also undertaken at the Sri Lanka Institute for Development Administration, to enumerate the scientific and technological expertise available in the country. The main purpose of this study is to prepare a Directory of High Level S&T Manpower in Sri Lanka during 1983/84.

It is evident from the above, that over the past 15 years or so, there had been a clear and conscious effort on the part of various scientific organizations and individuals to evaluate the scientific and technical resources potential in the country, through survey procedures which have been continuously subjected to refinements. While some of the early data may not have been sufficiently precise to be used as indicators for science planning, it is doubtful whether any effort had been made at the national planning level to extract or utilize even the most valid and significant information that has evolved from the later studies.

1.3 WORLD TRENDS IN DEPLOYMENT OF S&T RESOURCES

1.3.1. EXPENDITURE ON RESEARCH AND EXPERIMENTAL DEVELOPMENT

Science and technology viewed as an integrated system constitutes a dynamic instrument for creative advancement of society. Unfortunately two world wars during the first half of this century have been instrumental in changing the course of events, leading to incoherent and undisciplined deployment of scientific resources which threatens mans environment and his very existence. During the late 1950's and early 1960's many scientists began to express disapproval of the use of research results for war, prestige and domination, which brought disrepute for scientific research. It was even worse for a few powerful industrialized states to apportion disproportionately large sums of money for military R&D. Thus in 1967 alone, the percentage allocated to the military sector in the budgets of five major world powers was between 30 to 50 per cent of the national resources earmarked for R&D (UNESCO, 1979). By the early seventies the estimated total annual expenditure on military research was about US $ 25 billion; an amount which represented 30 – 40 per cent of the total world expenditure on R&D, exceeding by three-fold the total official aid to the Third World Countries (UNESCO, 1979).

Although by the 1980's the expenditure on military R&D had dropped to about 20 per cent of the world share of R&D expenditure, the United States and Britain were still devoting around 50 per cent of their national R&D expenditure on defence (UNESCO, 1985).

In the light of the above revelations it would be relevant to consider the three financial targets specified in the World Plan of Action for the Application of Science and Technology for the Decade 1970 – 1980.

Target I recommends that developing countries should attain, by 1980, a minimum level equal to 1 per cent of their GNP on the sums allocated to science and technology (research, experimental development, S&T services): of this, at least 0.5 per cent of the GNP should be for R&D. Countries below this level should aim at increasing the financial resources devoted to S&T at a rate of about 15 per cent per year.

Target II recommends that highly developed countries should increase their direct support of science and technology to reach by 1980, an average level equivalent to 0.05 per cent of their GNP. This corresponds to 5 per cent of the total foreign aid, if the latter is calculated at 1 per cent of the GNP of the highly developed countries (UNESCO, 1979).

Target III recommends that each of the highly developed countries should by 1980 devote at least 5 per cent of their own internal non-military R&D expenditure to research on problems of specific importance to developing nations.

Table 1.1 below summarizes the performance of 20 selected countries during the early 1980's. Column 1 of the table shows that not withstanding the efforts of the UN system, none of the countries (including Sri Lanka), in groups (B) and (C), have achieved the set target of 1 per cent of GNP for R&D expenditure, at the end of the development decade. It must be noted however, that from among all the countries listed as Less Developed (LDC), the following have been fortunate enough to reach or exceed Target I of the World Plan of Action: Senegal – 1.0% (in 1976), Seychelles 1.3% (in 1983), El Salvador – 2.3% (in 1980), Isreal – 2.5% (in 1978), Jordon – 1.8% (in 1979) and the Republic of Korea – 1.1% (in 1983) (UNESCO, 1979).

Table 1.1 also shows that whilst there are no major differences between the two groups of developing countries in respect to their status in scientific and technological activities, industrialized countries, and the Socialist Block Countries comprise of two distinct categories especially in relation to R&D expenditure. The achievements in relation to Targets II and III of the World Plan of Action are difficult to determine, largely due to involvement of political issues. Nevertheless it is significant to note that the overall R&D expenditure of developing countries had increased during the development decade from 2.3 per cent of the world total in 1970 to 6.0 per cent in 1980. This increase was greater in the Asian and the Latin American/Carribean Region than in the African Region (UNESCO, 1979).

It is unfortunate that most of the developing countries still continue to concentrate on the traditional administrative type of budgeting, where the components of science and technology are not identifiable. Most developed countries on the other hand now prepare both an administrative budget as well as a functional programme budget in which the S&T components are distinctly identified and elaborated. This does not mean that all S&T activities are entrusted to one ministry; on the contrary all S&T activities of each ministry are partitioned and consolidated under major functional groupings, in what is now commonly referred to as the "Science (and Technology) Budget". One of the main advantages of this type of budgeting is that, any *ad hoc* decisions on increases or cuts need not be generalized and applied to all sectors, but be specified, so that any planned activities need not be disrupted. This is specifically important for R&D activities which are vulnerable to adverse decisions because of their long gestation period or observable benefits.

Table 1.2 shows the distribution of R&D funds for types of research in 20 selected countries. Although the relevant information is not available for many of the developing countries, the distinction in resource allocation between developing countries and the advanced countries of the Eastern and Western power blocks is quite obvious.

1.3.2. S&T MANPOWER RESOURCES

An important objective of a science plan is the management and deployment of human resources through education and training oriented towards employment. It is indeed a complex task because it not only involves scientific and technical considerations, but also impinges on economic and political issues.

Hence, unless there is a conscious political effort, this vital resource will be tacitly over-exploited or aimlessly under-utilized. It is regrettable that despite the efforts of UNESCO to strengthen the hands of national governments through a set of recommendations, in respect of the status of scientific researchers, adopted at the 18th General Conference in 1974 (UNESCO, 1974), many developing countries have failed to respond positively, mainly due to the pressures of antagonistic internal groups. Most developing countries have therefore side-stepped this problem, leading to distrust and frustration among the trained technical personnel, thereby inducing migration to the western industrialized countries.

The point at issue emerges clearly from a number of studies carried out in Sri Lanka on the problem. Thus in 1974, a high-level ministerial committee discovered that over a 30-month period from May 1971 to June 1974 some 1705 persons had migrated for employment abroad. This amounted to 18 per cent of the total number of professional and technical personnel available in the country in 1971 (Sessional Paper No. X of the Government of Sri Lanka, 1974). While another study in 1976 had shown that the migration of professionally skilled Sri Lankans to Britain during the period 1968 to 1974 had been 1013, of which medical personnel numbered 430 and engineers 260 (Gunawardene, 1976). This same survey estimated the "net social" gain to Britain from the migration of Sri Lankan engineers and doctors during this period to be nearly 56 million pounds sterling, suggesting that this was a vital invisible channel for the reverse flow of aid to a wealthy aid-giving country. However, in the latter part of the last decade when the migratory patterns changed on account of new openings in the African and West Asian countries, not only did the proportion of professionals migrating declined in relation to the total outward flow of labour, there was also a substantial credit transfer of funds to Sri Lanka (Central Bank of Ceylon, 1980).

Nevertheless, the tragic and unavoidable draining out of the intellectuals has not only stalled the development efforts of LDC's but also promoted the widening of the technological gap between developed and less developed countries. Thus even as late as the mid 1970's, more than 90 per cent of the world's total economically active scientists and engineers were in the industrialized countries. During the same period the number of scientists and engineers (in R&D) per million population, in the industrialized countries ranged from 150 to 400, whereas in developing countries it was less than 70 (UNESCO, 1979). As evident from Table 1.1 this disparity continues and even widens in the 1980's. Encouragingly however, the world share of scientists and engineers engaged in R&D in developing countries has increased significantly from 7.9 per cent in 1970 to 10.6 per cent in 1980. As with R&D expenditure, this increase was pronounced in the Asian Region than in the African Region.

In conclusion it has to be stated, that despite the intervention of international, regional and more recently even of sub-regional agencies, fears of displacement, and de-stabilization lurk the Less Developed Countries because of the ever increasing technological gap, caused mainly by the serious disparity in the global deployment of scientific and technical resources.

TABLE 1.1

GLOBAL TRENDS IN THE DEPLOYMENT OF S&T RESOURCES *(Source : UNESCO, 1985).*

	Expenditure on R&D				Scientists and Engineers			
Countries	As % of GNP	Year	Per R&D Sc or Eng in US $ '000	Year	Per million population	Year	In R&D per million population	Year
INDUSTRIALIZED COUNTRIES								
USA	2.7	83	120000	83	14789	83	3107	82
Japan	2.6	83	54792	82	59486	84	4458	83
France	1.8	79	142349	79	23747	79	1363	79
Sweden	1.9	81	136090	79	40499	79	2174	81
UK	2.4	81	77932	78	—	81	1549	78
DEVELOPING COUNTRIES								
In Asia								
India	0.7	82	16311	77	2937	82	131	82
Pakistan	0.2	79	—	—	1154	73	59	82
Philippines	0.2	82	11892	82	—	—	101	82
Indonesia	0.4	83	25810	82	1306	83	152	83
Sri Lanka	0.18	84	5077	84	481	84	220	84
Other								
Nigeria	0.3	77	71985	77	274	80	30	80
Kenya	0.2	77	—	—	909	82	27	82
Malawi	0.2	77	7532	77	723	77	34	77
Brazil	0.6	82	54507	82	11482	82	256	82
Guyana	0.2	82	10499	82	1710	82	99	82
SOCIALIST COUNTRIES								
USSR	4.7	83	23891	81	49494	83	5284	83
Bulgaria	2.9	83	17378	81	33875	83	4862	83
Czechoslovakia	3.9	83	28300	81	35443	83	3714	83
Poland	2.2	82	17720	81	30706	83	2051	83
Hungary	2.3	83	27617	81	38763	83	2070	83

TABLE 1.2

GLOBAL TRENDS IN THE ALLOCATIO.J OF R&D FUNDS FOR TYPES OF RESEARCH *(Source : UNESCO 1985)*

Country	Year	Fundamental Research (%)	Applied Research (%)	Experimental Development (%)
INDUSTRIALIZED COUNTRIES				
USA	1983	12.5	25.5	62.0
Japan	1983	14.6	25.4	60.1
France (1)	1979	20.9	33.0	46.1
Sweden (2)	1981	24.6	17.4	57.9
UK (3)	1978	7.1	23.3	69.6
DEVELOPING COUNTRIES				
In Asia				
India	1983	21.0	43.0	36.0*
Pakistan	—	—	—	—
Philippines	1975	18.9	71.8	9.3
Indonesia	—	—	—	—
Sri Lanka	1984	10.0	72.0	18.0
Other				
Nigeria	—	—	—	—
Kenya	—	—	—	—
Malawi	1977	27.0	68.8	4.2
Brazil	—	—	—	—
Guyana	—	—	—	—
SOCIALIST COUNTRIES				
USSR	—	—	—	—
Bulgaria	1983	13.3	86.7	—
Czechoslavakia (4)	1983	12.3	87.7	—
Poland (5)	1983	16.9	33.4	49.8
Hungary	1983	11.3	34.6	54.1

(1) Incl. total military R&D.
(2) Incl. military and Defence R&D but excluding Social Science & Humanities.
(3) Excl. Social Sciences & humanities.
(4) Incl. part of military R&D.
(5) Excl. military R&D.
* R&D Statistics, 1982–83 – Dept. of Science & Technology, New Delhi.

Chapter 2

EVOLUTION AND ORGANIZATION OF THE INSTITUTIONAL FRAMEWORK FOR SCIENCE AND TECHNOLOGY IN SRI LANKA

2.1 BACKGROUND

The post-colonial advancement of science and technology in Sri Lanka (or Ceylon as it was then known) was indeed the result of several complementary catalytic forces. At least during the early phase, this progress can be attributed partly to the pressures built up by the emergence of an educated class resulting from the educational reforms of the 1940's, combined with new avenues of training abroad, and partly to the demand pull originating from the development aspirations of an emerging sovereign state. In these circumstances, a review of the present status of science and technology would appear unintelligible and incomplete without a brief reference to the historical process which led to the creation of the present organizational framework, and to the manner in which an endogenous S&T capacity has been nutured and sustained.

2.2 THE GROWTH OF SCIENCE AND TECHNICAL EDUCATION

2.2.1 SECONDARY SCHOOL EDUCATION

A major crisis in the educational system of the country during the colonial era was the failure of the authorities to offer equal opportunities for education at all levels. However, the introduction of free education in 1945, followed by the reforms in the medium of instruction, brought about a radical change in outlook towards education in Sri Lanka.

There was an addition, the controversial Assisted Schools and Training College Act No: 8 of 1961, which empowered the Government of the day to take over all denominational private schools, and run them as assisted schools. By these reforms a significant effort was made to remove the inequalities in opportunities for a basic education in Sri Lanka.

Thus by the early 1980's, almost four decades after the introduction of free education, school enrollment had risen by about 300 per cent, bringing in its wake a dramatic increase in the literacy levels. There is no doubt that these changes constituted a major factor in taking science education to the villages, thus helping the growth of a new generation of educated rural youth.

However, the realization that a general education in science, arts or commerce leading to a terminal examination such as the General Certificate of Education – Ordinary Level (GCE – O/L) or the General Certificate of Education – Advanced Level (GCE A/L), does not provide the necessary specialzation for school leavers to enter the labour market, prompted the authorities in the early 1970's to introduce a scheme for vocational training. Under this scheme students at grade six had the option of selecting one technical subject representing a vocational field.

These reforms attempted to change the conventional type of class-room education to a type of learning by experience in which there was a greater rapport between student and teacher (Diyasena; 1983). Accordingly instead of streaming students into arts, science and commerce at Grade 9, the new scheme required students to follow a common comprehensive curriculum from Grade 6 to 9, which included science as one of the 10 regular subjects. At the end of Grade 9 was the National Certificate of General Education (NCGE) Examination in all subjects. In Grade 10 and 11, the usual streaming was done to meet the entry requirements of the University. There were yet five compulsory core subjects for all students. The terminal examination at this level was the Higher National Certificate of Education (HNCE) Examination.

A feature of these educational reforms was the proposal to divert some of the students passing the NCGE into a network of junior technical, polytechnical and aesthetic educational institutions. Unfortunately this scheme never materialized because such a network of junior technical schools could not be established due to various causes, which included political changes and consequent reversals in educational policies.

Since 1977, major structural changes have been introduced in the secondary education system leading to the abolition of NCGE and HNCE Examinations and the re-introduction of the GCE Examination. But, unlike the GCE (O/L) Examination of the 1960's, which had the arts, science and commerce streams, the new GCE (O/L) Examination, was a common exam in which all students offer science as a subject.

However, those students qualifying to proceed for the GCE (A/L) Examination, and opting to enter the science stream, were then expected to select 4 subjects in suitable combinations, out of a total of 8 subjects categorized as science subjects. It has often been commented that the major draw-back in the present structure of secondary school science education is the massive gap between the general science curriculum of the GCE (O/L) Examination and the curriculum of the discipline-oriented science subjects of the GCE (A/L) Examination.

It is significant to note that between 1961 and 1969, the disparity between districts in respect of student enrollment for Grades 9 and 10 (GCE O/L Classes) had steadily declined (with the coefficient of variation dropping from 161.7 to 57.5), indicating that science education was reaching the rural sectors (Alles, 1986). It has also been shown that the total enrollment for Grades 11 and 12 (GCE – A/L Classes) for the science streams had increased from 1.1 per 1000 population in 1969 to 3.09 per 1000 population in 1985. The corresponding figure for the Arts stream are 2.6 and 3.1 respectively. These data indicate the increasing interest in science education at the secondary school level (Alles, 1986).

2.2.2 TECHNICAL AND VOCATIONAL EDUCATION

Outside the school education system there are several other technical training programmes covering a range of vocations and crafts which serve the demands of the country for middle grade supervisory and lower grade crafts personnel. There are several types of technical training programmes of which the following could be considered the most important: (Ministry of Plan Implementation, 1982).

(A) Technical education organized and conducted by the Ministry of Higher Education.

(B) Vocational training provided by various ministries to meet the requirements of middle level technical personnel of the various departments.

(C) Apprenticeship training in specific crafts and vocations conducted by the National Apprenticeship Board.

(D) In-service training programmes of different institutions.

Prior to 1978, technical education programmes were organized by the Ministry of Education, and consisted of five types of courses of which one led to commercial education. Of the others, the "National Diploma" courses in technology, which were of 3 years duration, were offered only by the University of Moratuwa and the Hardy Senior Technical Institute established in 1956 in the Eastern Province. The "National Certificate" courses which were of 1 – 3 years duration were meant to train persons for middle level supervisory positions in a number of technical subjects which included civil, mechanical and electrical engineering, rubber technology and geology, and were available at the polytechnical and junior technical institutes. The other two types of courses were the "National Crafts Certificate" course and the "Short term" course (Ministry of Plan Implementation, 1982).

There are at present 23 polytechnical and junior technical institutes in the country functioning under the Ministry of Higher Education, of which the oldest is the Sri Lanka Technical College established in 1894. Some of the study courses offered by this college, gradually advanced in scope and quality over the years, resulting in these being absorbed into the University system. The expansion of the technical education scheme over the past few years can be judged from the student enrollment at these technical institutes which rose from 9830 in 1976 to 20,796 in 1985/86 (Kalpage, 1986).

The Technical training programmes of the ministries and departments are of two types. The craft training provided by the Small Industries Department and the vocational training courses of the Labour Department are mainly directed to school drop-outs and unemployed persons, to prepare them for self-employment or for the West Asian labour market. Whereas the training programmes offered by other ministries such as Agriculture, Fishery and Health, are mainly to serve their own needs for middle grade supervisory personnel, and such categories as techincal assistants, laboratory technologists and extension officers.

The National Apprenticeship Scheme came into operation in 1971, when the National Apprenticeship Board (NAB) was created under the Ministry of Industries and Scientific Affairs. Its main objectives were to formulate, implement and supervise a scheme of training to cover a range of vocations and trades. In 1978 the scope of activities of the NAB were widened, and assigned to the Ministry of Youth Affairs and Employment, which now co-ordinates most of the other training programmes too. At present the NAB has about 125 trades for the category of craft apprenticeship, 10 fields for technical grades, 11 fields for special engineering apprentices and 11 fields for undergraduate engineering apprentices.

Finally there are the in-service training programmes conducted by departments and institutions mainly as refresher courses to re-orient and update technical knowledge of the various categories of technical personnel.

Although over the past few years many voluntary groups and non-governmental social service organizations have entered the field largely to provide occupational type of craft and technical training, the schemes for specialized training discussed above could be considered the most significant and regular type of technical education in the country.

2.2.3 TERTIARY EDUCATION

The establishment of the University of Ceylon in 1942 and the long drawn out controversy in the siting of this Institution at Peradeniya, dominated the scene in higher education at the time of independence. The first major shift to Peradeniya was in 1949 when the Law, Agriculture and Veterinary science students were moved from their abode in Colombo to the new universitiy. This was followed in 1952 by the transfer of 820 students for the faculties of Art and Oriental Studies.

In the meanwhile as a result of a major policy decision, two prestigious Buddhist pirivenas were elevated to university status by Act No' 45 of 1958. The Vidyodaya Pirivena founded in 1873 was by this Act named the Vidyodaya University and the Vidyalankara Pirivena founded in 1875 at Kelaniya was renamed the Vidyalankara University. These two institutions which excelled in the fields of oriental languages, eastern religions and philosophy, unfortunately had no facilities to commence courses in science and technology. Nevertheless, their creation brought to an end the earlier concept of a single university for the country.

In 1961, when arrangements were underway for the mass transfer of the Science Faculty to Peradeniya, a change of strategy took place, and instead of shifting the Colombo Science Faculty, for the first time a second Science Faculty was established in Sri Lanka in 1961 at the Peradeniya Campus (Fernando, 1982). This was indeed the beginning of an extensive proliferation of higher education in Science in Sri Lanka. In 1983 a second Arts Faculty was established in Colombo, followed by a second Medical Faculty at Peradeniya. Thus by the mid 1960's the original University of Ceylon which was intended to be located only at Peradeniya, became firmly rooted in both Peradeniya and Colombo, as two campuses of one university. While the Faculties of Oriental Studies and Arts, Science and Medicine were common to both institutions, the Peradeniya Campus had in addition a Faculty of Agriculture and Veterinary Sciences and a Faculty of Engineering Sciences. There was obviously some displeasure in these faculty shifts, because in 1964, to the dismay of the authorities in Colombo the special degree course in Chemistry was transferred to Peradeniya (Fernando, 1982).

However, a few years later due to persistent requests, a special degree course in chemistry was reintroduced in the Colombo University (Fernando, 1982).

A significant landmark in the growth of higher education was the inactment of the Higher Education Act No. 20 of 1966, which resulted in the establishment of the National Council for Higher Education, to establish institutions having the status of universities and junior university colleges. Under the provisions of this Act, the two campuses of the University of Ceylon were re-constituted as the fully-fledged Universities of Peradeniya and Colombo, thereby creating four separate universities. A further development was the establishment of several junior university colleges, one of which was the College of Technology at Katubedda.

In the meanwhile the third Science Faculty was estabilshed at the Vidyodaya University in 1965, followed by the fourth Science Faculty at Vidyalankara University in 1967 (Fernando, 1982). At the Peradeniya University, the Department of Veterinary Sciences, progressed rapidly in 1966 when provision was made for the award of higher degrees such as M.Sc., Ph.D. and also a Diploma in Tropical Veterinary Medicine (Seneviratne, P. 1965).

The next major structural change in tertiary education came in the early 1970's, when by the Act No. 1 of 1972, the four universities plus the College of Technology at Katubedda were converted to five campuses of a single, centrally managed University of Sri Lanka. In 1974, with the establishment of a seat for tertiary education in the Jaffna Peninsula, the sixth campus was added to the University Complex. This same year Vidyodaya Campus became the third centre to start special degree course in Chemical Science. Earlier in 1973, the Department of Veterinary Sciences at the University of Peradeniya was transferred from the Faculty of Agriculture and Veterinary Science to the Faculty of Medical, Dental and Veterinary Sciences.

Apart from these major organizational changes under the provisions of the above Act, six institutes were created for specialized training and for post-graduate studies. Among these were the Post-graduate Institute of Agriculture, the Post-graduate Institute of Medicine and the Institute of Ayurveda. A separate organization called the External Services Agency was also established for the purpose of conducting the external examinations of the university.

It is significant to note that during the first 30 years (1942 – 1972) of the existence of the university system in Sri Lanka, only 12 students are recorded to have obtained post-graduate degrees in the fields of science (biology, chemistry, physics, veterinary sciences and agriculture) as against 102 post-graduates on the fields of social science and humanities. The absence of attractive post-graduate programmes, was a major short-coming in the tertiary education system, which promoted the flight of high calibre students to foreign universities for post-graduate work. It was hoped that the creation of post-graduate institutes for agriculture and medicine would arrest this trend.

In 1978 came the New University Act No. 16, which led to the creation of the University Grants Commission and a University Services Appeals Board. The latter is considered to be a unique step in the field of higher education, and is said to be the only one of its kind anywhere in the world. The new Act also had the provision for the conversion of the six campuses of the University of Sri Lanka into fully fledged autonomous universities (Fergusons Directory, 1984). The six new universities which came into existence on 1st January 1979 were as follows: The University of Peradeniya, the University of Colombo, the Univerisity of Kelaniya (former Vidyodaya Campus), the University of Sri Jayawardenepura (former Vidyalankara Campus), the University of Moratuwa (former Katubedda campus) and the University of Jaffna. In addition to these unversities, a University College established at Ruhuna in 1979 was transformed into the University of Ruhuna in 1984, and a University College established in Batticaloa in 1981 was upgraded this year as the Eastern University of Sri Lanka, to bring the total to eight universities. In addition to these, an Open

University was established in 1979, and a college affiliated to the Peradeniya University called the Dumbara campus came into existence in 1978.

During the past ten years to serve the needs of the country, several new faculties, departments and courses have been instituted in the areas of science, technology and medicine. Thus veterinary science which was first grouped with agriculture as a single department, was later affiliated to Medical and Dental Sciences at the Peradeniya University as the school of Veterinary Science and finally transformed into a separate faculty in 1980. More recently (from 1st October 1986) the School of Dental Science itself has been de-linked and up-graded to a Faculty. Since 1981, Peradeniya University's Medical Faculty has also expanded its fields of study by opening new departments for Oral Medicine and Periodontology, Oral Surgery and Oral Pathology, and Prosthetics. Computer Science is another area which has made major inroads to tertiary education with at least three universities offering degree courses in this subject. Agriculture, which was till recently available only at the University of Peradeniya, is now being offered both by the Ruhuna University and the Eastern University. There are also highly specialized courses in Microbiology (Kelaniya), Soil Science (Peradeniya), Food Science and Technology (Peradeniya) and Fishery biology (Ruhuna) (Kalpage, 1986). The new universities of Ruhuna and Batticaloa (Eastern University) are expected to expand considerably their areas of study in agriculture, medicine and natural sciences during 1987 (Kalpage, 1986). In the field of technology, the University of Moratuwa has added at least five new departments to its fold of activity since 1985, which include chemical engineering, materials engineering, mining and mineral engineering, textile technology, and now more recently computer science.

The growth of higher education in Science, Agriculture, Engineering, Medical Science, Veterinary Science and Dental Science, during the last few years can be seen from the data summarized in Table 2.1 below:

TABLE 2.1

TRENDS IN UNDERGRADUATE ADMISSIONS AND TURNOUT OF GRADUATES IN THE UNIVERSITIES OF SRI LANKA.

Field of Science	**Year**	**1975**	**1980**	**1984**
Agriculture	University admission	90	146	181
	Output of graduates	92	103	144
Dental Sciences	University admissions	50	58	65
	Output of graduates	50	32	42
Engineering Sciences	University admissions	310	476	667
	Output of graduates	214	187	182
Medical Sciences	University admissions	247	403	435
	Output of graduates	150	237	385
Natural Sciences	University admissions	579	739	1379
	Output of graduates	407	665	660
Veterinary Sciences	University admissions	NA	25	34
	Output of graduates	25	27	23

2.3 THE ORGANIZATIONAL FRAMEWORK FOR SCIENCE AND TECHNOLOGY

Outside the educational system discussed in the previous section, the organizational framework for science and technology can be considered to be made up of three major institutional components. These are:

(A) Institutions established for research, experimental development and scientific services.

(B) Institutions set up to promote science and technology and provide guidance to government on specific S&T policy issues.

(C) Professional S&T bodies.

2.3.1 INSTITUTIONS FOR RESEARCH AND SCIENTIFIC SERVICES

In Sri Lanka research and experimental development in the fields of science and technology are performed by a number of state organizations placed under different ministries. Atlhough there is no assigned agency for the overall planning and co-ordination of S&T activities, the plurality and diversity of organizational structures have not been a major barrier for the implementation of science based programmes.

In recent times however, due mainly to spin-offs from the gigantic multipurpose Mahaweli River development programme, certain microlevel sub-sectoral activities in agriculture, forestry, aquaculture, etc., have been partly de-linked from the traditional ministries and assigned to various functional agencies making it more difficult for the formulation of an integrated S&T plan.

Historically the foundations of organized scientific research were laid in Sri Lanka during the period of the British rule; the emphasis then being on public health, fishery and agriculture. The establishment of a Department of National Museums in 1893, the Bacteriological Institute in 1900 and the Ceylon Agricultural Society in 1904 were reflections of this policy (Wijesinghe and De Silva, 1981).

The Bacteriological Institute was later transformed into the Medical Research Institute, and the Ceylon Agricultural Soceity provided the nucleus for the establishment of the Department of Agriculture, and its network of regional experimental stations. The initial stages of agricultural research was conducted at the Royal Botanical Gardens which was established in 1822.

During the first quarter of this century a significant development took place in science and technology when the British authorities took the initiative to set up research institutes for the plantation sector. These were of course mainly to serve the British economic and trade interests, since the research policies of these institutes were very much influenced by the activities of what were later recognized as the "Scientific Advisory Committees" (for tea and rubber), based in London (De Silva, 1986).

The first such institute to be establlished was the Rubber Research Institute (RRI), which came into existence at Agalawatte in 1910. This was followed by the Tea Research Institute (TRI) at Talawakelle in 1922, and the Coconut Research Institute (CRI) at Lunuwila in 1928.

The beginnings of industrial research can be traced back to the creation of an Industrial Research Laboratory in 1941 and the Rubber Service Laboratory in 1948. The resources of these two institutions were later transferred to the Ceylon Institute of Scientific and Industrial Research (CISIR) in 1955, which then became the central agency for industrial research.

The main features of the R&D institutional framework in Sri Lanka may be summarized as follows:—

(A) Agriculture and Veterinary Science.

One of the most significant and biggest producers of scientific information in Sri Lanka is the **Department of Agriculture.** Established in 1912, and presently instituted under the Ministry of Agricultural Development and Research, this Department is responsible for the development and dissemination of new technology for the small farm sector in Sri Lanka. The Department of Agriculture consists of six technical divisions namely: Research, Extension, Education and Training, Farms & Horticulture, Agricultural Economics and Projects and the Royal Botanical Gardens. There are also three supporting divisions. The organizational chart in Figure 2.1 indicates the structure and linkages of the different divisions of the Department. The Research Division based at the Head Office in Peradeniya is responsible for the formulation of the overall national research strategy in respect of following categories of arable crops:

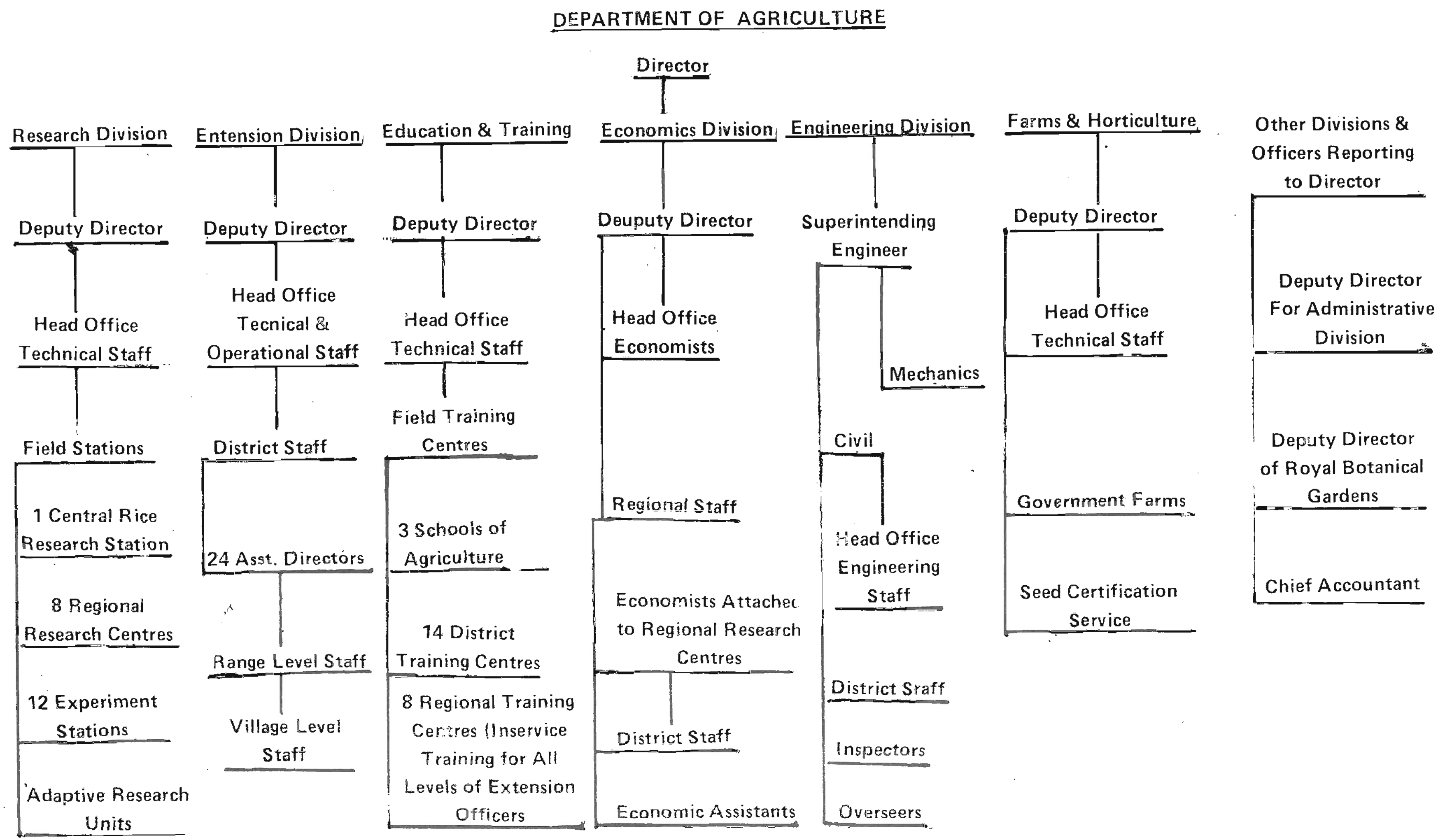
(i) rice, (ii) coarse grains (i.e. maize, millets, wheat and triticale), (iii) roots and tubers (i.e. potatoe, cassava, sweet potatoe, dioscoreas, colocasias, alocasias), (iv) grain legumes (i.e. mung, cowpea, black gram, soya bean, pigeon pea and chick pea), (v) condiments (i.e. chillie, onion, garlic, tumeric, fenugreek, cumin and fennel), (vi) agro-industrial crops (i.e. cotton kenaf, ground nut, sesame, castor, sunflower and safflower), (vii) horticultural crops (i.e. vegetables, fruits and cut flowers).

Agricultural research is conducted primarily on a regional basis, and for this purpose 8 major agro-ecological regions based on climate, relief and soils have been identified. Each of these major agro-ecological zones has a Regional Research Centre, supported by satellite experiment stations as indicated below:

Regional Research Centres			Satellite Stations
1.	Killinochchi (Northern Dry Zone)	— Coarse grain, grain legumes condiments, potatoes & vegetables	(a) Thirunelvely (b) Paranthan — Rice (c) Murunkan
2.	Maha Illuppalama (Central Dry Zone)	— coarse grain, grain legumes, agro-industrial crops, rice cultivation under poor irrigated systems & upland culitvation. Rice based system under tank-fed and rain-fed farming.	
3.	Karadiyan Aru	— rice, coarse grain, grain legumes rice based cropping system	

Figure 2.1

ORGANIZATION CHART OF THE DEPARTMENT OF AGRICULTURE – SRI LANKA



4.	Angunukolapelessa	– research on cotton improvement coarse grains, grain legumes, agro-industrial crops and rice based cropping system.	(a)	Ambalantota – rice breeding with emphasis on short duration, redpericarped varieties & salt tolerant varieties.
5.	Makandura (Low-country Intermediate Zone)	– rice based cropping system & intercropping under coconut.	(a) (b)	Wanathavillu – Kalpitiya – Regosol development.
6.	Bandarawela (Up-country Intermediate Zone)	– rice based cropping system, vegetables, potatoes, condiments, soya beans	(a) (b) (c)	Rahanagala – temperate fruits, vegetables, potatoes Monaragala – coarse grain & grain legumes Bibile – citrus
7.	Gannoruwa (Mid-country Wet Zone)	– vegetables, fruits, ginger, tumeric, root crop improvement, soya bean, fertilizer studies, food technology, cereal chemistry & bio-fertilizer.	(a)	Pussellawa
8.	Bombuwela (Low-country Wet Zone)	– rice breeding, root crops, low country vegetables	(a) (b)	Labuduwa–vegetables Bentota-rice bredding
9.	Girandurukotte	– determination of crops adapted to Mahaweli B&C systems.	(a)	Aralaganwila – systems C&B of the Mahaweli.

In addition to the Regional Research Centres and Satellite Stations, there are four special Research Centres:

I Batalagoda – Central Rice Breeding Station
II Sita Eliya Research Station (for potatoes and vegetables)
III Land and Water Use Division
IV Soil Conservation Division

Among the Regional Research Centres, the **Central Agricultural Research Institute** (CARI) at Gannoruwa, approximately 110 km from Colombo is the largest R&D complex of the Department. Inaugurated in 1967 and headed by a Deputy Director (Research), it has 8 divisions, each with a head of the division. The research programmes of the Institute are generally linked to the national agricultural development programme of the Department of Agriculture.

Among the other regional research centres, the **Dry Zone Research** Station at Maha Illuppalama take a special place, because its creation in 1903 predates even the formation of the Department of Agriculture. However, its failures during the initial phase to determine the most suitable crops for cultivation under rain fed conditions led to its closure in 1919. Several decades later when a number of dry-farming schemes were opened up in the North Central Province, it became clear that permanent farming could not be sustained without intensive scientific crop management. This led to the re-opening of the Maha Illuppalama Research Station in 1950, with a grant from the Government of New Zealand, to investigate cropping patterns for the two distinctly different ill-drained and well drained soil types of the region.

The Department of Agriculture also administer three botanic gardens situated in three agro-climatic regions and are supervised by the Superintendent of Gardens. Established primarily for the purpose of investigating into the flora of the country, and introduction of economic crops such as tea, rubber, cocoa and cinchona, these gardens have become centres for botanical research and floricultural development. All these gardens have representative collections of tropical and temperate plants from different parts of the world. The Royal Botanic Gardens established at Peradeniya in 1822 enjoys world-wide fame for its wealth of tropical vegetation. In fact until the Regional Research Centres were established during the second quarter of this century, the Royal Botanic Gardens was the nerve centre of agricultural research in the country.

The research findings of the Agriculture Department are disseminated through its Extension Services Division which is also headed by a Deputy Director. This division has a network of regional offices with several agricultural instructors attached to each regional office. The department is also assisted in its extension services by the Agricultural Information Division which prepares and distributes information packages to users.

Research in respect of animal husbandry and veterinary clinical work is carried out by the **Veterinary Research Institute (VRI)** situated at Gannoruwa. The VRI had its origin in the Veterinary Research Laboratory established in 1937, mainly for the purpose of disease investigations. By the early 1960's with the assigning of specific research disciplines to its small cadre of officers, the laboratory initiated multidisciplinary research activities. Finally in 1967 the Veterinary Research Institute was established with functional divisions for Animal Breeding, Animal Nutrition, Parasitology, Virology and Bacteriology, Pathology and Poultry Diseases. Since then two other divisions for Pasture and Fodder (1970) and Reproductive Disorders (1975) have been added.

In 1978, when the Ministry of Rural Industrial Development was formed, the VRI was moved out of the Department of Agriculture and instituted in the Department of Animal Production and Health under this new Ministry.

Livestock research is also carried out at the School of Veterinary Medicine and Animal Science of the University of Peradeniya, which later assumed the status of a Faculty in 1980. Its areas of research have been mainly on parasitology, pathology, diseases and reproductive physiology.

As mentioned earlier, research in the plantation sector is concentrated in the three crop-research institutes; **Tea Research Institute (TRI)**, **Rubber Research Institute** (RRI) and the **Coconut Research Institute** (CRI). These three institutions being statutory bodies enjoy a measure of autonomy with respect to most matters. Unlike the research stations of the Department of Agriculture and the VRI, whose finances are totally from government estimates, the crop research institutes receive government grants in addition to cess collections from exports of the products of the crops they serve. These institutions have their own extension services to transfer the know-how to growers. Each institution disseminates its findings through their respective quarterly journals and other bulletins.

The organizational aspects of these research institutions are comparable; there being several discipline-oriented divisions, each managed by a sectional head and assisted by several research officers. The research programmes are generally problem-oriented and designed to meet the demands of the respective plantation industries, but research interests of individual officers are also largely satisfied. Each research institute is managed by a Board of Management, with the Chairman functioning as a working or non-working director.

Over the past 15 years spurred by favourable international market trends, the demand for scientific cultivation, and management of many commercial crops such as sugar, spices, cocoa and coffee became evident. Consequently research activities in relation to agronomic and plant propagation work were initiated by the recently constituted **Sugar Research Institute** at Kantalai in respect of sugar-cane cultivation, and the **Department of Minor Export Crops** in respect of the other crops.

Apart from the national centres for scientific research in agriculture referred to above, an international research centre was established in 1982 to study the potential of the legume, popularly known as winged bean or dambala. Set up by a charter at Pallekelle in the Central Province, the **International Dambala (Winged Bean) Institute** commenced an ambitious research programme to develop new varieties of the legumes, considered by its specialists to be underutilized. Unfortunately due to lack of interest by funding agencies, this Institute has not been able to sustain its international status, and later the institute was re-constituted as a national research centre. This institute has been managed by a 10-member multinational Board of Directors, whose Chairman also functioned as the Director of the Institute.

Among the supporting institutions for agricultural development is the Department of Irrigation, which has as its main objectives, the development of water resources for its rational use in irrigated agriculture. The research wing of the department has six divisions and is headed by a deputy director. The Land Use Division has as its head a specialist scientific officer, who is assisted by soil chemists, soil surveyors, cartographers and other supporting staff. The research projects are specifically related to national programmes leading to the development of irrigated agriculture.

There is also the **Agrarian Research and Training Institute** (ARTI) which attempts to analyse, monitor and forecast trends in the economics and sociology of agrarian work. First established in 1972 by Act No. 5 and restructured by the Amendment Act No. 29 of 1981, the ARTI has been a key instrument for policy analysis in agricultural development strategies.

(B) Forestry, Wild Life and Fishery

Forestry research in Sri Lanka has not been very extensive. The **Forests Department's** research has mainly been in silviculture, entomology and timber utilization. However, over the last 10 – 15 years, university researchers have taken to the field in a significant way to investigate the micro-biology and forestry eco-system of some of the primary rain forests in the country. Associated with forestry, is the conservation of wild life. The enforcement of the fauna and flora protection ordinance is the responsibility of the **Department of Wild**

Life Conservation. A total of 6198 square kilometers (2,393 sq. miles) consisting of a little over 9 per cent of the total land area of the country had been proclaimed as protected by 1982. This is another area where scientific research has been trailing. Recently however, a scientific programme has been initiated by the Natural Resources, Energy and Science Authority of Sri Lanka to survey the fauna and flora of Sri Lanka with special emphasis on the endangered species.

The National Zoological Garden at Dehiwela is another national reserve associated with the conservation of wild life. It covers an extent of about 21.1 hectares (52 acres), and is considered to have the best collection of fauna in Asia.

The National Aquatic Resources Agency (NARA) is the main state sector research organization for fisheries. Established in 1981 by Act No. 54, it took over from the Fisheries Research Institute of the Ministry of Fisheries some of the key scientific work on fishery. Its main areas of activity include, coastal in-shore fishing, prawn fishery, coral reef management, ornamental fishery, fish-technology development; and geological, geophysical and hydrography surveys.

In recent years considerable interest has been generated in aquaculture and aquatic research, especially in the universities. Evidently the expansion of the university system, and the resulting proliferation of higher education in biological sciences, leading even to the establishment of specialized courses such as the fisheries biology course at the Ruhuna University, may have contributed to this new spurt of activity in this field.

(C) Health and Nutrition

In the field of health science, the **Medical Research Institute** (MRI) has the biggest laboratory complex for servicing the curative and preventive activities in the country. Established in March 1946, as the successor to the De Soysa Bacteriological Institute (Est. 1900) and the Pasteur Institute (Est. 1918), the MRI's activities have been categorized as follows: (1) Routine diagnosis, (2) National Reference Laboratory (3) Diseases surveillance and other public health activities, (4) Production of vaccines, (5) Teaching and training, (6) Laboratory services stores, and (7) Research. It has at least 14 important divisions for virology, vaccines, rabies diagnosis, entomology, natural products, biochemistry, parasitology, pharmacology, bacteriology (and serology), mycology, food and water, leptospirosis, nutrition and pathology. The Institute is headed by a director and its organization is typical of a government department. In spite of its excellent laboratory facilities, its research function is relatively small, there being no departmental allocation of funds for research. The formulation and selection of research programmes is solely by individual staff members who solicit funds from external sources for their research activities.

In 1962, by the establishment of the **Bandaranaike Memorial Ayurvedic Research Institute** at Nawinna, an attempt was made to give a scientific thrust to the indigenous medical and health-care system in the country. Until recently this Institute had only a part-time director as the chief executive. The main divisions of chemical research, drug research and literacy research, have been seriously affected by shortages of trained personnel.

It is however, relevant to mention that the medical faculties of the universities, the **National Institute of Health,** the **Anti-Malaria** and **Anti-Filaria Campaigns,** and the **Food and Nutrition Division of the Ministry of Plan Implementation** also carry out health-related research programmes.

(D) Industrial and Mineral Resources

Research and experimental development work in relation to the development of industrial activities, and the exploitation of mineral resources are mainly carried out by the S&T organizations of the Ministry of Industries and Scientific Affairs. The major scientific and technological institutions in this Ministry are:

(a) Geological Survey Department
(b) Ceylon Institute of Scientific and Industrial Research (CISIR)
(c) National Engineering Research and Development (NERD) Centre
(d) Atomic Energy Authority
(e) Sri Lanka Standards Institute

The **Geological Survey Department** was instituted in 1962 as the successor to the Mineral Survey of Sri Lanka, established in 1903. Over the years its main functions changed from surveys of economic mineral resources to geological survey and geological mapping. The Department is headed by a director, and includes a deputy director, a staff of 10 geologists, 2 chemists and a geophysicist. In recent years it has ventured on an exploration programme on raw materials for nuclear energy. It has also been engaged in the study of heavy mineral potential and copper-magnetite deposits in the North Eastern regions of Sri Lanka, and a study of the coral and dolomitic limestone deposits of the country (Jayawardene, 1986). Unfortunately, like for most other similar government departments, the Geological Survey Department also suffers from a lack of budgetary allocations for scientific research. However, with the creation of the **Geology Department at the University of Peradeniya,** and the entry of its academics into the area of scientific research new grounds have been broken, especially in characterizing the mineral composition of water resources and the studies on geological formations.

The Ceylon Institute of Scientific and Industrial Research, which is the largest industrial research organization in the country, was set up in 1955 to provide the industry with expertise and services for the development of industrial processes, testing and quality control. It has 16 research divisions and is headed by a director, who is assisted by the Deputy Director for research. A Research Planning Council composed of heads of technical sections, as well as outside specialists in science, engineering and industry, advises the Governing Board of the Institute on all matters pertaining to planning of scientific research. The research findings of this Institute are generally put out in the form of reports or as bulletins. A serious drawback is the lack of a technical journal for the Institute to publicize its important research findings.

The National Engineering, Research and Development (NERD) Centre was established in 1974 to promote technological research and experimental development. Among its main objectives are the following:

(a) To provide institutional mechanism for progressive development of indigenous technology, through co-ordination of technological, engineering and research capabilities of various public and private sector industries.

(b) To advise and assist adoption and assimilation of technologies that are consistent with the country's resource endowment and design, manufacture and testing of protype machinery or pilot plants.

In 1978 after the NERD Centre offices were moved to the Ekala Industrial Estate at Jaela, permanent facilities and buildings were constructed which included a basic workshop and laboratory.

The Chairman of the Board of Management is the Chief Executive, and under him are eight divisional heads for Electrical and Electronics, Process Plant and Agricultural Machinery, Machinery Development and Technical Services, Solar Energy, Techno-Economics, Wind and Bio-Energy, Chemical Engineering and Civil Engineering.

The Atomic Energy Authority (AEA) was established in 1969. Its main function is to develop the necessary resources for the utilization of atomic energy for economic development. It also maintains a national radiation protection service to enforce atomic energy regulations. With the assistance from the International Atomic Energy Agency, it has awarded several research grants for work in the agricultural, medical and veterinary clinical fields using nuclear techniques. In recent years it has also helped in dating archaeological finds using modern carbon dating techniques.

The AEA with the aid of the Radioisotope laboratory at the University of Colombo has embarked on a post-graduate training programme in nuclear physics and chemistry, with the long term objectives of establishing a technical manpower pool capable of studying, evaluating and if required establishing and operating nuclear power generators.

The Authority comprises of a working Chairman and six members who constitute the Board of Management, and a technical staff of scientific officers.

The **Sri Lanka Standards Institute** was constituted in 1984 as the successor to the Bureau of Ceylon Standards which was first established in 1964. Its main responsibilities are to prepare and implement standard specifications of both industrial and consumer products. It administers its own certification marks scheme and export inspection programme.

The Institute is headed by a Director, who is assisted by five Assistant Directors and several senior standards officers and others dealing with standards, testing textile technology and statistics.

Apart from the scientific institutions discussed above, the Industries Ministry has 40 manufacturing and service-providing corporations, many of which are not oriented to perform R&D activities. The scientific personnel attached to these corporations are mainly concerned with quality testing and monitoring for quality control.

However, in September 1984, the **Ceramic Corporation** established a well equipped laboratory at Piliyandala, for quality testing, scientific research and experimental development work. It has seven technical divisions in respect of X-ray and Thermal Analysis, Microscopy, Pilot Plant, Kiln Room, Physical Testing, Chemical Work and the Library, each with one Senior Research Officer and two Research Officers. The objectives of this laboratory system are, (1) to investigate availability and usage of local raw materials, (2) to develop new non-metallic inorganic products through firing processes, e.g. ceramic ware, porcelain cement, glass, heavy clay products and electronic items, (3) to investigate and develop new technologies in respect of the ceramic industry, (4) to service the industrial and scientific sector.

The **Industrial Development Board** (IDB) can be considered as the main extension services wing of the government, on matters pertaining to small and medium scale industries. Established under the Industrial Development Act No. 36 of 1969, the IDB was earlier under the Ministry dealing with major industries. However, now it functions under the more appropriate Ministry of Rural Industrial Development. The IDB is managed by a 9-member Board of Directors whose Chairman is the Chief Executive. With eight functional divisions each headed by a Director, the IDB provides a package of integrated services for small and medium scale industries covering (1) industrial information, (2) identification of industrial opportunities (3) identification of raw materials (4) marketing adivice and assistance (5) feasibility studies (6) technical assistance (7) engineering services (8) workshop and foundry facilities (9) management training and consultancy (10) entrepreneur development (11) product development (12) factory space and (13) graphic designs.

(E) Other Scientific Services

There are several other scientific and technological service organizations performing small components of R&D. Among these may be mentioned the **State Engineering Corporation (SEC)** with a subsidiary unit known as the **National Building Research Organization**, the **Ceylon Engineering Consultancy Bureau (CECB)**, the **Mahaweli Authority** and its various agencies, the **Government Analysis Department**, the **Telecommunication Department**, the **Water Resources Board**, the **Ceylon Electricity Board (CEB)** and the workshops of the state run railway and omnibus transport services.

Most of these organizations do not have specified allocations of funds for scientific research, but carry out investigative work either as part of the service functions they perform, or because of personal interest of individual workers.

Before concluding this section it is necessary to mention the scientific services provided by the **University system** in Sri Lanka. Unlike in most industrialized countries, universities in Sri Lanka have only a meagre budgetary allocation for scientific research. Hence, university researchers seek outside sources for research funding. Over the last 15 years or so, simultaneously with the expansion of the tertiary education system in the country, the research effort also increased steeply (see chapter 3). As could be expected research activities of universities are largely geared to the training of young scientists in research methodology, and hence mainly academic in nature. However, in recent years there has been an increasing tendency for university academics to establish linkages with industry for technical work and creative research.

2.3.2 INSTITUTIONS GUIDING POLICY PLANNING IN SCIENCE AND TECHNOLOGY

The creation of the **National Science Council of Sri Lanka (NSC)** in 1968 under the Ministry of Scientific Research and Housing was the first major step by the government to initiate science planning. The Council had the mandate to advise the Minister in charge of scientific affairs on the formulation of Science Policy and the application of science and technology for development. As an initial step in this direction the NSC commenced in 1970 a scheme to award research grants to young scientists. By this means it was hoped that the Council would be able to build the necessary research capability in the young scientific talent. As would be expected this research grants scheme was a boon to the researchers of the universities who were virtually without any resources for research. In fact 80—90 per cent of the funds allocated by NSC for scientific research went to the universities. Between 1976 and 1982 the Council sought the assistance of a Committee of Specialists to advise it on matters pertaining to S&T Policy. This Committee known as Statutory Working Committee on Science Policy Research formulated a policy framework for S&T which was accepted and promulgated by the grovernment in 1978. In 1982 when the NSC Act was repealed and in its place the **Natural Resources, Energy and Science Authority** (NARESA) was created, all activities previously carried out by the NSC were transferred to the new Authority. With this change, its hierarchial position in the government's organizational structure was also changed, when it was moved out of the Ministry of Industries and Scientific Affairs and placed under the Presidential Secretariat. Between 1970 and 1984, NARESA's grant-awarding scheme had produced 70 M.Sc's, 6 Ph.D's and over 150 scientific publications out of a total of 261 completed grants (De Silva, 1986).

NARESA also established two specialized glass-blowing units and a well equiped workshop for the maintenance and repair of electronic equipment to serve all scientists. It also established the Sri Lanka Scientific and Technical Information Centre which is the nerve centre for the network of scientific libraries in the country.

During the last few years NARESA has been actively engaged in policy analysis studies and surveys of scientific resources which are key policy instruments for science planning.

The Authority consists of 11 members, whose Chairman is the Director-General of the organization.

The **Central Environmental Authority** (CEA) was established by the National Environmental Act No. 47 of 1980 for the main purpose of controlling, monitoring and planning ecological and environmental issues in the country. It is also responsible for the formulation of national environmental policies, and consequently undertake surveys to study causes, nature and extent of polution as seen for example, in their studies on the Hunupitiya Fertilizer Complex, Hikkaduwa Tourist Development and the Kelani River Polution issue. It also conducts and co-ordinates ecological and environmental research.

Since the early 1970's the need for a Institute of Theoretical Studies had been foremost in the minds of many physicists and mathematicians. In fact the justification for the creation of such a centre, and the manner in which such an institute should be built and developed was extensively studied and reported by a small committee of scientists. Although the findings of this study were not implemented, the ground was prepared for the growth of its ideology, whence in 1981 by Act No. 55, the **Institute of Fundamental Studies** (IFS) was established. After a shaky initial phase, this Institute got into full operation in Feburary 1984. Its areas of work covered, earth and space science, Life science, Physical and chemical sciences, Philosophy and mathematics. Among its major activities are the monthly public lectures, and the weekly research colloquia which are meant to create public awareness of science. The institute now has its own laboratories and is engaged in an extensive research programme with foreign collaboration. It initiates and sponsor scientific research, but unlike NARESA, the research programmes of IFS are on very specific issues, identified by the organization.

2.3.3 S&T PROFESSIONAL BODIES

Sri Lanka is one of the few examples of developing countries in which learned societies have made tremendous impact on moulding and guiding the structure and organizational framework of science and technology in the country. Many of these societies have been held in high esteem by successive governments resulting in a close rapport between the state and scientists. Hence their role and status in the country's scientific and technical organizational structure has to be given due recognition.

Professional bodies in science and technology can broadly categorized into two groups:

(a) Discipline-oriented societies and associations established for the purpose of fostering scientific interaction, creating interest in the relevant disciplines and hence promoting the advancement of the profession.

(b) Academically-oriented professional institutions in which conferment of membership bestow on its contituents a professional qualification or recognition.

(a) Scientific Societies and Associations

Among the scientific associations, the **Sri Lanka Association for the Advancement of Science (SLAAS)** takes a special place for several reasons. It is the largest and most representative body of scientists in the country. Formed in 1944, it pioneered the agitation for recognition of scientists and technologists as participants of the country's development planning machinery. In this effort, the SLAAS was able to induce the government to create an apex organization for science planning i.e. the National Science Council of Sri Lanka (De Silva, 1986). With over 2000 members, the SLAAS encompasses all fields of science including medical, engineering and social sciences.

The SLAAS is considered the brain child of the **Chemical Society of Ceylon**, which was itself formed four years earlier in 1940. The ability of this Society to bring together scientists, engineers, medical personnel and social scientists under one banner was indeed a remarkable achievement. The Chemical Society has also a chequered history, since it is said that in 1942, the Society had been able to induce the British Governor of that time, to give formal recognition to the appointment of a "Scientific Advisory Committee" proposed by the Society (Institute of Chemistry, 1986). However, in 1971 after 30 years of productive existence, it was replaced by the academically oriented **Institute of Chemistry**.

The **Sri Lanka Medical Association (SLMA)** was formed in 1951 as the successor to the **Ceylon Branch of the British Medical Association** which was itself established in 1887. There are several other societies for the medical profession, for example the **Sri Lanka College of Obsteristics and Gynecologists, College of General Practitioners of Sri Lanka, College of Surgeons, College of Anaesthesiologists, College of Pathologists of Sri Lanka, Society of General Practitioners** and the **Indepedent Medical Practitioners Association of Sri Lanka**. The other professions are also well organized as for example, the **Sri Lanka Veterinary Association**, the **Sri Lanka College of Microbiologists**, the **College of Community Dentistry of Sri Lanka**, the **Sri Lanka Dental Association**, the **Agricultural Society of Sri Lanka** and the **Soil Science Society of Sri Lanka**.

(b) Professional Institutions

The oldest professional institution is said to be the **Institute of Engineers**. First established in 1906 as the Engineering Association of Ceylon, the Institute of Engineers is also the first scientific organization to offer professional qualifications to its members. Presently it has a membership of over 3000.

The **Institute of Chemistry** which succeeded the Chemical Society of Ceylon in 1971 is the professional body for the area of chemical sciences. Like the Institute of Engineers, the Institute of Chemistry offers several types of training programmes in chemical sciences to create a professional attitude towards this subject. In fact in 1977, the government accepted the conferment of the membership of Fellows, Associates and Graduates of the Institute of Chemistry as equivalent to corresponding grades of membership of the Royal Society of Chemistry of Britain. The present membership of the Institution is about 450. Parallel to the Institute of Chemistry is the **Ceylon Branch of the Royal Soceity of Chemistry.** The members of this body are those who have obtained the relevant membership grades of the Royal Society of Chemistry (U.K.).

Over the past few years two other professional institutes have been formed for Physics and Biology. These have not embarked on professional training yet. But it is presumed that in the years to come, these two institutions will also follow the example set by the Institute of Engineers and the Institute of Chemistry.

The common feature of these professional associations and institutions is the staging of annual scientific conventions or sessions to promote the interaction of professionals in their respective fields.

In this Chapter an attempt has been made to illustrate broadly the structural and functional features of the scientific and technical organizational framework in the country, with brief references to the historical processes which led to its creation. It is evident that inspite of over 450 years of colonial domination, during which an advanced culture and civilization was progressively eroded, a stable scientific system had emerged, which was capable of meeting the challenges of a modern society. As pointed out earlier, the multiplicity of organizational patterns, the diversity in the mechanism of operation and the plurality of the administrative approach, have not been a hindrance to science planning. However, it has to be surmised that a coherent and co-ordinated system could lead to a more efficient deployment of the limited resources of the country.

Chapter 3

FINANCIAL SUPPORT FOR RESEARCH AND DEVELOPMENT

3.1 GENERAL TRENDS

The support for research during the last decade has increased sharply and has now reached an all time high. Particularly, the funds from the government and foreign sources have shown a remarkable increase. The total R&D expenditure has increased by nearly five times from Rs 45 million in 1975 to Rs 257 million in 1984. However, this investment measured in terms of constant 1975 prices[2] shows only a marginal rise from Rs. 45 million in 1975 to Rs 78 million in 1984. The cost of research has escalated dramatically due to rising prices of consumables and materials. The decreasing value of research funds has affected some areas of science more seriously than the other areas. The analysis of financial investment needs to take into account differences and changes in the growth of different disciplines. This chapter reviews the significant changes in research funding and spending strategies of R&D institutions. It also examines the nature of research undertaken in R&D institutions, and the research intensities of different sectors, by evaluating the funding and spending patterns of national S&T institutions.

The public sector was responsible for maintaining national R&D service, and its funding strategy governs the progress and direction of science and technology in the country.

The Private Sector and the Higher Education Sector were responsible only for a very small portion of research effort in the country. The universities are generally regarded as centres for basic research, and a rich source of qualified manpower are available for R&D activities.

However, the shortage of funds for research, and the high rate of migration have retarded the research effort in the universities. The allocation of research funds from university sources was negligible, in contrast to the situation in advanced societies.

The research interests in the private sector had declined due to the weakening of the manufacturing industries[3]. The liberalized imports – exports policy, and lack of differential tariffs for imports have been disincentives for the performance of R&D in the private sector institutions. The private sector accounts for only 7 per cent of the R&D expenditure

2) Based on implicity Gross Domestic Product deflators (source Central Bank, 1986).

3) According to Central Bank statistics, manufacturing industry contribution to economy has increased marginally. The industrial output is estimated to have increased by 5 per cent in 1985 and 15 per cent in 1984 measured in real terms (Central Bank Annual Report, 1985).

in the country. The level of R&D effort in the private sector has remained virtually unchanged during the past 10 years.

The research activities in Sri Lanka are primarily conducted at state owned or state controlled agencies; and these are performed in the different sectors of economy, which range from traditional agriculture and plantation crops to management and policy research. Over the last 15 years or so there has been a significant proliferation of governmental and non-governmental scientific organizations in the country, some of which have been responsible for nourishing and catalysing the consciousness and growth of scientific research. The intensity of research performed by these organizations differ vastly. Certain specialized research institutions such as the Coconut, Rubber and Tea Research Institutes, which have had a long standing reputation as research-intensive organizations, continue to maintain their pace of activity in applied research in the export oriented plantation crop industries.

3.2 FINANCIAL RESOURCES DEVOTED TO R&D DURING 1984

The expenditure incurred in R&D activities by the private and public sector institutions is a measure of the research effort in various sectors of the economy. In terms of broad economic perspectives, the Agriculture, Fishery and Forestry Sector has been the most active, contributing 27 per cent to the Gross Domestic Product and utilizing about 50 per cent of the employed labour force.

Nearly 60 per cent of the foreign exchange earnings in 1984 was from Agriculture, Forestry and Fishery Sector (Central Bank, 1984). The national commitment to agricultural research remains strong.

The estimation of R&D expenditure in various institutions is a tedious task. There are various methods for accounting R&D expenditure. In many cases, the separation of R&D expenditure from other related scientific activities, which are closely associated with R&D activities is difficult. This is particularly so for those institutions where research is a minor activity, and where extraction of data becomes an unreliable exercise. It is common for most institutions to link R&D activities with other related activities such as quality control, testing, consultancy, teaching and library services. Thus for example in the case of the Medical Research Institute, the work component for such related S&T activities well exceed the quantum of R&D work.

R&D expenditure presented in this study is the actual expenditure incurred for 1984 and excludes the expenditure on related R&D activities. All R&D performers were included in the study.

3.2.1 MAJOR PERFORMERS OF R&D ACTIVITIES

A total of about 131 private and public sector institutions are involved in research activities. Of these 64 major institutions perform R&D on a regular basis, though only 36 of these have a separate R&D budget. Some of the major R&D performers have under their hold several units which are administratively independent, though financial control is centralized. For example, the Dept. of Agriculture which has regional centres of research in 9 agro-climatic regions. Likewise the National Aquatic Resources Agency and the plantation research institutions have substations which are both administratively and financially managed centrally. Nearly half of the major R&D performers fall into the Agriculture, Forestry and Fisheries Sector.

The state sector institutions continue to dominate the research scene in the hard sciences. There are however, private sector institutions conducting scientific research in the area of industrial and social sciences. In the absence of strong government interest for social science research, private foundations and non-governmental organizations have captured a large share of foreign funds available for social science research. Table 3.1 illustrates the commitment of state and private sector for scientific research in 1984.

TABLE 3.1

GROSS NATIONAL R&D EXPENDITURE BY SECTOR AND TYPE OF EXPENDITURE DURING 1984 (nearest Rs '000)

Sector/Type of Exp.	Recurrent		Capital		Total	
State	161533	(67%)	77876	(33%)	239409	(93%)
Private	12802	(74%)	4588	(26%)	17390	(7%)
	174335	(68%)	82464	(32%)	256799	(100%)

These figures show the extent of State influence in directing of scientific research. This would also mean that the State policies related to science development have a profound impact in building a viable S&T structure in the country.

The development of science and technology in the country depends on the selection of research themes and problems by the state sector institutions, and the effectiveness of such research, needs to be assessed to determine the rate of return. It is unfortunate that some important sectors such as energy, communication and transport have shown very little interest in undertaking research and innovation. For example, the major energy producing and processing agencies such as the Ceylon Electricity Board and the Petroleum Corporation were slow to invest in R&D. The Department of Telecommunications has not invested in R&D activities, and it functions mainly as a service institution. The tendency for new innovations and high risk investments were not prominent. The research activities in most sectors were carried out without proper planning and evaluation of new areas of products and processes. The private sector industries depend on non-technological parameters for productivity growth and have limited investments on new technological changes. As a result the inhouse R&D activities in many institutions remain at a low level.

3.2.2 R&D EXPENDITURE BY SECTOR OF PERFORMANCE

R&D institutions can be categorized into three major sectors of performance. These are:—

(a) General Service Sector

(b) Productive Service Sector

(c) Higher Education Sector

The separation of R&D institutes into these three sectors is important because of the apparent difference in the objectives of research carried out by institutions in these sectors. For example, the research effort in the Higher Education Institutions is academic in character and devoted to the advancement of scientific knowledge, whereas the institutions in the Productive Sector concentrate on the application of research knowledge for productivity improvement, hence mainly involved in applied research and experimental development work. The objectives of institutions which fall within the General Service Sector, on the other hand, are concerned with the general economic and social development. The research activities undertaken by this sector aims at fulfilling the needs of a large number of users. The distribution of R&D expenditure according to the sector of performance is given in Table 3.2.

TABLE 3.2

R&D EXPENDITURE BY TYPE OF EXPENDITURE & SECTOR OF PERFORMANCE DURING 1984 (nearest Rs '000)

Sector/Type of Exp.	Recurrent		Capital		Total	
General Service Sector	143840	(66%)	72503	(34%)	216343	(84%)
Productive Sector	15980	(66%)	8338	(34%)	24318	(10%)
Higher Education Sector	14515	(90%)	1623	(10%)	16138	(6%)
	174335	(68%)	82464	(32%)	256799	(100%)

About 84% of the expenditure has been incurred by the General Service Sector institutions. Both Productive and Higher Education Sector institutions have incurred relatively a low proportion of national R&D expenditure. The recurrent R&D expenditure averaged 68% of the total R&D expenditure. The proportion of recurrent expenditure in the General Service Sector institutions and Productive Sector institutions has been more or less the same. The exact research expenditure incurred by the Higher Education institutions was difficult to quantify. R&D expenditure in the universities were identified according to:—

(1) the direct R&D expenditure incurred on specific R&D projects.
(2) the indirect expenditure of academics salaries and services, incurred on R&D activities. The time devoted to R&D activities was taken as a measure to estimate the indirect R&D expenditure.

Some of the capital equipment received as gifts and donations by the universities are not reflected in the capital expenditure cost in universities. The exact expenditure on research equipment in the universities was also difficult to separate from the university budgets. Neither a separate budget nor an accounting system was available for research in the universities. The university research funds originate mainly from non-university sources, and is provided by various donors.

The General Service Sector emerges as the major contributor to the national R&D system. The under-investment in research in the Productive Sector indicates a disinterest towards innovative capacity of productive enterprises. The transfer of research knowledge from the General Service Sector institutions to Productive Sector institutions is an important channel for promoting potentially useful innovations in the country. The linkages between General Service Sector institutions and the Productive Sector institutions are vital to sustain a flow of research information. In fact, the weakest point in the country's R&D system could be identified as the interaction between producers and users of research knowledge.

3.2.3 NATIONAL RESEARCH EXPENDITURE BY FIELD OF SCIENCE

The national R&D effort is heavily biased towards agricultural sciences. This trend not only reflects the continuing support for a strong agricultural economy, but also the government's policy on food and nutrition. The Agriculture, Forestry and Fisheries Sector accounts for nearly 60% of the total R&D investment in the country. This percentage can be even higher, as the research expenditure in the natural and engineering sciences can directly or indirectly serve the needs of the agricultural sector. The research investments in the natural sciences, engineering sciences and social sciences remained more or less at the same level. The medical sciences have shown the lowest investment in R&D, and accounted for about 5% of the total R&D expenditure. One of the reasons for the low investment in medical research could be the weakness in research infrastructure. The Medical Research Institute for example, functions primarily as a medical service institute and a reference laboratory rather than as a research institute. The major performers of research in the medical sciences are the universities.

TABLE 3.3

R&D EXPENDITURE ACCORDING TO THE FIELD OF SCIENCE AND TYPE OF EXPENDITURE DURING 1984 (nearest Rs '000)

Field of Science/ Type of Exp.	Recurrent		Capital			
	Salary	Other	Equip.	Other	Total	
Nat. Sc.	11539	8776	9114	1310	30739	(12%)
Agr. Sc.	62505	45239	23386	22324	153454	(60%)
Eng. Sc.	7684	6118	11587	7378	32767	(13%)
Med. Sc.	3358	6013	2689	1239	13299	(5%)
Soc. Sc.	10676	12427	2085	1352	26540	(10%)
	95762(37%)	78573(31%)	48861(19%)	33603(13%)	256799	

The personal emoluments account for about 37% of the total R&D expenditure or 55% of the recurrent R&D expenditure. Generally, the high cost of chemicals and other consumables, and the cost of maintaining auxiliary services such as electricity, have been responsible for a large share of recurrent R&D expenditure. The medical, engineering and social sciences show a relatively higher outlay on "Other" recurrent expenditure than in the case of the agriculture and natural sciences.

It is important to note that the proportion of personnel emoluments of recurrent expenditure has dropped from about 70% for the period 1965 – 1975 to about 47% for the period 1983 – 1984. It suggests that the rate of increase in wages was much lower than the rate of increase in other recurrent costs. The cost of scientific equipment also has increased at a high rate.

3.3 RESEARCH EXPENDITURE IN THE STATE SECTOR INSTITUTIONS

Among the State Sector research performers, at least four categories of institutions can be identified. They are the:

(a) Government Departments & Ministries
(b) State Corporations & Statutory Boards
(c) Research Institutions
(d) Universities & Higher Education Institutions.

The resource allocations to scientific research by the government institutions such as the Ministry of Plan Implementation, Ministry of Health, Ministry of Fisheries, Geological Survey Department, Government Analyst Department, Meteorological Department, Survey Department, Irrigation Department and Forest Department are small. These institutions are mainly involved in the S&T services rather than research activities. There is no separate allocation for research in most of these institutions. The research and development work in these departments is usually undertaken along with other related S&T activities. Hence, the identification of R&D expenditure incurred by them from their budgets is difficult. The only government department which carries out research as a priority function is the Agriculture Department. The second category of institutions include the government supported, semi-autonomous institutions such as the statutory boards and state corporations. They are involved in R&D activities to service their products and production processes. The state corporations such as Steel, Ceramic, Cement, Borewood, Cashew and Silk & Allied Products are involved in research and development activities to upgrade their products.

Among the most prolific research performers are the state run research organizations. Research Institutions for Tea, Rubber and Coconut research, and the Sugarcane Research Institute are among these research organizations.

The state universities in the country are also actively involved in research in various fields. The technical colleges are not involved in research work. It is observed that the state research institutions account for nearly 80% of the total R&D expenditure in the country. In general it was noted that 15 major organizations were responsible for setting priorities in research, and directing S&T development in Sri Lanka. As discussed in chapter 2, major research institutions were established to meet the economic strategies of selected agricultural commodities in the country. Table 3.4 shows the manner in which these organizations contribute their research effort (measured in terms of allocation of funds for research), to three vital sector of the economy.

TABLE 3.4

R&D EXPENDITURE OUTLAY OF 15 MAJOR RESEARCH PERFORMERS TO THREE SECTORS (nearest Rs '000)

	Recurrent		Capital			
	Salary	Other	Equip.	Other	Total	
Agr. & Animal Husbandry	59002	43496	14440	14968	131906	(71%)
Forestry & Fishery	2445	1269	1526	7475	12715	(7%)
Industry	12540	5216	15284	7346	40386	(22%)
	73987	49981	31250	29789	185007	(100%)

(Gross Research & Development Expenditure Rs 256799/-).

Among the major R&D performers, 12 major R&D institutions servicing the Agriculture, Forestry and Fishery sector received nearly 77% of the research allocations. Industrial research sector received 22% of R&D funds which were distributed among three industrial research institutes. R&D activities undertaken in these three industrial research institutes were hardly sufficient to provide industrial innovations and technical support needed for an expanding industrial sector. The state intervention in industrial R&D was insufficient, with little or no incentives to develop inhouse research capabilities in industries. The lack of tax concessions for R&D investment, and protective tariffs for high risk locally manufactured products and processes may be a significant factor for the low indigenous industrial growth.

3.4 CHARACTER OF RESEARCH AND DEVELOPMENT ACTIVITIES

The character of research performed in the country can be categorized according to the objectives of research as Basic, Applied and Experimental Development. Basic research activities are those without a specific practical application in view, and are conducted to accumulate and advance the pool of scientific knowledge.

Applied research is undertaken with a specific aim in view and are more problem-oriented. Applied research intends to solve a specific user need. Experimental Development activities are undertaken to test the feasibility, or put into practical use the knowledge generated by Basic and Applied research. It is a necessary intermediary in the development of products and processes, and may in fact involve a chain of activities, consisting of engineering design, fabrication,erection and commissoning of prototype and pilot plants.

In general the ratio of Basic, Applied and Experimental Development expenditure for U.S., Japan, France, U.K., Netherlands and Norway was in the region of 1:2:4. This shows the heavy concentration of expenditure in Experimental Development activities. However, in developing countries such as Malaysia, Philippines, India, Sri Lanka, Mauritius the ratio of Basic, Applied and Experimental was approximately 1:5:2 and this indicates heavy concentration on Applied research with relatively low expenditure in Experimental Development. It is important to note that the Basic research components do not differ for the above mentioned developed and developing countries. Average allocation for Basic research was 15% for developed countries and 14% for developing countries.

3.4.1 BASIC RESEARCH

The Basic research component in the R&D activities in Sri Lanka is not very high. It was believed that the establishment of an Institute for Theoretical Studies might provide the necessary impetus for Basic research. It is these considerations which ultimately led to the establishment of the Institute of Fundamental Studies.

Basic research expenditure in 1984 was 10% of the total R&D expenditure, whereas applied research had consumed 72%. Experimental Development activities had taken 18% of the total R&D expenditure. However, the proportion of R&D expenditure spent on basic research was somewhat lower when compared with some selected industrialized countries (about 16%) as shown in Table 1.2.

Basic research components in the Higher Education institutions were generally high, being about 50% of recurrent expenditure. In the General Service Sector institutions it was of the order of 8% of the total expenditure, and in the Productive Sector, it was only about 1% of the total expenditure. It is important to note that most researchers even in the Higher Education Sector are reluctant to undertake basic research mainly due to inadequate facilities and the high prices for services at reference laboratories abroad.

3.4.2 APPLIED RESEARCH

Most developing countries are known to concentrate on problem-specific research, and this has led to the debate on what should be the desirable ratio of applied and basic research that should be maintained in the R&D system. Generally applied research component is high in developing countries. About 80 – 90% of research and development funds in developing countries are directed towards applied research (Pardee & Moravcsik, 1982). Some have argued that most research problems selected by third world researchers are not directly relevant to the socio-economic needs of their countries, and that they are directed towards imitating western scientific traditions. Whilst others have argued that basic research is vital for developing countries to establish a stable scientific base. Scientists in third world countries while being conscious of their responsibilities are also anxious to contribute to the international character of science and technology. Thus a rational balance has to be struck between basic and applied research for the production of scientific and technological knowledge, and their optimal utilization for the social needs.

In Sri Lanka most of the state sector research institutions have concentrated on problems of an applied nature. This was evidently necessary to advance and sustain the traditional agricultural economy. However, if a shift towards an increased industrial economic growth is expected, a conscious effort will have to be made to change the investment pattern of research to strengthen industrial R&D.

The level of applied research in the General Service Sector was very high (74%), and the Higher Education Institutions have also undertaken a high proportion of applied research (40%). The Productive Sector Institutions have allocated about 81% of resources to applied research.

3.4.3 EXPERIMENTAL DEVELOPMENT ACTIVITIES

The experimental development activity in the country was noticeably low. In particular, industrial research demands a greater sponsorship for experimental development work in order to transfer results of basic and applied research to practical applications. The Industrial Development Board, the Ceylon Institute for Scientific and Industrial Research and the National Engineering Research and Development Centre were established with a view towards transforming R&D knowledge generated by research institutions to useful products and processes. However, these institutions had limited impact on fulfilling this task and were unable to meet this challenge, apparantly due to lack of adequate financial and human resources, as well as the absence of an industrial research strategy. Most research institutions concentrate on applied research than on experimental development work. Hence there is a apparent lacuna in the commercialization and marketing of research results.

Table 3.5 provides the composition of R&D expenditure according to character of S&T. It is however, satisfying to note that over the period 1975 to 1984, there has been a substantial increase in the investments on basic research and experimental development work. Basic research has increased at an average annual rate of 98% for this period, while the corresponding rate of growth of expenditure for applied research and experimental development was 48 and 39 per cent respectively. Basic research effort was considerably high in the medical sciences. Among the natural science fields the investment on basic research problems is high for chemical sciences.

TABLE 3.5

R&D EXPENDITURE ACCORDING TO BASIC, APPLIED & EXPERIMENTAL DEVELOPMENT PERFORMANCE OF RESEARCH (1984) (nearest Rs '000)

Type of Activity	Basic	Applied	Exp. Dev.
Natural Science	5254 (22%)	21720 (12%)	3765 (08%)
Agricultural Science	11841 (48%)	111495 (61%)	30118 (64%)
Engineering Science	117	20619 (11%)	12031 (26%)
Medical Science	6056 (24%)	6788 (08%)	455 (19%)
Social Science	1485 (06%)	24535 (13%)	520 (01%)
	24753	185157	46889
	(10%)	(72%)	(18%)

As in the case of previous years, the trend towards applied research was significantly high, although the percentage expenditure on applied research and experimental development has slightly dropped in relation to the percentage of expenditure on basic research during 1983 and 1984. The low emphasis on experimental development work, evidently reflects a weakness in the R&D system.

3.5 R&D EXPENDITURE ACCORDING TO SOURCE OF FUNDS

As pointed out earlier the major contributor for research expenditure has been the State and other local sources. In recent years foreign funds have made significant inroads to the investment patterns in R&D. Among the foreign donors for R&D activities are the USAID, IDRC, CIDA, SIDA, Ford Foundation, SAREC, NORAD, IFS and the United Nations Agencies such as UNESCO, UNDP, FAO and WHO and other governments.

USAID	—	United States Agency for International Development
IFS	—	International Foundation for Science
IDRC	—	International Development & Research Centre
CIDA	—	Canadian International Development Agency
SIDA	—	Swedish International Development Agency
UNESCO	—	United Nations Educational, Scientific and Cultural Organization
UNDP	—	United Nations Development Programme
FAO	—	Food and Agriculture Organization
WHO	—	World Health Organization
SAREC	—	Swedish Agency for Research Co-operation with Developing Countries
NORAD	—	Norwegian Organization for Research & Development

It is worth noting that a major portion of foreign funds are utilized to purchase scientific equipment (about 65%). Table 3.6 provides the distribution of local and foreign funds according to fields of science.

TABLE 3.6

R&D EXPENDITURE BY SOURCE OF FUNDS AND FIELDS OF SCIENCE (1984) (nearest Rs '000)

	Local Funds	Foreign Funds	Total
Natural Science	30111 (98%)	628 (02%)	30739
Agricultural Science	135824 (89%)	17630 (11%)	153454
Engineering Science	25025 (76%)	7742 (24%)	32767
Medical Science	7221 (54%)	6078 (46%)	13299
Social Science	16779 (63%)	9761 (37%)	26540
	214960 (84%)	41839 (16%)	256799

Note: The separation of foreign funds to fields of science is difficult. Some equipment acquired by the universities are not reflected in these figures.

Nearly 46% of the funds available for research in medical sciences originated from foreign sources. The allocation of local funds for medical research was too little. Social sciences also received a considerable proportion of foreign funds. The funding for scientific research from foreign sources increased at a rate of 38% from 1983 to 1984. This was a significant trend when compared with the relatively low level of foreign assistances in the 1970's. However, the actual R&D funds allocated from the foreign sources is difficult to identify from the budgets of most institutions. The expenditure reported here is the actual expenditure incurred from foreign funds during the year and not the allocated sum. It is rather difficult to identify the sources of some foreign funds as these are chanelled through several agencies before it finally reaches the executing agency. An attempt was made to identify the foreign funding component by examining the institute budget. However, to get confirmatory evidence of the actual magnitude of foreign funds, it may be required to seek information directly from the donor. The other problem was that there is no assurance that the sum allocated by the donor for a particular year will be spent in the same year. More often the money allocated for research for a particular year was not necessarily spent during that year. It is important to note that some of the foreign capital grants received by the universities and other agencies cannot be considered as exclusively utilized for research. Reference may be made to a study carried out recently in Sri Lanka by the Swedish Agency for Research Co-operation with Developing Countries (SAREC) which discusses the role of foreign donor agencies in research support to Sri Lanka (Thornstrom, 1986).

3.6 EXTRAMURAL FUNDS FOR R&D

Several agencies act as funding organizations for specific research projects which are executed by various research groups. Such extramural R&D funding are useful particularly for areas which need extra funding support. Most of these extramural funds are directed to universities. Since 1970, the National Science Council and its successor the Natural Resources, Energy and Science Authority of Sri Lanka (NARESA), has functioned as the major local funding agency on scientific research. The local funds disbursed by NARESA for scientific research has increased from around 0.5 million in 1970 to 3.5 million in 1986. A large amount of foreign funds are also chanelled through the research granting scheme of NARESA.

Other local agencies which provide funds for contract research are the Central Environmental Authority, Mahaweli Development Authority and the Coast Conservation Department. These institutions support research studies which are specific to the development of their organizational functions. In recent times, the Institute of Fundamental Studies has also entered the field as a funding agency for research in specific areas.

Table 3.7 shows the distribution of R&D expenditure for extramural activities. The support for natural sciences and medical sciences was the strongest.

TABLE 3.7

EXTRAMURAL FUNDS FOR R&D BY FIELDS OF SCIENCE AT CURRENT PRICES (in Rs '000)

	R&D Exp.	Percentages
Natural Science	7044	38%
Agricultural Science	3074	17%
Engineering Science	387	2%
Medical Science	6787	37%
Social Science	1062	6%
	18354	100%

3.7 R&D EXPENDITURE BY MAJOR BRANCHES OF ECONOMIC ACTIVITY

The R&D expenditure can be separated according to major branches of economic activity. R&D effort is largely confined to few economic branches such as agriculture, forestry and fishery, manufacturing, community, social and personal services. Table 3.8 shows the R&D expenditure according to major economic sectors during 1983 and 1984.

TABLE 3.8

R&D EXPENDITURE BY MAJOR ECONOMIC DIVISIONS (in Rs '000)

I.S.I.C	1983	1984
1. Agriculture, Hunting, Fishery & Forestry	131218 (60.3%)	147860 (57.6%)
2. Mining & Quarrying	20	23
3. Manufacturing	7523 (3.5%)	15737 (6.3%)

I.S.I.C.		1983	1984
4.	Electricity, gas & water	902 (0.4%)	100
5.	Construction	998 (0.5%)	874 (0.3%)
6.	Wholesale and retail trade	1732 (0.8%)	176
7.	Transport and communication	222 (0.1%)	350 (0.1%)
8.	Finance, Insurance, real estate and business services	6152 (2.8%)	6843 (2.7%)
9.	Community, social, personal services	68841 (31.6%)	84836 (33%)
		217608	256799

The patterns of R&D expenditure according to major economic activities has remained somewhat unchanged for the period between 1983 to 1984. The breakdown given here may not be very accurate as some research organizations are engaged in a wide variety of economic activities, and the separation of R&D activity into various economic activities is a tedious task.

TABLE 3.9

R&D EXPENDITURE ACCORDING TO MAJOR SOCIO-ECONOMIC OBJECTIVES FOR 1984 (nearest Rs '000)

	Basic Res.	Applied Res.	Development	Total
Exploration & assessment of biosphere	—	—	—	—
Utilization of civil space for social welfare	—	—	—	—
Development of agriculture forestry & fisheries	10393	109977	28040	148410
Promotion of industrial development	2680	37266	15906	55852
Production, conservation & distribution of energy	315	1261	526	2102
Development of transport/ communication	—	350	—	350
Development of educational services	8074	6908	1610	16592
Development of health services	482	4188	181	4851
Development of urban/rural settlement	—	263	631	894
Social development and socio-economic services	—	15820	—	15820
Protection of the environment	—	302	—	302

	Basic Res.	Applied Res	Development	Total
General advancement of knowledge	2793	8388	–	11181
Defence	–	445	–	445
Other	–	–	–	–
Total	24737	185168	46994	256799

The major thrust of the R&D system has been towards agricultural research activities. The low emphasis on manufacturing industry has to be noted (about 6% in 1984). Research on community, social and personal service objectives has taken nearly 33% of research effort in 1984. It is evident that a large number of economic sectors have enjoyed only a small fraction of R&D effort in the country.

The distribution of research expenditure according to character of R&D activity and major socio-economic aims are given in Table 3.9. R&D expenditure devoted towards the promotion of industrial development and general advancement of science was significantly high. On the other hand research into exploration and assessment of the biosphere, and space research in the country was absent. The development of the agriculture sector, promotion of industrial development, the development of educational services, social development and advancement of knowledge were evidently the major concerns of the R&D systems.

3.8 GROWTH OF R&D EXPENDITURE IN SRI LANKA

The level of R&D expenditure has increased from Rs 45 million in 1975 to nearly Rs 257 million in 1984 at an annual average growth rate of 48%. At constant 1975 prices the R&D expenditure has increased from Rs 45 million to Rs 78 million for this same period and shows an average growth rate of 7.3%. Although there was a noticeable increase in R&D expenditure both at current and constant prices, the allocation of funds for research as a percentage of the Gross Domestic Product (GDP) shows a slight decline from 0.2 per cent in 1975 to 0.19 per cent in 1983 and to 0.18 per cent in 1984. The decline in funds for R&D could be more prominent if a realistic R&D deflator based on the costs of R&D services, equipment and consumables could be used to deflate R&D expenditure. The cost of most chemicals, books and journals, equipment and spare parts have escalated at a very high rate. For example, as shown in Table 3.10, the cost of selected chemicals shows a high rate of escalation, with the prices of some chemicals increasing by more than 100%.

TABLE 3.10

ESCALATING EXPENDITURE OF SELECTED CHEMICALS

	1976 price Rs/Litre or Kg	1986 price Rs/Litre or Kg	Rate of Annual Increase
Ethanol	52	325	65%
Pet Ether	18	28	7%
Chloroform	130	380	24%
Methanol	110	200	10%
Na_2SO_4 (anhyd)	40	450	126%
Potassium Chloride	160	520	28%

Table 3.11 shows the growth of the Gross Expenditure on R&D at current and constant prices.

TABLE 3.11

GROWTH OF R&D EXPENDITURE

Year	Current(Exp)	Constant prices	As a % of GDP
1975	45.1	45.1	0.2
1983	218	77.4	0.19
1984	257	77.9	0.18

Based on GDP deflator at 1975 constant prices.

Although there seems to be an overall increase in the enthusiasm to undertake research in many institutions, the quantum of work carried out by these institutions seems to have remained static over the years and in some institutions the R&D effort has declined. The lowering of R&D effort was due to many factors. Among these were the lack of competent senior staff to lead projects, lack of researchers and the escalating cost of research work. For example, the Higher Education sector was severely affected due to the lack of trained manpower and scientific equipment. The existing staff, particularly those who were attached to the science faculties, were over-loaded with teaching activities. In this connection, it may be relevant to note that since 1977, 253 professionals are reported to have left the university service (Ministry of Finance and Planning, 1986).

3.9 SRI LANKA'S POSITION IN INTERNATIONAL SCIENCE AND TECHNOLOGY SYSTEM

The strategies for science and technology development in the country should take note of the interactions and relative position of the S&T system with respect to the international scene in S&T. Both the production of scientific knowledge and its application goes beyond the national boundaries in the context of the competitive international markets. A nation's ability to capture the comparative advantages of international markets and global economic situation, depends on the competitive edge of the science and technology system of the nation. And to this end, innovations are required to keep up the industrial growth.

The development of indicators for international comparisons are not only useful to understand the status of the country's effort in S&T development in relation to other countries, but also to understand the intrinsic characteristics of the domestic S&T system.

The resources devoted to S&T activities in Sri Lanka are negligible in comparison with developed economies. The proportion of R&D to GDP in Sri Lanka remains at a level around 0.2% and it is well below the recommended level (1% of GDP) for developing countries. As discussed in chapter 1 the countries with developed economies such as USA, West Germany, Japan, France and UK have allocated between 1–3% of GDP for R&D activities. The prospects for improving the proportion of national GDP allocated to R&D in the near future seems to be gloomy. The only hope for increased research funding would be the foreign donors.

The R&D effort in Sri Lanka is mainly financed through government sources, while private industries have invested not more than 5% for the national effort. The relatively weak inaus-trial sector was a great disadvantage for industrial R&D investments.

According to UNESCO statistics (UNESCO, 1986) the average estimated number of R&D scientists and engineers per million population in developing countries was 127 during 1980, whereas in developed countries, the number was 2986. The financial allocation for R&D as a proportion of GNP has averaged 2.23% for developed countries and 0.45% for developing countries during 1980. Scientists and engineers engaged in R&D activity in Sri Lanka, per million population was 220 during 1984/85. The number of scientists and engineers engaged in R&D activities has increased over the last decade due to expansion in private and public sector investment programmes. Although the number of personnel engaged in R&D activities in Sri Lanka was above the average for developing countries, the R&D expenditure allocation was well below the average level for developing countries.

Table 3.12 indicates the relative position of R&D effort of Sri Lanka among selected developing countries.

TABLE 3.12

NUMBER OF R&D SCIENTISTS & ENGINEERS PER MILLION POPULATION & R&D EXPENDITURE AS A PERCENTAGE OF GNP FOR SELECTED DEVELOPING COUNTRIES

		Scientists & Engineers per million population	R&D Exp. as a percentage of GNP
Burma	1975	57	–
Ghana	1976	403	–
India	1982	131	0.6
Indonesia	1983	152	0.4
Malaysia	1983	182	–
Mauritius	1984	255	0.3
Nigeria	1980	30	–
Pakistan	1982	59	0.2
Philippines	1982	101	0.2
Seychelles	1983	254	1.3
Singapore	1981	296	0.3
Sri Lanka	1984	220	0.18

Source: *Statistics on Science and Techonology,* UNESCO, Paris, Oct. '86.

It is evident that in Sri Lanka science and technology development has stagnated for many years without showing much improvement. Although manpower has shown an increase over the years, R&D expenditure shows no corresponding improvement. This suggests that infras-tructure development and provision of adequate level of resources per R&D person has not improved, and in fact has deteriorated over the years, with a relatively high proportion of research scientists having to depend on a smaller amount of financial resources for R&D.

Chapter 4

MANPOWER RESOURCES DEVOTED TO RESEARCH AND DEVELOPMENT

4.1 GENERAL TRENDS

The manpower allocated to scientific and technological activities has been increasing steadily since 1978 indicating an increased dependence of economic activities on science & technology. The natural scientists and engineers employed by S&T institutions increased from 4567 in 1978 to 6985 in 1984 and to 8253 persons by the end of 1985. The average annual growth of scientists and engineers was nearly 10% during 1978–1985. However, recent studies show that the major problem concerning the S&T workforce is the continuous erosion of trained and qualified manpower due to migration. It has resulted in weakening of some areas of economic activities. The expansion of economic activities and the development of S&T infrastructure in the recent past has resulted in the scattering of existing S&T personnel among a large number of S&T organizations.

Scientific and technical personnel in a country play a vital role in economic growth by advancing scientific and technological knowledge required for productivity improvement. They are responsible for promoting new products, processes and improved services. Employment opportunities for scientists and engineers are available in a large number of economic activities, and in diverse S&T activities such as testing, quality control, engineering designs, feasibility studies, teaching, consultancy, construction work, utility services and research and development. During the 1984–86 period, employment of engineers increased more rapidly than employment of natural scientists (9.8% per year versus 5.9% per year). The growth in the construction industry and engineering services was primarily responsible for the increase in recruitment of engineers.

Among the S&T workforce, those who are involved in research and development activities and production of new innovations play a key role in economic development. The quality of S&T workforce measured in terms of experience and skills, educational attainments and areas of operations, are important determinants of the productive capability of the S&T workforce. This chapter examines the quantitative and some qualitative parameters of the scientific and technical manpower employed in research and development activities in Sri Lanka. These include the types of employment, educational attainments, sectors of employment, fields of specialization and areas of work of the S&T workforce.

However, the diverse character of the work involved, and the variety of organizational systems available makes it difficult to include in this study all the variable factors that characterize the S&T workforce. The S&T workforce can be broadly categorised into three types of personnel.

(A) Scientists and Engineers
(B) Technicians
(C) Auxiliary personnel

According to definitions of UNESCO (1984), scientists and engineers are defined as persons having scientific or technological training in any field of science and who are engaged in professional work of R&D activities, including administration, management, directing and execution of R&D activities. Technicians are defined as persons engaged in that capacity in R&D activities and who have received vocational or technical training in any branch of knowledge or technology of a specified standard. While auxiliary personnel are those who are indirectly associated with the performance of R&D activities i.e., clerical, secretarial and administrative personnel, skilled, semi-skilled and unskilled workers in various trades, and all other auxiliary personnel.

This study while adopting the same definitions as spelt out by UNESCO, has limited its scope to scientists, engineers and technicians. The determination of auxiliary personnel directly associated with R&D is difficult in the Sri Lankan situation, because R&D is carried out as a minor function in most institutions.

In accordance with the conceptual framework developed for this study, related scientific activities such as secondary school teaching and health services are excluded. However, in order to give the reader an indication of the total numerical strength of economically active S&T persons, those possessing requisite qualifications to be categorized as scientists, engineers or technicians, are enumerated in Table 4.1. The institutions included in the study cover both public and private sectors. Nearly 650 institutions have been surveyed, but only 254 institutions employed S&T personnel. The institutions reporting R&D personnel were 131. All institutions engaged in R&D activities have been covered in this study. The categories of scientists and engineers included are as follows:

Scientists	—	Natural Scientists Medical Scientists Social Scientists
Engineers	—	Engineers Architects

TABLE 4.1

DISTRIBUTION OF SCIENTISTS & TECHNICAL PERSONNEL IN ALL SERVICES

S&T SERVICES	
Scientists and engineers	10579
Technicians	3908
MEDICAL SERVICES	
Medical officers	2451

Medical technologists	639
SECONDARY SCHOOLS	
Natural Science graduates	2695
Social Science graduates	1261
TOTAL	21533

Note: Statistics on Health Services and Secondary schools were provided by the Ministry of Health and the Education Department respectively.

It is to be noted that only the scientific and technical manpower engaged in the S&T services in the country have been analysed in detail in this study. A detail review of the medical officers servicing the Health sector, as well as secondary graduate teachers have been deliberately left out for logistic reasons, which include among others, the indeterminate system of transfers, mobility and migration of personnel.

4.2 UTILIZATION OF SCIENTIFIC AND TECHNICAL PERSONNEL

The magnitude of scientists, engineers and technicians in employment, is a principal indicator of the level of S&T activities in the country. In Sri Lanka the scientific and technical staff in S&T organizations represent only a small fraction (0.14%) of the labour force. Of these the engineers comprise the major professional group representing 42% of the S&T workforce. Females comprise only 15% of the S&T personnel.

The number engaged in research and development activities on part-time and full-time basis amounted to 4108 or 28% of the S&T workforce. The conversion of part-time researcher to full-time equivalent (FTE) personnel, indicates that the number engaged in R&D was approximately 3483 FTE persons or 24% of the S&T workforce. There were more scientists than engineers in R&D work.

Table 4.2 gives the breakdown of the economically active scientific and technical personnel during 1985 together with the corresponding numbers involved in R&D activities. Nearly 40% of the natural scientists and 43% of social scientists are reported to be engaged in R&D activities.

TABLE 4.2

ECONOMICALLY ACTIVE SCIENTIFIC & TECHNICAL PERSONNEL DURING 1985

S&T ACTIVITIES

	Scientists		Engineers		Architects		Medical Scientists		Social Scientists		Technicians	
Male	2802	81%	4165	93%	268	81%	244	65%	1448	74%	3419	87%
Female	640	19%	315	7%	63	19%	133	35%	501	26%	489	13%
TOTAL	3442		4480		331		377		1949		3908	

ALL S&T ACTIVITIES

Male	12345	(85%)
Female	2142	(15%)
TOTAL	14487	

ENGAGED IN R&D

	Scientists				Engineers				Architects			
	FT	PT	FTE	%	FT	PT	FTE	%	FT	PT	FTE	%
Male	1103	122	1144	91	205	173	263	38	2	1	3	71
Female	400	47	416	9	20	15	25	62	2	2	2	29
	1503	169	1560		225	188	288		4	3	5	

	Medical Sc.				Social Sc.				Technicians			
	FT	PT	FTE	%	FT	PT	FTE	%	FT	PT	FTE	%
Male	128	19	134	85	483	292	579	55	464	122	505	81
Female	67	21	74	15	116	102	150	45	181	21	188	19
	195	40	208		599	394	729		645	143	693	

R&D ACTIVITIES

	FT	PT	FTE	
Male	2385	729	2628	(77%)
Female	786	208	855	(23%)
	3171	937	3483	

Note:
FT, PT and FTE denotes Full-time, Part-time and Full-time Equivalent respectively.

4.3 GROWTH TRENDS OF S&T WORKFORCE

A gradual increase in S&T workforce is evident, with engineering graduates increasing from 3814 to 4480 during 1983/84 to 1985, at an annual growth rate of 9%. Similarly natural science graduates also increased from 2967 to 3442 during 1983/84 to 1985 at an annual growth rate of 8%. The overall growth rate for S&T personnel was 10% per annum for the period 1978 – 1985.

The university graduate output may provide a proxy for the annual increase in the national S&T workforce. The output of university graduates in 1984 averaged 703 for natural sciences and 362 for engineering sciences. The corresponding annual increases in S&T workforce for scientists and engineers were 238 and 333 respectively. These figures apparently indicate that most engineering graduates have joined the S&T services. On the other hand the low absorption of natural science graduates into the S&T services could be attributed to the availability of a variety of employment opportunities both in the private and public sectors and their adaptability to different employment situations.

The utilization of S&T personnel in the S&T institutions needs categorization, since a considerable number of scientists and engineers have sought jobs in non-science related and non-engineering related institutions, such as commercial organizations. It is evident from Table 4.2 that the total number of personnel involved in R&D is a small fraction of the total S&T personnel. However, there has been an increase in R&D personnel during the last two years with the full-time equivalent researchers increasing at an annual growth rate of about 4%. Although the number of engineers in R&D has increased at a rate of 19% per annum during the last two years, the fraction of engineers involved in R&D was very small (about 9%).

4.4 S&T PERSONNEL ACCORDING TO CATEGORY OF EMPLOYMENT

The state agencies have employed a large proportion of scientists and engineers accounting for nearly 91% of the total personnel. On the other hand architects are largely employed by the private sector institutions. The female S&T personnel in the private sector was 3% compared with 16% in the state sector. A high proportion of females in the state sector was employed in the area of medical sciences. The number of female technicians in the S&T workforce was small. The ratio of females in the private and public sectors was approximately 1:11. The lower employment opportunities for all categories of S&T personnel in the private sector can be attributed to the relatively low emphasis for technology development and applications in this sector. However, recent trends indicate that technology intensive industries such as chemicals, electronics, computers and construction in the private sector have opened the doors for a greater employment of local graduates.

TABLE 4.3

EMPLOYMENT IN THE PRIVATE AND PUBLIC SECTOR S&T INSTITUTIONS DURING 1985

	STATE SECTOR				PRIVATE SECTOR			
	Male	Female	Total	%	Male	Female	Total	%
Scientists	2584	623	3207	24.5	217	18	235	18
Engineers	3681	310	3991	30.0	484	5	489	38
Architects	126	47	173	0.5	142	16	158	13
Medical Sc.	228	132	360	3.0	16	1	17	1
Social Sc.	1410	499	1909	15.0	38	2	40	3
Technician	3088	485	3573	27.0	331	4	335	27
TOTAL	11117	2096	13213	100	1228	46	1274	100

Total S&T Personnel = 14487.

These statistics indicate that the application of science and technology in the private sector continues to be at a comparatively low profile with the state sector taking the major burden in the application and utilization of S&T resources.

4.5 EMPLOYMENT OF S&T PERSONNEL BY SECTOR OF PERFORMANCE

The sectors of performance are the areas of the national economy comprising a significant number of institutions where science and technology activities are performed. The General Service Sector includes various public or government establishments servicing the entire community. The Productive Sector includes industrial and trading establishments which are involved in the production and distribution of goods and services for sale. The Higher Education Sector includes the establishment of education at the third level and their research centres.

The total number of institutions belonging to the General Service Sector was 138. The Productive Sector comprised of 17 institutions. Nearly 60% of S&T personnel are employed in the General Service Sector institutions. These institutions are involved in a wide range of S&T services such as quality control, standardization, testing, education, teaching and research and development services. The Productive Sector institutions are responsible for employing about 25% of the S&T personnel in the country. While 15% of the S&T personnel are employed by the Higher Education Sector institutions. The distribution of S&T personnel according to the sector of performance is given in Table 4.4.

TABLE 4.4

THE DISTRIBUTION OF S&T PERSONNEL ACCORDING TO SECTOR OF PERFORMANCE

Category of per./Sector

	General Sector				Productive Sector				Higher Education			
	M	F	Total		M	F	Total		M	F	Total	
Sci.	1589	389	1978	23%	729	62	791	22%	473	190	663	29%
Eng.	2699	256	2955	34%	1204	31	1235	34%	262	28	290	13%
Arc.	114	53	167	2%	143	16	159	4%	11	4	15	1%
Med.	94	52	146	2%	35	13	48	1%	115	68	183	8%
Soc.	605	256	861	10%	164	62	226	6%	679	183	862	38%
Tec.	2109	404	2513	29%	1122	22	1144	33%	188	63	251	11%
Total	7210	1410	8620		3397	206	3603		1728	536	2264	

Note: M & F denotes Males and Females

The proportion of female employment was highest (23%) in the Higher Education Sector institutions, while the General Service Sector and Productive Sectors have employed respectively 16% and 6% of the female S&T personnel. The high concentration of females in the Higher Education institutions indicates their preference for teaching jobs. The employment of engineering graduates in the Productive Sector was high compared with the employment of science graduates. A large proportion of scientists are employed in the General Service and Higher Education Sectors.

The General Service institutions provides more employment opportunities for engineering graduates. About 65% of engineers and 52% of scientists are employed in the General Service Sector institutions. The Productive Sector employed 29% of scientists and 18% of engineers in the country. The Higher Education Sector institutions provided employment for 6% of engineers and 30% of scientists in the country. The employment of technicians was heavy in the General Service Sector (64%), as compared with the Productive Sector (29%) and the Higher Education Sector (7%).

The Department of Agriculture is the single largest employer of science graduates, while the Department of Irrigation, Mahaweli Development Authority, the Ceylon Electricity Board and the State Engineering Corporation were the major employers of engineering graduates during 1985. The state corporations such as ceramic, cement, steel and tyre are the major employers of Productive Sector scientific and technical personnel.

4.6 WORK EXPERIENCE OF S&T PERSONNEL

The experience of the workforce is determined by the number of years of service of S&T personnel in a particular field of science. With greater experience and maturity the S&T workforce can be expected to be more productive and innovative, resulting in productivity growth in industries (Rosenberg, 1980). Hence the magnitude of the pool of matured and experienced S&T personnel with advance training is a reflection of the country's capability to direct and manage its S&T development. The age factor of S&T personnel can be taken as a partial indicator of the experience of the workforce, although it may not necessarily reflect the actual work experience in a particular field of specialization. Table 4.5 illustrates the distribution of S&T personnel according to age categories.

TABLE 4.5

THE PERCENTAGE DISTRIBUTION OF S&T PERSONNEL ACCORDING TO AGE CATEGORIES

Type of per./Age Cetegory	upto 29	29 – 39	40 – 49	50 – 59	Over 59
Scientists	20%	51%	19%	8%	2%
Engineers	23%	47%	20%	8%	2%
Architects	9%	51%	27%	12%	1%
Medical	7%	38%	31%	18%	6%
Social Sc.	8%	40%	36%	15%	1%
Technicians	22%	51%	21%	6%	–

With nearly 68 per cent of the total S&T workforce being below 39 years of age, it is evident that a significant proportion was relatively young. The experienced and qualified staff over 40 years of age was small in number in all categories of S&T personnel. Nearly 71% of the natural scientist and 70% of engineers in the S&T workforce were less than 39 years of age. This sharp disparity between the number of experienced and less experienced personnel may indicate a deficiency in the S&T system in terms of high level managerial capability. This has led to a situation where young scientists have been entrusted with the burden of management and administration of S&T activities, rather than actual execution of R&D activities. A further implication is the recall and re-employment of retired persons over 55 years of age, to meet this shortage of high level managerial personnel. In the fields of medical and social sciences however, there is a better balance between the young and experienced personnel. In the technicians grade, high proportion of technicians were below the age of 39 years.

4.7 FIELD OF EMPLOYMENT OF S&T PERSONNEL

The frequency distribution of S&T workforce according to major field of science provides a useful guide to the availability of personnel for various scientific activities. The type of S&T work carried out in the country can be illustrated by the density of S&T personnel in different fields of science.

The distribution of scientists and engineers according to the field of science is given in Table Table 4.6.

TABLE 4.6

DISTRIBUTION OF S&T PERSONNEL ACCORDING TO FIELD OF SCIENCE

Field of Sc./Cat. of Personnel

	SC	ENG	ARC	MED	SOC	TEC	TOTAL	%
Nat Sc	1092	588	–	222	376	636	2914	22
Agr Sc	1736	246	–	11	96	1145	3234	20
Eng Sc	443	3596	318	66	281	1864	6569	47
Med Sc	25	1	–	74	3	87	190	1
Soc Sc	145	49	13	4	1193	176	1580	10
TOTAL	3442	4480	331	377	1949	3908	14487	100

Nearly 47% of the total S&T workforce is engaged in engineering and technological sciences. This indicates that technology related fields provide ample employment opportunities for the S&T workforce. The demand for technologists arise mainly through the major construction and civil engineering projects. The second largest field of employment for S&T personnel was in natural sciences which accounted for about 22% of the total S&T workforce. Although agriculture is the mainstay in the economy of Sri Lanka, agricultural sciences have attracted only 20% of the total S&T personnel. Social scientists comprised about 10% of the S&T workforce in S&T institutions.

Nearly 50% of the natural science graduates are employed in agricultural sciences and 32% in natural science areas. About 13% of natural scientists are also employed in engineering fields, working mostly in agricultural, chemical and production engineering areas. The engineers employed in agricultural sciences was 5% with 3% employed in natural science fields in S&T service institutions. The employment pattern of social scientists indicates that about 19% are employed in natural science areas and 14% in engineering sciences. The employment patterns of technicians show that 47% are involved in engineering sciences, while 29% were in agricultural sciences.

It is not clear whether the employment pattern of scientists and engineers reviewed here is a true indication of the intensity of S&T activities in the various sectors. It is however, important to assess the requirement of different categories of personnel in different fields of science. For example, it would be opportune to see why engineering graduates have not made significant in-roads to agricultural engineering sciences with its potential in several areas, including agro-industries.

4.8 EDUCATIONAL ATTAINMENT OF S&T PERSONNEL

The numerical strength of persons with high educational attainments is an index of the quality of the workforce. Here one would obviously look at the proportion of scientists and technologists with post-graduate qualifications as a measure of the S&T workforce. Scientists and engineers in the national S&T workforce usually have the minimum qualification of bachelors degree. However, in some state sector institutions, equivalent recognition has been given for engineers and technologists according to their experience and success at departmentally conducted examinations. The number of engineers and scientists falling into this category is small, about 14% of the total S&T population. However, the non-degree holders among engineers and surveyors were relatively high.

Table 4.7 shows the distribution of S&T personnel according to their educational qualifications. Only 25% of the scientific and technical personnel possessed post-graduate qualifications, with those holding doctoral degrees being only about 9%. This situation should indeed be given serious consideration by the planners, educationalists and policy makers, especially because most research institutions have experienced difficulties in recruiting trained staff due to the dearth of post-graduate qualified persons. The retention of high qualified staff in technical positions also has become a major problem due to lack of incentives and unattractive salaries.

TABLE 4.7

EDUCATIONAL ATTAINMENT OF S&T WORKFORCE DURING 1985/86

Type of Per/Qualification

	Bachelors Deg.	Post-grad Dip.	Masters	PhD
Scientists	1919	100	488	336
Engineers	2987	125	320	81
Architects	89	27	33	21
Medical	223	34	59	25
Social Sc	1352	122	116	256
TOTAL	6570	408	1016	719

It is important to note that some professional groups such as engineers and architects tend to seek professional qualifications rather than post-graduate qualifications after their first degree.

The percentage of degree holders among the total scientific and technical personnel was 72%. About 7% of the S&T workforce had masters degrees and 5% had doctoral degrees. Among scientists, 11% had masters and 10% had doctoral degrees, while among engineers 7% had masters and 3% had PhD. The number of PhD holders among natural scientists was 9%, and 7% among social scientists. The data discussed above indicates that academically qualified and experienced S&T personnel, capable of formulating and supervising research projects, are in short supply especially with respect to the Agriculture, Forestry and Fishery Sector. The deficiencies of post-graduate qualified personnel was highlighted in a recent draft report on agricultural planning (Ministry of Finance and Planniing, 1986a). According, to this report, most research institutions had one or two doctoral degree holders per division in the institute. The position of post-graduate qualified research personnel in the Tea, Rubber and Coconut Research Institutes were reported as respectively 14%, 13% and 9% of the total scientific staff. The share of scientists and engineers with doctoral degrees in the Higher Education Institutions was relatively high (66%), with the remaining 34% distributed among research institutions and other S&T institutions.

The high turnover of post-graduate qualified personnel in research institutions was a major hurdle in the implementation of their research programmes. In a recent report of a working group on Brain Drain (Ministry of Finance & Planning, 1986c) several recommendations were made to curtail this outflow of qualified manpower from the services. The present findings indicate the need to increase opportunities for post-graduate training of S&T personnel to meet this challenge. It is to be noted that the availability of doctoral and masters degree-qualified personnel is confined to a limited number of fields. The absence of sufficient number of post-graduate qualified staff in different fields, is a barrier to critical mass formation so vital for cross-fertilization and advancement of knowledge.

4.9 THE AVAILABILITY OF SPECIALIZED SKILLS IN S&T WORKFORCE

The specialities or expertise available in a workforce have a bearing on science planning; and therefore the abundance of such personnel in a specific speciality is a point of interest to science policy makers, especially when special S&T programmes are to be formulated. The specialities of S&T workforce are determined partly by the formal training of work-force, and partly by the experience gained by working in a specific branch of science. The availability of expertise in any branch of sciences therefore should be evaluated from the basic qualifications as well as from the work experience in a given field. The lack of information on the availability and distribution of expertise in the country has often resulted in the employment of foreign consultants.

The diversity and versatility of the expertise available in different fields of science provides a useful index of the structure of S&T framework. In this study the specialities of S&T workforce was obtained mainly from the relevant institutions. Therefore, the specialities listed here may not necessarily represent the actual specialization of the S&T workforce. However, most of the information provided are expected to indicate at least broadly the area of interest of an individual. The specialities listed in this study provides a general guide to the overall availability of expertise in the S&T workforce. Most of the specialities listed below in Table 4.8 refers to the area of post-graduate training or basic academic qualifications.

TABLE 4.8

SPECIALITIES IN SELECTED FIELDS OF SCIENCE

EARTH & SPACE SCIENCE		NO. OF SCIENTISTS
Surveying	–	35
Ecology	–	47
Climatology	–	23
Oceanography	–	10
PHYSICAL SCIENCE		
Natural Science	–	441
Chemistry	–	176
Quality control/standardization	–	62
Nuclear, atomic & Molecular physics	–	55
Experimental & preparative chemistry	–	29

		NO. OF SCIENTISTS
Bio-chemistry	—	25
Rubber chemistry	—	22
Textile Chemistry	—	16
Organic Chemistry	—	13
Pulp technology	—	10
BIOLOGICAL SCIENCE		
Botany	—	55
Entomology	—	48
Zoology	—	45
Microbiology	—	32
Marine biology	—	25
Plant pathology	—	18
Bio-chemistry	—	12
MATHEMATICS & COMPUTER SCIENCE		
Mathematics	—	74
Statistics	—	47
Computing	—	36
Data processing	—	31
Operation Research	—	13
AGRICULTURAL SCIENCE		
Field Crop Production	—	1511
Agricultural science	—	442
Agronomy	—	272
Agricultural extensions	—	111
Pasture-agronomy	—	88
Aquaculture	—	42
Food science	—	37
Plant breeding & propogation	—	34
Horticulture	—	31
Agriculture economics	—	30
Seed production	—	27
MEDICAL SCIENCE		
Medical Sciences	—	73
Medicine	—	26
Dental surgery	—	24
Obstetrics/Gynaecology	—	20
Community medicine	—	18
Anatomy	—	13
Pathology	—	12
SOCIAL SCIENCE		
Economics	—	172
Management	—	71

		NO. OF SCIENTISTS
Archives administration	–	57
Commerce	–	53
Accountancy/Auditing	–	49
Philosophy	–	43
Public relations	–	42
Management	–	37
Archaeology	–	36
Trade	–	31

The availability of expertise in some fields was small due to a variety of reasons, but the disturbing aspect was the existence of striking im-balances in certain disciplines. For example, the number of personnel specialised in organic chemistry was much higher than the number trained in the associated fields of physical and inorganic chemistry.

The development and proliferation of specialities can be due to a combination of factors whch include availability of research funds, national importance, tradition in research, high employment potential, group activity and prestige value of the field. The specialities in engineering fields are also quite diverse. However, a large number of engineers fall into a few categories of engineering fields. Among the engineering personnel engaged in S&T activities, the number of engineers in the top 10 specialities are as follows:

Civil engineering	–	1739
Mechanical engineering	–	721
Engineering science	–	583
Electrical engineering	–	460
Sanitary engineering	–	166
Electronics engineering	–	159
Chemical engineering	–	107
Mechanical engineering	–	40
Production engineering	–	30
Marine engineering	–	29

Specialists in some areas of engineering sciences seem to be in short supply. For example, computer technology, electronic engineering and production engineering are poorly represented. It is important to orient national educational policies to cater for specialities that have a greater potential in new and emerging technology areas.

4.10 DISTRIBUTION OF SCIENTIFIC & TECHNICAL PERSONNEL ACCORDING TO MAJOR AREAS OF SPECIALIZATION

A significant number of natural scientists are engaged in agricultural science areas, while others are distributed among physical sciences, biological sciences and earth & space sciences. As could be expected, scientists have been able to enter a wider range of specialities than engineers, who have virtually been compartmentalized to engineering fields. (Table 4.9).

TABLE 4.9

DISTRIBUTION OF S&T PERSONNEL ACCORDING TO AREAS OF SPECIALIZATION

	SC	ENG	ARC	MED	SOC	TECH
Eng Sc.	101	4361	327	1	565	1682
Earth & space	146	16	–	–	106	14
Physical	968	23	1	1	6	118
Bio	341	–	–	7	37	165
Maths & Computing	210	15	1	2	68	10
Agr.	1547	39	1	23	78	884
Med.	26	16	–	341	2	68
Soc.	73	9	1	–	1084	79
Not responded	19	1	–	2	3	899
TOTAL	3431	4480	331	377	1949	3919

4.11 AVAILABILITY OF RESEARCH & DEVELOPMENT PERSONNEL IN THE COUNTRY

The number of S&T workforce engaged in R&D activities is an important indicator of the intensity of S&T activities in the country. The R&D personnel provide the new knowledge, processes, innovations and solutions to problems in many S&T areas. The proportion of S&T personnel engaged in research and development activities was small. Most of the R&D activities are carried out either by full-time or part-time personnel attached to research institutions, research divisions of departments and private industries, and the academic staff of universities. The exact number of full-time equivalent researchers in some institutions such as the universities, is difficult to ascertain because of the different types of activities and duties undertaken by these personnel. In some organizations considerable amount of time has to be devoted to non-R&D work by scientific personnel. For example, routine testing, teaching, advisory and consultation work and information dissemination are part of the functions of some R&D personnel. Therefore even in the so-called research institutes, most of the research personnel do not spend their time entirely for research.

The full-time scientific personnel engaged in research are those who will devote most of their working time to R&D (about 90% of working time). Part-time scientific and technical personnel are defined as those personnel who devote only a part of their working time to R&D activity which should not be less than 10% of their working time.

The concept of full-time equivalent has been used in science statistics to provide a common measure in which part-time workers are converted to the equivalent of full-time. In this procedure the time spent on R&D work is taken in the parameter for the conversion. This study has not attempted to ascertain the time devoted for research by S&T personnel in all institutions. However, in the higher education institutions, where most of the part-time research personnel are employed, a study was carried out to ascertain the time devoted for R&D, which was then used for conversion to Full-Time Equivalent.

In this study three part-time workers are taken as equivalent to one full-time R&D worker on the basis of a random inquiry made from the institutions conducting R&D. Usually part-time workers included in this study have spent between 20% — 40% of their working time on R&D activities.

In the case of universities, a representative sample of researchers from each university was taken, and the average time spent on research by different faculties was evaluated to determine the R&D effort.

TABLE 4.10

AVERAGE PERCENTAGE OF TIME DEVOTED TO RESEARCH BY A SELECTED SAMPLE OF UNIVERSITY STAFF

University of Peradeniya	—	42%
University of Katubedda	—	46%
University of Colombo	—	34%
University of Jaffna	—	30%
University of Ruhuna	—	35%
University of Jayawardenapura	—	30%

The number of research personnel available in the country according to different categories of personnel totals upto 4108. Out of these personnel, 3171 were engaged in full-time research work and 937 were engaged in part-time research. The nature of activities of the S&T personnel can vary substantially in a given period of time, there being an interconnection between various scientific and technological work such as research and development routine testing, consultancy and teaching, production etc. Scientists and technologists invariably devote only a part of their working time to each of these activities.

Table 4.11 indicates the number of full-time, part-time and full-time equivalent personnel engaged in R&D activities among different categories of personnel.

TABLE 4.11

R&D SCIENTISTS & ENGINEERS BY TYPE OF PERSONNEL 1985/86

	Full-time	(Female)	Part-time	(Female)	FTE
Nat Sc Per.	1503	(400)	169	(47)	1559
Med Sc. Per.	195	(67)	40	(21)	208
Soc. Sc. Per.	599	(116)	394	(102)	730
Eng. Sc. Per.	229	(22)	191	(17)	293
Technicians	645	(181)	143	(21)	693
TOTAL	3171	(786)	937	(208)	3483

The number of Full-Time Equivalent S&T personnel engaged in R&D activities has increased from 3211 in 1984/85 to 3483 in 1985/86, at an annual rate of growth of 8.5%. The rate of increase in respect of R&D engineers was higher (16%) than that of natural scientists (7%).

The increase in social scientists was from 691 in 1984/85 to 730 in 1985/86 with a growth rate of 6% per annum. The female R&D scientists and eigineers represents 24% of the R&D personnel. Among medical personnel, the females engaged in R&D was quite high (37%), in contrast to the situation with scientists, where the female R&D population was only 27%.

The distribution of R&D personnel according to sector of performance is given in Table 4.12.

TABLE 4.12

DISTRIBUTION OF R&D PERSONNEL ACCORDING TO SECTOR OF PERFORMANCE

	SCIENTISTS			ENGINEERS			TECHNICIANS		
	FT	PT	FTE	FT	PT	FTE	FT	PT	FTE
Gen. Ser. Sec.	1209	55	1227	114	9	117	462	1	462
Prod. Sec.	161	19	167	15	65	37	10	100	43
Higher Edu.	927	529	1103	100	117	139	173	42	188
TOTAL	2297	603	2497	229	191	293	645	143	693

A majority of research scientists are employed by the General Service Sector and the Higher Education Sector. It is important to note that the R&D personnel in the Productive Sector is relatively small for all categories of personnel, indicating the low profile for research and development in this vital sector. Thus the country's research effort is concentrated mainly in the General Service Sector institutions, such as government research institutions, and the institutes of Higher Education. The Productive Sector institutions evidently depend on the General Service Sector and Higher Education institutions for the advances in knowledge.

The distribution of R&D personnel according to field of science is given in Table 4.13.

TABLE 4.13

DISTRIBUTION OF R&D PERSONNEL ACCORDING TO FIELD OF SCIENCE

	SCIENTISTS			ENGINEERS			TECHNICIANS		
	FT	PT	FTE	FT	PT	FTE	FT	PT	FTE
Nat. Sc.	1130	137	1176	95	2	96	279	3	280
Agr. Sc.	794	27	803	20	4	21	317	–	317
Eng. Sc.	93	39	106	114	185	176	39	137	85
Med. Sc.	45	34	55	–	–	–	4	3	5
Soc. Sc.	235	366	357	–	–	–	6	–	6
TOTAL	2297	603	2497	229	191	293	645	143	693

These results show that most of the research scientists are engaged in natural science and agriculture science areas. However, a considerable number of engineering personnel are also working on research problems related to natural sciences and agricultural sciences, besides the engineering sciences. The technical staff associated with research are mainly in the fields of natural sciences, agricultural sciences and engineering sciences. The lower number of technical staff for research in medical science can be attributed to their involvement in routine S&T activities other than research. For example, the Medical Research Institute which employs nearly 74 technicians, has most of them on routine testing. It should be noted that most of the chemical, biochemical, pharmacognostic and biological screening work in relation with research on medicinal and aromatic plants, and other natural product research, are calssified under natural sciences.

This study also shows that most of the scientific personnel with post-graduate qualifications were involved in research activities. For example, out of 617 PhD holders among scientists, 536 were involved in R&D activities. Similarly 45% of the Master degree holders were involved in R&D activities. The educational attainment of R&D personnel are given in Table 4.14.

TABLE 4.14

EDUCATIONAL ATTAINMENT OF R&D PERSONNEL

	SCIENTISTS		ENGINEERS	
	Male	Female	Male	Female
Doctoral	437	99	51	2
Masters	340	115	62	7
Post-Grad. Dip	93	25	8	2
Bachelors	1377	514	260	28
	2247	753	381	39

Among women scientists, 13% had doctoral degrees and 15% has masters degrees. However, the percentage of women holding doctoral and master degrees in engineering sciences was small.

The age distribution and maturity of R&D scientists is given in Table 4.15.

TABLE 4.15

DISTRIBUTION OF R&D PERSONNEL ACCORDING TO AGE CATEGORY

	Less than 29 years	29 – 39	40 – 49	50 – 59	Over 59
Scientists	18%	46%	25%	10%	1%
Engineers	22%	57%	17%	3%	1%
Technicians	32%	43%	17%	8%	–

The age distribution of R&D personnel followed the general pattern for the stock of scientific and technical personnel, with about 64% falling into the younger age group of under 40 years. This would also mean, that there would be less of experienced personnel to direct, supervise and manage R&D activities.

4.12 SALARIES AND REMUNERATION OF SCIENTISTS AND ENGINEERS

The emoluments payable to scientists in the public sector are determined by the state. The disparities of salaries that can be earned locally and abroad by scientists have resulted in a large exodus of high level S&T manpower from the country. The average earnings of different categories of R&D personnel are given below:

APPROXIMATE GROSS MONTHLY SALARY (1986)			US $
Graduates at Recruiting level	—	In University (eg. Asst. lecturer)	75
	—	In State Research Institute (eg. Scientific Officer)	75
Post-graduate with less than 5 years experience	—	In University (lecturer, senior lecturer)	101 – 219
	—	Research Inst. & Govt. Sector (Scientific Officer with post-graduate qualifications)	114 – 128
Post-graduate with over 5 years experience	—	In University (Asst. Professor, Professor)	144 – 159
	—	State Sector Research Inst. (Director level)	149 – 166

It is important to note that none of the above categories received extra incentives such as transport, housing, loans or other financial benefits unlike in the case of private sector employees.

In recent years there has been a substantial increase in wages for graduate and post-graduate level personnel in the private sector institutions, and also in the financial institutions. Therefore, there has been an increasing tendency for science graduates to move away from science-related activities by seeking employment in more lucrative positions in non-scientific organizations.

There are no fringe benefits for scientists working in S&T institutions. For example, state banking sector provides free medical facilities, bonuses, low interest loans for housing and other facilities which are not enjoyed by scientists and engineers engaged in S&T services.

The recent government policy to curtail expenses by temporarily stopping the recruitment of personnel has resulted in the unemployment of S&T personnel in the country. This situation has also created unmanageable staff depletion in some institutions. The recent incident in which deans of university faculties resigned their administrative posts in protest against the deplorable staff levels was in fact a repercussion.

Chapter 5

STRATEGIC INDICATORS OF SCIENCE & TECHNOLOGY IN SRI LANKA

Science and technology in Sri Lanka as mentioned earlier, have received heavy state patronage, both in terms of financial allocations, and deployment of manpower resources. However, in the long run, economic progress through technological competitiveness and high productivity can be achieved only through strategic policy directives and planned deployment of resources related to science and technology. The question that has to be posed is, has this happened so far, and if not, what were the reasons. On the other hand, if such strategic planning of science and technology had been accomplished, what has been the outcome. It is obvious that no simple answer could be found for any of this questions.

At this stage it would be relevant to compare the performance of Sri Lanka with some of the South and South Eastern nations in Asia, in respect of economic and industrial pointers. Some relevant data drawn from a recent UNIDO publication, (UNIDO, 1986), are summarized in the table below:—

TABLE 5.1

INTER-COUNTRY COMPARISON OF SELECTED POINTERS (1983)

Pointer/Country	Sri Lanka	Indonesia	Malaysia	Philippines	Singapore	Thailand
Agriculture (% GDP)	27	26	21	22	1	23
Industry (% GDP)	26	39	35	36	37	27
Manufacturing (% GDP)	14	13	19	25	24	19
Services (% GDP)	47	35	44	42	62	50
Manufacturing value added (MVA) *	581	6072	3287	5510	2431	4837
Share of MVA in GDP (%)	14	13	19	25	24	19
Growth of MVA (1973—1983) (Annual %)	3.4	12.6	10.6	5.0	7.9	8.9

* 1982 data in million dollars at constant 1975 prices.

The inter-country comparisons show that except in the case of agriculture, in which Sri

Lanka out-shines the other countries, in all other sectors Sri Lanka is **placed at the lower** end of the scale (UNIDO, 1986). The evidence presented in the previous chapters whilst substantiating these claims, demonstrated the unenviable state to which science and technology has declined in Sri Lanka.

Although the agricultural sector, still shows some resistance to decline, a recent study has highlighted its fragile R&D system and proposed various measures to revive this vital area of activity (ISNAR Report, 1985).

The present study has identified at least three major defects in the R&D system in the country. These are:

(A) the disparity in resource deployment and the resulting imbalance in the growth of science and its various disciplines.
(B) the low priority for experimental development work that can facilitate a take-off from the bench to commercial areas, and
(C) the absence of a mechanism to link up the chain of events from the laboratory, bench through innovative designs, fabrications and operations of laboratory scale and pilot plant level units for the production of marketable goods and services.

In this chapter an attempt will be made to review the strategies in the R&D system in some of the key sectors using appropriate indicators as pointers to policy directions:

5.1 TRENDS IN AGRICULTURAL RESEARCH

The research and development strategies in the agriculture sector can be broadly classified according to:

(A) Crop oriented development strategies and
(B) Agroclimatic development strategies

The department of Agriculture plays a prominent role in the performance of agriculture research through its extensive network of field research stations spread over the country as described in Chapter Two. Research in Agriculture, Forestry & Fisheries Sector deals with the following aspects.

(A) Paddy
(B) Sugar cane
(C) Minor export crops
(D) Field crops such as soya, greengram & seeds
(E) Fruits and vegetables
(F) Inland & Marine fishery, aquaculture, mariculture etc.
(G) Livestock
(H) Export crops such as tea, rubber & coconuts.

Agricultural research accounted for nearly 60% of the national R&D budget in 1984. The Major performers of research in agriculture, forestry & fishery included the following institutions:

(A) Dept. of Agriculture
(B) Agrarian Research & Training Institute
(C) Minor Export Crops Department
(D) Sugarcane Research Institute
(E) Coconut Research Institute
(F) Tea Research Institute
(G) Rubber Research Institute
(H) Veterinary Research Institute
(I) National Aquatic Resources Agency
(J) Fisheries Ministry and Forest Department.

The university agriculture faculties also contribute substantially to the agricultural research effort in the country.

The research funds available for Agriculture, Fishery and Forestry Sector has declined steadily at constant 1975 prices (Table 5.2). This was inspite of a substantial increase in the allocation of research funds at current prices, up from about Rs. 129 million in 1983 to Rs. 153 million in 1984. Per capita research expenditure at 1975 constant prices for the agricultural, forestry & fishery research has declined from Rs. 66,900 (US $ 2843) to Rs. 54,700 (US $ 2150) during 1983 to 1984.

TABLE 5.2

TRENDS IN THE SUPPORT FOR AGRICULTURE RESEARCH AT CONSTANT 1975 PRICES US $ ('000)

Year	No. of Research Scientists	R&D Expenditure	R&D Exp/Researcher
1970	109	3713	34.1
1975	202	3254	16.1
1980	422	2836	6.7
1983	683	1943	2.8
1984	846	1818	2.1

Note: Data for 1970 – 1980 was given in *ISNAR Report* (1985), **Sri Lanka Agricultural Research Projects, National Planning Division,** Ministry of Finance and Planning, Colombo.

Constant 1975 prices are based on GDP implicit deflator.

The research manpower has increased at an annual average growth rate of 48% from 109 to 846 for the period 1970 – 1984, whereas the research expenditure has steadily declined since 1970.

5.1.1 RESEARCH INTENSITIES OF MAJOR PERFORMERS IN AGRICULTURAL RESEARCH

The eleven major agricultural R&D performing organizations mentioned above, without counting the universities, and taking the Department of Agriculture as one unit, have accounted for nearly 59% of national R&D expenditure, and 50% of research scientists in the country. 96% of funds spent on agricultural research in the country is accounted for by these organizations. Therefore, the direction and strategies of agriculture research are governed by the policies and programmes adopted by these institutions. Some of the research programmes and R&D spending strategies adopted by these institutions are described in a recent report of the Finance and Planning Ministry (Agriculture Research Group, 1986). The future needs and infrastructure development required for the agriculture research system has also been well documented (Ministry of Finance and Planning, 1986 b and ISNAR Report, 1985).

The major institutions mentioned above, have consumed nearly Rs 41 million as capital R&D expenditure (about 28% of total R&D expenditure of these institutions) during 1984. The remaining 72% (about Rs 106 million) was spent on recurrent expenditure. The average research expenditure per research scientist available in these institutions was Rs 184,000 in 1984. The R&D expenditure per post-graduate research scientist averaged Rs 654,000 in 1984. It indicates the relative scarcity of post-graduate trained staff in research institutions, rather than the ample amount of resources at the disposal of post-graduate researchers.

The recurrent maintenance cost of research in the agricultural research system was much higher than the capital equipment cost. The average recurrent maintenance cost per research scientist was Rs 73,000 and equipment expenditure per researcher was Rs 35,000 during 1984. Only 43% of the recurrent expenditure was spent on staff salaries.

The fishery and forestry research component in this sector was small. Only 8% of the research expenditure in the agriculture research system was directed towards fishery and forestry research. Although these 11 institutions dominate the national research scene, the total R&D expenditure incurred by these institutions was only 0.38% of Gross National Product at current factor cost of the Agriculture, Forestry & Fishery Sector. The R&D expenditure in this sector as a proportion of Gross Domestic Product was only 0.1%.

These institutions of the agriculutural research system employed 846 research scientists during 1985/86, and nearly 27% of these scientists (about 225) were holders of masters or doctoral degrees.

The Department of Agriculture was responsible for 28% of the expenditure incurred by these 11 R&D performers, and the funds were distributed among 9 regional research centres and four specialized research units. The Agricultural Department was responsible for employing 310 researchers during 1985/86.

The disbursement of funds and priorities for research in the institutions differed according to the development strategies of the sub sectors of the agricultural research system. The institutional resource allocations to increase S&T knowledge can be used as proxies for the R&D intensity in institutes. Generally, R&D intensity is measured as the ratio of institutions own research effort to its production output (Palda, 1986). The research intensity can be also presented as a partial indicator of R&D expenditure per researcher, which reflects the resource availability according to R&D personnel in different institutions.

Table 5.3 shows the research intensity indicators for major performers of the agricultural research system, determined as the R&D expenditure as a portion of GDP and per researcher at constant 1975 prices.

TABLE 5.3

RESEARCH INTENSITY OF SELCETED MAJOR R&D PERFORMERS OF AGRICULTURAL SECTOR 1983 – 1984 AT CONSTANT 1975 PRICES

	R&D Exp/GDP (value added)		R&D Exp/Researcher (Rs'000)	
	1983	**1984**	**1983**	**1984**
Dept. of Agr.	.0029	.0022	55	48
RRI	.0259	.024	177	141
TRI	.0044	.004	56	37
CRI	.0092	.011	350	259
VRI	.0015	.0036	36	72
MEC	.0028.	.0026	68	70
Fishery	.0028	.0063	26	24
Forestry	.002	.001	20	21

The research intensity measured in terms of R&D expenditure to production output tends to vary among institutions, with the export crop research institutions Tea, Rubber & Coconut showing relatively high intensities. However, the research intensities presented here should be considered with caution as the output of agriculture sector can be influenced by factors other than the R&D effort.

In the absence of direct indicators on the effect of R&D inputs on economic performance, the overall performance of the agriculture sector was taken as a proxy for the measurement of R&D intensities.

The fluctuation of the R&D intensity ratio given in Table 5.3 is due to several causes. One of these was the decline in R&D expenditure from 1983 to 1984 at real prices, while at the same time there were fluctuations in the value of the domestic product.

R&D expenditure per researcher is considerably low in the Fishery and Forestry sub-sectors. However, the high R&D expenditure per researcher in institutions such as Rubber Research Institute and Coconut Research Institute may not be necessarily due to an appreciable research intensity, rather the shortage of staff.

Table 5.4 indicates that per capita R&D expenditure for 1983 and 1984 among different institutions is consistent. The R&D expenditure at current prices has generally increased in these institutions in relation to the increase in manpower. However, in real terms the R&D expenditure per researcher has declined in many cases.

TABLE 5.4

PER CAPITA R&D EXPENDITURE FOR MAJOR R&D PERFORMERS IN AGRICULTURE SECTOR AT CURRENT & CONSTANT 1975 PRICES (Rs '000)

	R&D Exp per Researcher		R&D Exp per Post-graduate Res.	
	1983	1984	1983	1984
Dept. of Agr.	154 (55)	158 (48)	620 (220)	539 (163)

	1983	1984	1983	1984
ARTI	73 (26)	104 (32)	303 (92)	383 (116)
MEC	193 (68)	231 (70)	405 (143)	441 (134)
SRI	n.a.	432 (103)	n.a.	686 (207)
CRI	987 (350)	856 (259)	2303 (817)	2396 (726)
RRI	499 (177)	467 (141)	998 (354)	1105 (335)
TRI	159 (56)	121 (37)	317 (72)	504 (152)
VRI	101 (36)	237 (72)	203 (62)	568 (172)
NARA	121 (43)	133 (40)	413 (177)	757 (229)
Fishery	25 (9)	25 (8)	152 (54)	158 (48)
Forestry	56 (20)	68 (21)	231 (82)	229 (69)

Note: R&D expenditure are for calendar years and the manpower correspond to survey years of 1984/85 and 1985/86. The constant prices are given in parenthesis.

It is also evident that the proportion of R&D expenditure to manpower available for research in institutions of the same sector of economy, differ considerably.

The proportion of post-graduate researchers to total number of researchers within these institutions was generally low (Table 5.5), with an uneven growth during the period 1983 to 1984. According to a recent report, most research institutions had one or two post-graduate researchers per division (Ministry of Finance & Planning, 1986a).

TABLE 5.5

RATIO OF POST-GRADUATE RESEARCHERS TO TOTAL NO. OF RESEARCHERS FOR SELECTED AGRICULTURAL RESEARCH PERFORMERS

	1984/85	1985/86
Dept. of Agr.	0.25	0.26
ARTI	0.45	0.27
MEC	0.46	0.48
CRI	0.42	0.36
TRI	0.05	0.24
RRI	0.22	0.42
VRI	0.50	0.42
SRI	n.a.	0.50
NARA	0.29	0.18
Fishery Ministry	0.17	0.16
Forest Ministry	0.24	0.29

The low ratio of post-graduate trained researchers to other researchers reflects a defect in the R&D Structure. The absence of adequate number of post-graduate researchers also meant that the critical numbers required to initiate a research thrust was seriously lacking. Further more, the absence of critical masses with formal training, to direct, formulate and supervise research projects was a severe constraint for the institutional R&D programme. The policies of science educational institutions need to be oriented towards meeting the shortages of S&T graduates in the areas of high demand for employment. Adequate steps should also be taken to retain skilled manpower in S&T services. Further deterioration of manpower-needs would not only weaken existing S&T infrastructure but also dampen the progress of S&T work initiated by national S&T institutions.

5.1.2 PRODUCTION PERFORMANCE AND R&D INPUTS TO AGRICULTURE SECTOR

The agriculture sector continued to expand and to contribute about 25% to the country's Gross Domestic Product during 1983 and 1984 years. Yet the growth rate of agriculture sector recorded a negative value (−0.4) in 1984. This was largely due to the transitory adverse weather conditions that prevailed in the country (Central Bank, 1985).

The research expenditure in the agriculture sector increased from Rs 128.8 million to Rs. 152.6 million in 1984, at an annual growth rate of 15.6%, but in real terms, the increase in R&D expenditure was only marginal. Based on 1975 constant prices R&D expenditure increased from Rs 45.7 million to Rs 46.3 million at an annual rate of 1.3% from 1983 to 1984.

The allocation of research funds in relation to output criteria of the various sub-sectors of agriculture, show that some sub-sectors have provided comparatively low percentage of the national product. R&D expenditure as a percentage of GNP of the agriculture sector has declined from 0.47% to 0.43% during 1983–84. The resource allocations to R&D as a proportion of GNP in the fishery and forestry sub-sectors were much less than for the agriculture sub-sector. (Table 5.6).

TABLE 5.6

R&D EXPENDITURE AS A PERCENTAGE OF GROSS NATIONAL PRODUCT OF THE SECTOR AT CURRENT FACTOR COST PRICES DURING 1983 – 84

	1983	1984
Tea	0.42%	0.35%
Rubber	0.19%	0.14%
Coconut	1.8 %	1.9 %
Agriculture	0.47%	0.43%
Forestry	0.11%	0.11%
Fishery	0.16%	0.35%

A significant increase in resource allocation to R&D in fishery was noticeable during 1984, attributed largely to the establishment of the National Aquatic Resources Agency which now functions as the nerve center of fishery research. Research in forestry has lagged behind due to the absence of a national focal point for forestry research. Most of the research in forestry is conducted by the few researchers in the universities and the Forest Department.

Although the agriculture sector constitutes a vital component of the national economy, there is no firm and co-ordinated commitment to strengthen the R&D effort in relation to national product.

TABLE 5.7

R&D EXPENDITURE AS A PERCENTAGE OF VALUE OF THE SUB-SECTOR NATIONAL PRODUCT (in million Rs) FOR MAJOR EXPORT CROPS IN SRI LANKA 1983 – 1984

	1983	1984
Tea	0.15%	0.13%
Rubber	1.27%	1.22%
Coconut	1.57%	2.00%

Among plantation crops, tea is known to be the major contributor to the national product. Strangely however, it receives the lowest percentage of its national product for research. On the other hand, research allocations for the coconut and rubber industries, as percentages of their respective contributions to the national product, have been reasonably good. (Table 5.7). Most of the research conducted in these commodities was to sustain the plantation rather than to promote industrial application of new products & processes. The experimental development activities on these commodities were notably low, which little effort to promote the processed products. In otherwords agro-industrial activities in the country remained at a low level.

5.1.3 EXPORT PERFORMANCE AND R&D INVESTMENT

Agricultural commodities made a major contribution to export earnings in Sri Lanka. The export earnings of agricultural products amounted to 45% in 1983 and 52% in 1984. The contribution of research and development activities to export industries can be used as a proxy for the measurement of technological intensity of an industry. The production output and the resulting export performance is also sometimes linked to R&D inputs *ceteris paribus*. However, a degree of caution has to be exercised in such assumptions, since both productivity and export performance can be influenced by other factors, such as production subsidies, differential tariffs, export restrictions and market fluctuations. On the other hand if the effects of such extraneous factors could be eliminated, productivity as well as export performance could be linked to improved management practices resulting from R&D. This is a complicated process and has not been attempted in this study. Nevertheless R&D as a ratio of export earnings for a selected commodities are given in Table 5.8.

TABLE 5.8

R&D EXPENDITURE AS A PERCENTAGE OF EXPORT EARNINGS

	1983	1984
Tea	0.09%	0.06%
Rubber	0.62%	0.64%
Coconut	1.08%	1.13%
Minor Export Crops	0.27%	0.35%
Fishery	1.23%	1.69%

The above figures tend to indicate that coconut industries have a relatively high research intensity with respect to export earnings. The apparent high research intensity in the fisheries sector may be related to the small proportion of exports. The tea sub-sector although provides very high export earnings, allocates relatively a small proportion for R&D activities.

5.2 INDUSTRIAL RESEARCH STRATEGIES

The industrial sector in Sri Lanka was slow to start and it contributed a meagre 15% to the GDP. Both public sector and private sector industries had limited impact on the growth of economy. Recent government policies have encouraged the invesment in the private sector and supported the private industries through a range of incentives. The performance of industrial sector in 1984 was a distinct improvement in terms of the growth rate, expansion of exports and investments in the government sector (Central Bank, 1985). The private industries recorded a 26% growth as compared with 7% in public sector industries.

The government support to industry in terms of investment promotion and other infrastructure facilities have attracted foreign investment in the Free Trade Zones and the Greater Colombo Export Promotion Zone. However, the incentives to generate in-house technological capabilities and inventive activities were hardly visible. The R&D and innovative capabilities of the local industries were not impressive, with little or no effort to improve products and processes. The subsidiaries of foreign owned companies operating in the country, and other multi-national firms have little investments in local R&D activities. These companies operate through the transfer of technology and knowhow from the parent companies. Therefore, the type of industrial base in the country can hardly be described as oriented towards high technology industries. Industries dealing with professional and scientific equipment, machinery and tool making and motor vehicles, have not come up to the forefront. Most of these technology intensive products are still being imported.

The industrial research activities carried out by private industries, state sector industries and state owned research institutions have accounted for nearly 23% of total R&D expenditure in the country. The extent of R&D resource allocation to industrial research for 1983 and 1984 is given in Table 5.9.

TABLE 5.9

R&D EXPENTITURE FOR INDUSTRIAL RESEARCH AT CURRENT AND CONSTANT PRICES (Rs '000)

	1983		1984	
Public sector industry	7684 (2728)	16%	8202 (2485)	14%
Private sector industry	4508 (1600)	9%	9273 (2810)	16%
Public sector research units	36257 (12871)	75%	40386 (12237)	70%
	48449 (17199)		57861 (17532)	

(Constant prices are given in brackets)

The research effort of the public sector industries was small. The bulk of research effort in industrial sector was concentrated in the public sector research institutions. A small number of private industries are involved in R&D activities. The higher research expenditure in the private sector in 1984 was largely due to the high R&D investment of Tobacco Company for the year 1984 which carried out two major R&D projects.

R&D expenditure inputs as a percentage of value of imports and exports of industries show that the research inputs in a large number of industrial divisions were rather small (Table 5.10).

TABLE 5.10

INDUSTRIAL R&D EXPENDITURE OF PRIVATE & PUBLIC SECTOR INDUSTRIES IN RELATION TO VALUE ON IMPORTS & EXPORTS (as a percentage)

	1983		1984	
	Imports	Exports	imports	Exports
Food & live animal	.087	.038	.036	.009
Beverage & Tobacco	n.a.	n.a.	.26	4.2
Crude materials (inedible)	.032	.09	.037	.15
Chemicals & products	.12	1.93	.036	0.73
Manufactured good	.05	.04	.08	.054
Machinery & transport equip.	.085	.32	.009	.53
Miscellaneous	.002	.005	.009	.002

These figures indicate that the import of materials in some industry areas were higher than the exports. For example, the importation of chemicals far exceeded the amount exported. It is worth noting that the research effort in the chemicals and chemical product industries has been substantially high, although this may not be truthfully reflected in the imports and exports, partly because of the inevitable timelag in market acceptance.

Among the manufacturing industries, R&D expenditure for selected industry groups are given in Table 5.11, as percentages of the value of imports and exports.

TABLE 5.11

R&D EXPENDITURE OF PUBLIC & PRIVATE SECTOR INDUSTRIES AS A PERCENTAGE OF VALUE OF IMPORTS & EXPORTS OF MANUFACTURING INDUSTRY

	1983		1984	
	Value of Imp.	Value of Exp.	Value of Imp.	Value of Exp.
Resin, plastic & rubber	0.059	0.02	0.054	0.02
Leather & Leather products	0.34	0.15	n.a.	n.a.

Wood & Wood products	0.05	0.07	2.2	1.95
Paper & paper products	0.04	1.3	n.a.	n.a.
Foot wear	1.58	0.7	0.22	0.06
Cement & Allied products	0.36	0.76	0.34	0.76
Scientific equip	0.10	0.05	0.06	5.8

The R&D expenditure for technology intensive industries such as chemical and allied products, machinery and equipment, electrical equipment and scientific equipment were extremely low. Some of the local companies in recent years have turned their attention to high technology applications. For example, the Ceylon Tobacco Company has directed its research thrust towards energy-saving devices, like solar drying and development of briquetting material, and biotechnology research.

The output of inventions in Sri Lanka are reported as considerably low. An examination of patent statistics indicates that the number of patent applications filed by Sri Lankan nationals have increased at an annual growth rate of 10% from 11 applications in 1980 to 28 applications in 1985. The number of patent applications submitted and the number granted provides an indicator of the inventive capacity of the country. Nationals account for only 17% of the patent applications filed in the country, and only 15% of the patents granted belonged to Sri Lankan nationals in 1984. The applications for industrial designs have increased at a slower growth rate of 6% from 13 applications to 18 during 1980 to 1985. About 20% of industrial design applications were received from nationals, of which 50% received approval. Table 5.12 provides the break down of patent applications filed by individuals, companies and government institutions, and the patents granted for the period 1980 to 1985.

TABLE 5.12

TOTAL NO. OF PATENT APPLICATIONS BY NATIONALS AND NUMBER GRANTED DURING 1980 – 1985

	APPLICATIONS FILED				NUMBER GRANTED			
Year	Ind	Com	Gov	Total	Ind	Com	Gov	Total
1980	9	–	2	11	10	2	1	13
1981	2	3	1	6	10	5	4	19
1982	7	2	3	12	12	7	4	23
1983	12	3	1	16	10	–	1	11
1984	12	1	3	16	12	3	1	16
1985	22	4	2	28	13	4	1	18

Note: Ind, Com and Gov denote individuals, companies and government institutions respectively.

This table shows that a large number of patents came from individuals rather than industrial firms and government institutions. When one considers the government expenditure on industrial research, the number of patent applications lodged by the state sector institutions was discouragingly low. The number of patent applications received from individuals, and the proportion of patents granted for such individuals over the years indicate the presence of a significant number of individual inventors in industrial research activities. The low generation of patents from the national industrial laboratories should be a major policy concern for the industrial research policy makers.

The trend in respect of industrial designs follow the pattern, for patents with the numbers being even smaller. However, government institutions have not submitted a single industrial design for the period of 1980 – 1985 (Table 5.13).

TABLE 5.13

THE NUMBER OF INDUSTRIAL DESIGNS GRANTED FOR NATIONALS

	APPLICATIONS FILED				INDUSTRIAL DESIGNS GRANTED			
Year	Ind	Com	Gov	Total	Ind	Com	Gov	Total
1980	4	4	–	8	–	–	–	–
1981	5	1	–	6	1	2	–	3
1982	1	11	–	12	1	2	–	3
1983	1	4	–	5	3	2	–	5
1984	–	6	–	20	–	2	–	2
1985	–	15	–	15	–	–	–	–

The low output of patent and industrial design applications exposes a serious defect in the Sri Lankan research system, and is probably linked to the low level of investment in experimental development activities, as was reported in the previous chapter.

It is significant to note that the bulk of technological knowhow was purchased from overseas sources. According to Central Bank sources nearly US $ 8.3 million was spent on royalty, licencing and technical fees during the period of 1980 – 1985. These payments have increased from US $ 27,000 in 1980 to US $ 6,615,534 in 1985. Nearly 95%of these payments were made to developed countries. The industrial R&D expenditure as a proportion of the royalties and technical fees was 0.33% in 1983 and 0.17% in 1984. This represents heavy dependance on foreign technological knowledge and a relatively low investment in industrial research work.

5.3 ACADEMIC RESEARCH STRUCTURES

An increase in the investment in academic research in science and engineering was reported in the recent past, with both the public and private agencies supporting R&D activities. An increasing number of student enrolement for science and engineering courses were reported, with a corresponding number of graduates joining the S&T workforce. The strength and success of academic research in science and technology depend on a variety of factors. Among them, the availability of supporting facilities for research, availability of good quality faculty members and an intelligent student population, a conducive environment for research and an adequate rewarding system are some of the major determinants of success of the R&D system in universities.

As discussed in detail in Chapter 2, the university structure had expanded dramatically during the past two decades, with 8 science faculties, 2 engineering faculties and 4 medical faculties.

The expenditure on Higher Education Sector amounted to Rs. 691.6 million (about US $ 27 million) in 1984. However, the R&D expenditure of the Higher Education Sector accounted for only 2% of this total expenditure; teaching being the major activity of universities. The actual R&D funds allocated for the Higher Education Sector, was insignificant. Most of the resources for research in the Higher Education Sector originated from external funding agencies. The University-Industry linkage in research, although gradually increasing, still remains at a very low level. Therefore the sustenance of academic research depends heavily on other local and foreign funding sources. The national research funding institutions such as Natural Resources, Energy & Science Authority of Sri Lanka (NARESA), Atomic Energy Authority of Sri Lanka (AEA) and other state agaencies such as Central Environment Authority (CEA), Coast Conservation Division, Department of Agriculture and Department of Minor Export Crops have sponsored university research. A large proportion of Higher Education research was also supported by foreign agencies such as World Health Organization (WHO), Swedish Agency for Research Corporation (SAREC), Canadian International Development Agency (CIDA), Swedish International Development Agency (SIDA), International Development and Research Corporation (IDRC), Smithsonian Institute etc.

The private institutions for Higher Education were not very active in research. At present only one such institution is available for the teaching of medical sciences. The major function of Higher Education institutions has been the production of S&T graduates with research being a small component of university activities.

Table 5.14 indicates that the student enrolment in science and technology during 1983 and 1984 was about 45% of the total enrolment.

TABLE 5.14

TOTAL STUDENT ENROLMENT BY FIELD OF SPECIALIZATION DURING 1983/84 AND 1984/85

	1983/84		1984/85	
	Under Grad	Post-Grad	Under Grad	Post-Grad
Eng Science	1922	46	1791	38
Nat Science	3020	121	3018	111
Agr Science	824	185	726	165
Med Science	2185	226	2522	263
Soc Science	10545	709	10130	850
	18496	1287	18217	1427

The ratio of total graduate output to academic staff from the universities in 1984/85 indicates that the engineering and natural sciences had relatively low ratios compared to other fields (Table 5.15).

TABLE 5.15

RATIO OF GRADUATES OUTPUT TO ACADEMIC STAFF IN UNIVERSITIES (1984/85)

	Under Grad/Total Academic staff	Post- Graduate/ Post-graduate staff
Eng Sciecne	1.4	0.29
Nat Science	1.5	0.16
Agr Science	2.6	1.75
Med Science	4.7	0.83
Soc Science	10.6	1.49

With smaller student — teacher ratios, the engineering and natural science faculties enjoyed a better status than other faculties for undergraduate training. However, in respect of postgraduate training the faculties of Agriculture and Social Sciences fared better with more research students per supervisor. Only three doctoral degrees were awarded in science in 1984/85, and none for the engineering faculties.

Research in medical sciences have taken a prominent place in the Higher Education Sector. Nearly 42% of the estimated research expenditure was spent on medical research activities by the academics in the three medical faculties of the Universities of Colombo, Peradeniya & Ruhuna. Most of the funds for medical research (70%) came from foreign sources. A considerable amount of foreign funds were also channelled through local granting agencies such as NARESA, for specific research projects.

Some of the major programmes in universities which received generous funding include the following: Buffalo Research Programme, Inland Fishery Research, Development of Natural Product Chemistry, Development of Malaria Vaccine and Studies on Tropical Rain Forests. Some of these research programmes were done in collaboration with foreign counterparts. Foreign support for research projects, and link programmes with foreign universities, have provided a strong impetus for the development of S&T in universities.

As seen in Table 5.16 the availability of funds per researcher in the universities was not impressive. Some areas may require more resources than other areas. For example, research in engineering fields may be more expensive than the social sciences, or some areas in natural sciences.

TABLE 5.16

PER CAPITA R&D EXPENDITURE IN ACADEMIC RESEARCH (Rs '000) DURING 1984

	R&D Exp/Post-Grad Faculty Member	R&D Exp/ Faculty Member
Eng Science	2.1	0.7
Nat Science	16.4	8.4
Agr Science	34.0	14.4
Med Science	89.0	38.7
Soc Science	14.2	7.7

R&D expenditure per academic in engineering sciences was the weakest compared with other sciences. On the other hand medical research in universities appears to be the best supported in terms of funding per person. The medical faculties at Peradeniya and Colombo Universities were quite active in research during 1984, and have been mainly responsible for the national medical research effort. Infact most of the medical research output can be attributed to the university effort, since the output from other government institutions such as Health Services, Medical Services, Medical Research Institute remains relatively low. The research input to social sciences in the universities was quite low, with only about 18% of the R&D funds allocated to social science research being incurred in the Higher Education Sector. It is worth noting that a large number of social science researchers in the universities had to compete for small sums of money provided by the national funding agencies such as NARESA. Social science research was largely funded by foreign sources (44%), with a greater share being chanelled through non-governmental social science research organizations.

5.3.1 RESEARCH INTENSITIES IN UNIVERSITIES

Most of the university academics are involved in research activities along with teaching functions. The research intensities in different universities vary according to funding available for the faculties. The research programmes of some faculties are well organized whereas some faculties do not pay much attention for organized R&D activities. The major determinants for academic research were the availability of funds, personnel and equipment and other supporting facilities. The problems of infrastructure, lack of trained personnel, greater emphasis on teaching and the absence of a conducive environment for research have led to lower stress on research work in most universities. A large number of post-graduate trained staff have left the services of universities, creating a severe manpower shortage in the senior and intermediate level cadres of universities, thus creating a vacuum in academic research.

The research funds available per academic researcher and post-graduate academic staff is given in Table 5.17. The availability of post-graduate staff to the total academic staff shows that some universities have a low ratio of post-graduate staff to total academic staff. In comparison with other sectors, the research funds available per staff member in universities was very low. The funds available per post-graduate researcher was lowest at Sri Jayawardenepura University and highest in Jaffna University.

TABLE 5.17

PER CAPITA R&D EXPENDITURE (in Rs '000) PER ACADEMIC STAFF & POST-GRADUATE STAFF & THE RATIO OF TRAINED MANPOWER FOR SELECTED UNIVERSITIES

University	R&D Exp/Post Gr. Staff		R&D Exp/Total Academic Staff		Post Gr. Staff/ Total Staff
	Current	Constant	Current	Constant	
Kelaniya	21.2	6.4	13.3	4.0	0.62
Sri Jayawardenepura	11.5	3.5	5.2	1.5	0.45
Colombo	19.8	6.0	11.9	3.6	0.60

Peradeniya	38.8	11.7	15.9	4.8	0.39
Ruhuna	23.2	7.0	5.9	1.8	0.33
Eastern	21.4	6.5	5.1	1.5	0.24
Jaffna	39.1	11.8	17.4	5.2	0.44

Note: Constant 1975 prices are based on GDP implicit deflator.

The established universities such as Peradeniya and Colombo have generally consolidated their position in receiving research grants. Recently established universities such as Ruhuna and Eastern University, with low proportions of post-graduate trained academic staff, are in the process of developing the research capabilities in different faculties.

The absence of a strong drive for research in the universities could be regarded as a serious draw back in the national S&T system. The research output of the academic staff in some fields is remarkably high in comparison with the research inputs to universities. Scientific articles published by the staff of universities for selected years is given in Table 5.18. It indicates that some fields such as agriculture, medicine, veterinary science and natural sciences have shown a high productivity.

TABLE 5.18

AVERAGE ANNUAL RESEARCH PUBLICATIONS OF ACADEMIC STAFF IN UNIVERSITIES FOR THE PERIOD 1980/81 TO 1983/84

	Annual Out put/Researcher 1980/81 – 1982/83	Annual Out put/Researcher 1982/83 –1984/85
Arts/Social Science	1.28	1.24
Commerce & Management Studies	0.53	1.00
Law	4.00	2.00
Education	1.00	1.11
Science	2.00	1.79
Medicine	1.26	1.35
Veterinary Science	1.90	1.83
Agriculture	2.18	1.25
Engineering	0.96	1.12
Architecture	0.66	1.33

Source: University statistics (UGC).

5.4 NEW TRENDS IN SCIENTIFIC RESEARCH

In recent years a clear trend has been seen in the re-orientation of scientific research in Sri Lanka at all levels, towards new technologies. The early realization of the potential of technologies such as tissue culture, enzyme and fermentation technology, monoclonal anti-body technology etc. in fields covering molecular biology, the use of optical fibres and satellite communication system in Telecommunications, silicon chips and micro electronics, have resulted in a new thrust in R&D, especially in the Universities and research institutes, It is realized that these new approaches are costly by national standards, and cannot be supported and sustained with internal funds alone. Fortunately for Sri Lanka the high calibre of scientific personnel available (inspite of a continuous outflow), and the quality standards of research maintained by them (amidst severe contraints), has attracted the attention of foreign agencies with generous funding. A recent review on external funding by one of the donor agencies has highlighted some of these issues (Thornstrom, 1986). A detail evaluation of this aspect, and their impact on the national R&D system and the economy as a whole will not be taken up in this study. Issues relating to the national planning mechanism for S&T policies, transfer and assimilation of technologies etc., which have been reviewed recently (ESCAP/APCTT, 1986), will also not be taken up in this study.

5.5 PUBLIC AWARENESS OF SCIENCE AND TECHNOLOGY

The premier institutions which are involved in popularization of science and technology include the following:

(A) National TV and Broadcasting Corporation
(B) National Museum
(C) Natural Resources, Energy & Science Authority
(D) Sri Lanka Association for the Advancement of Science
(E) Department of Education
(F) Miscellaneous state and private agencies which are involved to a limited extent in S&T information dissemination.

e.g. Agriculture Department
Coast Conservation Department
Wild Life & Nature Protection Society – NGO
March for Conservation – NGO

The public societies and scientific associations are also actively involved in the advancement of science & technology by organizing public lectures, seminars, meetings and conferences. The extent of the involvement of these organizations in public awareness of science varies considerably. Some institutions such as the Sri Lanka Association for the Advancement of Science (SLAAS) and the Institute of Fundamental Studies (IFS), conduct regular programmes for the dissemination of science at various levels. In general, the programmes available for the general public are limited. Table 5.19 indicates the type of activities organized by the SLAAS from 1980 – 1984.

TABLE 5.19

SCIENCE COMMUNICATIONS ORGANIZED BY THE SRI LANKA ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

	1981	1982	1983	1984
Popular Science Lectures	31	13	15	12
Guest Lectures	7	4	6	5
Lectures & Discussions	22	37	26	53
Seminars	14	29	18	24
Science Films	3	5	1	3
All Island Inter-school Quiz	1	1	1	1
Science Exhibitions	1	1	4	2

5.5.1 TIME DEVOTED TO S&T TOPICS BY THE NATIONAL RADIO AND TV BROADCASTS

No definite time has been allocated to science topics in the radio broadcasts. The amount of time usually depends on the current affairs of science. The regular weekly programmes on current affairs, and "Behind The News" programmes carry science-related items.

The National Television provides two types of programmes for science and technology related subjects. The Educational Television Service (ETV) which commence its broadcasts during off peak hours (usually 9.00 a.m. to 12.00 noon), caters mainly for science students. The Educational Television Service has allocated about 30 – 50% of its air time for science subjects. The science subjects which are televised include mathematics, general science, agriculture and health science. The ETV also telecasts popular science documentaries from time to time. The service also caters for the two national language streams. The proportion of time devoted to science subjects by the radio broadcasts is given in Table 5.20.

TABLE 5.20

TIME DEVOTED TO RADIO PROGRAMMES ON SCIENCE AS PERCENTAGE OF TOTAL TIME DEVOTED TO EDUCATIONAL PROGRAMMES

	1983	1984	1985	1986
Total No. of hours of air time for educational programmes (Sinhala & Tamil)	—	—	1002 hrs & 55 mts	746 hrs & 40 mts
Total No. of hours of science related programmes	160 hrs & 20 mts	190 hrs	80 hrs & 15 mts	138 hrs & 40 mts
Percentage of science related programmes	—	—	12.50%	19%

Source: Sri Lanka Broadcasting Corporation.

5.6 NATIONAL AWARDS AVAILABLE IN RECOGNITION OF OUTSTANDING CONTRIBUTIONS TO S&T

The recognition of scientific and technological achievements through national awards and prizes have been institutionalised in Sri Lanka. There are three prestigious awards available for achievements of science which are organized by NARESA. These are as follows:

(A) President's Award for Scientific Achievement.
(B) NARESA Award for Scientific Achievement.
(C) IBM prize for Technological Research.

The President's Award and the NARESA Award are sponsored by the Natural Resources, Energy & Science Authority (NARESA) of Sri Lanka, whilst the IBM award is sponsored by, World Trade Corporation (Sri Lanka). The total prize money allocated for the Presidents Award for 1986 was Rs 100,000/- (about US $ 3,500), and the NARESA Award was worth Rs 75,000/- (about US $ 2,670). The IBM Award made in 1983 was valued at Rs 50,000/- (US $ 1,785).

These awards have been instituted only in recent years and they are becoming popular among the practicing scientists. These awards are the only form of national recognition for the achievements of scientists. The state sector which dominates the R&D scene in the country, unfortunately does not seek to recognize or promote career prospects of scientists. It is even more disheartening to realize the inability of authorities to use the appropriate provisions in the manuals of administration to provide such avenues of promotion. The convenience in seeking the criteria of seniority, regardless of work performance in promotional schemes has undoubtedly been a restraining factor for productive research.

Chapter 6

MAJOR FINDINGS AND SUMMARY

This study was inititated to examine in some detail the organizational framework and structural changes in the science and technology system in Sri Lanka. The organizational framework has been reviewed from an evolutionary outlook in order to understand the foundations of the S&T system in Sri Lanka, while the structural changes have been probed using both quantitative and qualitative measures. In order to facilitate international comparisons, the standard UNESCO methodology and terminology have been used in this study.

The main findings are summarized as follows:

* The total R&D investment in the country has increased from about Rs 217.6 million (US $ 9.26 million) in 1983 to Rs 256. 8 million (US $ 10.1 million) in 1984 – an increase of 15%.

* At constant 1975 prices the increase was marginal, being Rs 77.4 million (US $ 3.3 million) in 1983 to Rs 77.9 million (US $ 3.1 million) in 1984. In fact in terms of US Dollars the figures show a decline rather than an increase due to depreciation of the Rupee relative to the Dollar.

* Although research expenditure has increased in terms of current prices, when expressed as a proportion of Gross Domestic Product at current prices, it has declined from 0.2% in 1975 to 0.19% in 1983 and 0.18% in 1984. Compared to many other developing countries, Sri Lanka's level of funding for R&D has to be considered unsatisfactory.

* The major performer of R&D was the state sector, which was responsible for nearly 93% of the R&D expenditure incurred during 1984.

* R&D expenditure in the Productive and Higher Education Sectors was relatively small, being only 16% of the total R&D expenditure. The Productive Sector accounted for 10%, while the Higher Education institutions have incurred 6% of the gross R&D expenditure.

* The Agriculture, Fishery and Forestry Sector received the largest share of the R&D expenditure, consuming nearly 60% of the expenditure, and continuing to be the domi-

nant sector.

* Consistent with the general trend, R&D expenditure per researcher in the agriculture sector at constant 1975 prices declined from Rs 66,900 (US $ 2,843) in 1983 to Rs 54,700 (US $ 2,150) in 1984 at a rate of 18%.

* Basic research expenditure in the national R&D system was 10%, with most of it being spent on agricultural and medical science areas.

* Consuming 72% of the total R&D expenditure, Applied Research activities had the largest share of the national R&D budget.

* Experimental Development activities were notably low with only 18% of the national R&D expenditure devoted to this vital area.

* Foreign funds constituted about 16% of the total R&D expenditure during 1984.

* The industrial R&D effort was low. The manufacturing industries spent about 6% of the national R&D expenditure. Some growth of industrial R&D was evident in recent years, with private industries demonstrating an interest in increasing investments in R&D. The public sector industries appear to be generally cautious about R&D spending.

* The major thrust of national R&D expenditure was for non-defence purposes, and the defence R&D expenditure was negligible.

* Economically active scientists and engineers in science, technology and education activities has been enumerated as 21,533 in 1985/86 year.

* Out of 21,533 economically active S&T personnel, those who are employed in science and technology institutions (excluding health services and secondary educational institutions) was reported as 14,487 in 1985/86 an increase of 983 personnel over the 1983/84 level. Among them 24% were Natural Scientists, 32% were Engineers, 2% were Medical Scientists, 13% were Social Scientists and 29% were Technicians.

* Out of 14,487 S&T personnel, economically active Natural Scientists and Engineers were 7,923 in 1985/86, compared to 6,781 in 1983/84. This represents an increase of 8%.

* State sector was the major employer of S&T personnel with 91% of the S&T personnel in its service.

* Women scientists and engineers comprised of 15% of the S&T workforce.

* Total number of full-time and part-time personnel in R&D activities was 4,108 with the full-time equivalent determined as 3,483. A slight improvement in FTE research staff was noted from 3,211 in 1983/84 to 3,482 in 1985/86.

* The absorption of engineers into the S&T workforce increased at a higher rate than that of scientists. This is attributed to the expansion of engineering activities and development projects in the country.

* Inventive activities in Sri Lanka are noticeably very low. In 1984 only 17% of the patent applications filed were from nationals, and only 15% of the patents granted belonged to nationals.

* A major portion of technological knowhow was purchased from developed countries. Nearly 95% of the royalties, licencing and technical fees were paid to developed countries. The industrial R&D expenditure was a meagre percentage of the royalty, licencing and technical fees paid to all countries (0.33% in 1983 and 0.1% in 1984).

These findings suggest that Scientific and Technical activities in Sri Lanka needs re-structuring in order to strengthen the weak areas of the R&D system and align the scientific programmes towards socio-economic objectives. Some of the issues which need urgent consideration may be enumerated as follows :

1. Arrest the decline in the proportion of R&D funding in relation to the Gross Domestic Product, and strive to reach at least the average level for developing countries.

2. Correct the imbalances in the deployment of financial and manpower resources with special emphasis on the manufacturing industry to meet the development goals of the country.

3. Encourage more experimental development activities, and provide facilities for designing and fabricating work, pilot plant studies and scaling-up work, and feasibility studies.

4. Ensure a better balance in the distribution of foreign funds in relation to national priorities.

5. Provide incentives through tax concessions and protective trariffs for high risk investment in innovative research.

6. Promote inhouse R&D activities in the private sector industries, especially in the Productive Sector, by generous tax rebates.

7. Orient national educational policies to meet the demand for specialities that have a greater potential in new and emerging technologies.

8. Establish criteria for priority setting in scientific research giving due consideration to explorative work, biosphere assessment etc.

9. Cushion the escalating prices of scientific material through reduced duty and taxes.

10. Simplify exchange control and customs clearance procedures in the import of essential scientific material.

11. Derive a realistic and simple accounting procedure for scientific work.

12. Provide the necessary incentives and a conducive research environment to reverse the outward flow of high calibre S&T personnel.

13. Provide more opportunities for post-graduate training locally and abroad, not only to meet the present short fall in the cadre of high level scientific personnel, but also to ensure critical mass formation in the desirable areas.

14. Provide opportunities for carreer enhancement regardless of service qualifications by recognizing scientific achievements, to promote productive research.

It has been mentioned time and again that unless there is a strong political commitment to develop and utilize S&T indigenously, no amount of funds or trained manpower could deliver the instruments for progress. The need to understand the nature and manner in which research is performed is vital, especially in relation to bureaucratic financial and administrative controls that ultimately determine the end results. No serious attempts have been made so far to streamline procedures for the procurement and supply of even the basic requirements for research, with the result that commencement of research programmes have been considerably delayed. The progressive withdrawal of concessions for the procurement of essential scientific goods, and the time – consuming procedures for the import and clearance of such goods, have been serious impediments to the smooth conduct of research.

The evidence presented clearly shows that the Research and Development effort in the country has been progressively declining; a trend accelerated by weak management of resources and the falling purchasing value of our currency. And with the current tendency of looking for imported technology, the situation is unlikely to change, especially in the industrial sector. One is reminded of the Products Cycle Theory, in terms of which, a developing country like Sri Lanka will not be able to purchase front-line technology over the counter for its industrial growth. In any case the conviction that the technology gap can be easily bridged through importation of sophisticated technology is hardly tenable in the context of a developing country like Sri Lanka, where the S&T structure is unenviably fragile and the industrial research base is so delicately poised.

It is also unfortunate that although in certain specific fields, excellent contributions have been made, leading even to the establishment of centres of excellence, the planning process was not geared to make the best use of these efforts. There are in fact many instances where projects have been abandoned half-way, or left incomplete for one reason or other, and valuable basic work carried out remains unknown to others and even to researchers within the same organization. Dissemination of information relating to such imcomplete work has been slow or even absent, with the result that a new entry into the field begins to repeat the work already accomplished, dissipating unnecessarily the valuable time, effort and limited resources. The absence of a mechanism for continuous evaluation of research targets has also been a serious defect in our S&T System.

It is however, still not too late to change the dismal course of events, since a viable scientific infra-strucutre is available, and a variety of options are now at the disposal of planners and policy makers, to be selected and tailored for an indigenous development pathway in science and technology.

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