A REPORT ON THE

INPUTS INTO SCIENTIFIC RESEARCH IN SRI LANKA

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A study of Resources Availability and Constraints for the Development of Science and Technology

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1.0 INTRODUCTION

1.1 Background

Underdevelopment of science and technology in Third World[1] countries has been attributed to a number of causes. Among these are scarcity of financial resources, deficiencies in the state planning organizations and the planning methodology, an inadequately trained manpower pool and a dependency syndrome. The development of science and technology (S & T) in Third World countries, being an induced development, planning and co-ordinating of science and technology activities become important.

The need for proper mechanisms to plan and co-ordinate science and technology activities has been advocated forcefully in the post-independence era by Sri Lankan scientists[2]. Although attempts have been made to induce S & T planning processes in the country, these have either failed or turned ineffective owing to a variety of reasons. Among these have been the lack of appreciation of S & T at the highest political levels, a failure to realise the vital nature of S & T inputs in socio-economic development; the lack of human and financial resources, inefficiency of existing S & T infra-structures and under-utilization and misdirection of S & T resources.

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1) A considerable literature exists that describe the situation in developing countries with respect to S & T development and highlights various causes. See Herrera (1982) and Goonatilake (1984) for an overview of this subject.
Several studies have been conducted into the use of S & T indicators and statistics in (1) the evaluation of research programmes in institutions. (Irvine & Martin, 1980 and Smith and Karlesky, 1978), (b) the direction and growth of scientific fields (Bud. et al. 1979), and (c) in the evaluation of national research programmes (MITRE Corporation, 1980), Johnson and Liyanage (1984). These studies by and large have pointed out some of the difficulties in developing suitable indicators to describe a nation's S & T system and the advantages and limitations of such indicators in assessing a national R & D system and in formulating S & T policies.

2) Sri Lanka Association for the Advancement of Science was the prime mover in initiating science planning activities and was responsible for the creation of the National Science Council of Sri Lanka.

Further, there has been no reliable S & T data base to guide decision makers to launch S & T programmes and periodically assess the progress of these.

In Sri Lanka, a systematic and sustained effort to collect S & T statistics has not yet been made, and large gaps still exist in the S & T information on Sri Lanka. The aim of this study is to provide some of this basic data, namely to quantify the volume, structure and direction of S & T resources in Sri Lanka.

1.2. Previous studies on the disbursement of S & T activities

In the past decade or so several governmental and non-governmental institutions, such as the National Science Council of Sri Lanka, Sri Lanka Institute for Development Administration, Manpower Planning Division of the Ministry of Plan Implementation, the CISIR, and the SLAAS have been involved at different periods in S & T resources studies. These organizations, however, were not directly involved in S & T resources studies on a regular basis.

The Sri Lanka Association for the Advancement of Science (formally CAAS) has on several occasions stressed the need to maintain reliable statistics, and in fact conducted the first survey on S & T manpower (Pattiarachi, 1972). This survey, was largely confined to members of the SLAAS made an effort to include all officers in important scientific and technical institutions. However, only 60% of the scientists in public sector institutions were covered by this survey.

The first comprehensive and systematic survey of scientific and technical manpower was carried out by the National Science Council of Sri Lanka for the period 1972/73. The survey strictly adhered to the concepts and methodology suggested by UNESCO. The institutions were surveyed using three questionnaires. The first questionnaire addressed to the Secretaries of Ministries, yielded a response rate of 100%. The second questionnaire addressed to the Heads of Departments and requesting a list of names of scientists and engineers employed by the institution had a response rate of 80%. The last questionnaire addressed to each individual scientist had only a rate of return of 35%. A major outcome of this survey was the preparation of a Directory of S & T personnel in Sri Lanka. The results of this survey revealed that the total number of scientists and engineers during 1972/73 period was 3430.

The NSC undertook its second national survey of S & T manpower for the period 1977/78. A special feature of this survey was the use of a structured questionnaire for which detailed replies were sought directly from individuals. Under normal circumstances such an elaborate survey of the entire "Scientific Community", would be a long drawn out exercise. In fact in the NSC study, even after 12 months of sustained activity, involving intensive persuasion, personal interviews, radio and news media publicity, the final response rate did not exceed 60 percent.

The survey revealed that the number of scientists and engineers then engaged in S & T activities was 4567 (Liyanage, S. and de Silva, M.A.T., 1979).

In a recent effort to assess S & T manpower in Sri Lanka, the Institute for Development Administration carried out a survey to prepare a directory of High-level S & T manpower in the country for the 1983/84 period. A preparation of a directory is now underway.

The first attempt to survey research and development (R & D) expenditure was undertaken by the CISIR in 1970 (Cooray 1970) for the period 1955-1966. This survey, however, covered only public sector institutions and the information obtained was based on actual expenditure recorded under R & D expenditure in Government Estimates. This procedure was found to be inadequate as budgetary items listed as "research" were not necessarily meant for research as defined in the survey.

The amount of R & D expenditure was estimated by this survey to be in the region of 0.3% of GNP during the early 1960's.

The National Science Council also carried out in 1975 a study of R & D expenditure. This study found that R & D expenditure in 1975 was Rs.45.1 million (0.21% of GDP)(Liyanage, et al. 1977). These studies have paved the way to developing the beginnings of a S & T data base for Sri Lanka.

1.3 Aims and Methodology of the Study

The present study was initiated by the National Science Policy Co-ordinating Committee of the Ministry of Plan Implementation as a supplementary exercise in their efforts to formulate a unified science policy for Sri Lanka. The main objectives of the study were to review the current state of science and technology in the country and to examine the problems affecting the utilization of manpower and financial resources devoted to research and development. The study although wide in scope had to be completed in a short period, to meet the time constraints of the plan.

The present study attempts to elicit manpower data for the year 1984 and R & D expenditure data for the 1983 calendar year. It covers R & D activities in the natural sciences, engineering and technology, agricultural sciences, medical, social science and humanities. A total of 503 private and public sector institutions were surveyed.

The study aims at providing a basic data base for science policy studies. It intends to give a very broad picture of the national science and technological efforts and identify some constraints in conducting R & D in the country. This study concentrates primarily on inputs to R & D activities. The definitions and methodology used conformed broadly to UNESCO guidelines and concepts on the measurement of S & T activities (UNESCO, 1977).

The survey was conducted through a circular letter issued by the Ministry of Plan Implementation, giving background information to the survey and operational instructions on the manner in which three questionnaires were to be filled by each institution. The three questionnaires referred to as A, B and C sought to draw out three types of information.

Form 'A' sought individual information on scientists, engineers, medical personnel, social scientists and technicians. This form was to be completed by the Personnel Manager of the institute surveyed. The second questionnaire (form B) was directed to the Finance Manager of the institution, and called for information on the financial resources allocated for research and/or other scientific activities. The third questionnaire (form C) was to be completed by the head of the institution and it sought to elicit information pertaining to policy directions, research orientation, problems and constraints to research, and the head's personal viewpoints on future directions.

The study attempts to cover (a) private sector manufacturing institutions (b) those private companies likely to employ scientists, engineers, and (c) all public sector institutions. It should however, be noted that the medical service sector and the secondary school science education sector have not been covered in this survey.

The despatch of questionnaires was followed up later by personal visits to the institutions concerned by field investigators to assist the officers nominated by each institution to compile the necessary information. In many of the major state departments and institutions, however, this follow-up work itself was quite difficult.

For instance, the Department of Agriculture which has its head office in Peradeniya, has seven major technical divisions including the Royal Botanical Gardens. Agricultural

Research is carried out on a regional basis and serves 8 major agro-ecological divisions There are therefore eight Regional Research Centres, which together with 4 special research centres and 12 satellite experimental stations, form the arable crop research network in Sri Lanka. Its extension services are even more diverse. Thus with a total staff strength of about 17,000 distributed throughout the country, of which about 6,400 make up the technical grades, it was difficult to expect statistical information at short notice.

It is however, encouraging to note that in the public sector as a whole 70 percent of the institutions provided the necessary information within eight weeks of commencement of the study. This number effectively accounted for more than 90 percent of the S & T efforts in the public sector of the country, since a reconnaissance study has indicated that the institutions which failed to respond represented only a small segment of the national S & T effort (less than 250 scientists and engineers).

On the other hand, the response from the private sector was very poor, mainly because a great majority of these institutions do not engage in R & D. It is also significant to note that while all the state sector commercial banks and the only privately owned Sri Lankan bank provided all information without any hesitation, the foreign owned comercial banks, without exception, failed to respond.

The storage and analysis of data collected from this survey was processed using the computer facilities of the Department of Census and Statistics All items of information requested in the questionnaires were coded and fed into the computer for statistical analysis.

1.4 Scientific and Technical Manpower

The Questionnaire 'A' called for a listing of scientists, engineers, medical personnel, social scientists and technicians as defined in Annex I. It sought information on age, sex, academic and professional qualifications, subject speciality and whether or not engaged in research and development activities. Since the study was largely in respect of inputs to S & T activities, biographical and bibliometric information relavant to output studies were excluded. Again, since the respondents to this questionnaire were either the personnel manager or the administrative manger of the institution, the information provided in respect of subject speciality was in some cases based on broad subject areas in which the person had his first degree or higher degree. This information we believe was adequate and meets the requirements of this study.

1.5 Expenditure on Research and Development

The Questionnaire 'B' called for information on the intramural and extra-mural expenditure on R & D. Since the required information had to be provided by the accountant or finance manager of the institution, a simple apportioning of funds in respect of capital (equipment, instruments,etc.) and recurrent (wages, travel, etc.) expenditure were requested.

In many of the larger organizations handling heterogenous and complex activities, (e.g. Highways Department, Mahaweli Authority, etc.) the survey officials assisted the respective contact persons of the institutions to compile the necessary information. As had been anticipated, the major problems for many institutions was the difficulty in differentiating research and experimental development activities from service activities. Some service activities could sometimes lead to research activities, which are not recognized by the institution concerned as R & D. Here again the survey officials were in some instance able to assist respondents.

Employees in the Higher Education Sector, whose main function is teaching are also expected to devote time to research. This time component had to be quantified for purposes of estimating the expenditure on R & D. This was done by requesting the relevant higher education institutions to specify the percentage of time their S & T personnel devoted for the different activities such as teaching, research and others. This apportioning of time was also recommended to those other institutions that carried out research activities along with other functions.

1.6 Constraints to Scientific Research

The Questionnaire 'C' sought answers for 13 structured questions relating to managerial problems and constraints to scientific research. Many of the problems are very well known, yet each such problem is the result of different causes that affect each institution in diverse ways. Thus the purpose of this questionnaire was to help identify those heterogenous and diverse issues which affect the performance of research.

1.7 Coverage and response rate

A variety of scientific and technical (S & T)institutions were covered in this study, in addition an attempt was also made to include also all those non-S & T institutions in the state sector.

Scientists and engineers in all public sector institutions were thus covered extensively. The chief investigators also interviewed a cross section of research scientists and engineers. It should be noted that no attempt was made to include medical officers in Health Services and secondary school teachers in this survey, because of time constraints.

A list of institutions to be surveyed was compiled after consulting several sources such as directories and instutional lists as well as the previous NSC (1977) survey list Table 1 gives the extent of coverage.

Table 1

Response to questionnaire by
General Status of Institutions

Status of Institution	Total Issued	Replies	Response (percent)
Government	280	264	94%
Private	211	93	44%
Private Non-Profit	12	10	83%
Total	503	367	73%

The response rate of public sector institutions conducting S & T was over 94%. The survey thus covered almost all S & T institutions in the state sector and those who did not respond in state sector were found on closer examination to be in non-S & T institutions. Private sector response to the study was poor, presumably because of their relative lack of interest in R & D. However, most of the major enterprises conducting R & D activities were among those who responded in the private sector.

2.0 SUMMARY OF HIGHLIGHTS

* The total economically active scientists engaged in S & T activities reported in the study was 7221. Natural scientists comprised of 34% of the total, engineers and technologists were 43%, medical scientists 5% and social scientists 18%.

* Economically active natural scientists and engineers amount to 5557 in 1984 compared with 4567 personnel in 1978. This correspond to an average annual increase of 2.5 percent (141 person per year). This is compared with the annual average output of 645 scientists and engineers from the universities from 1977 to 1982

* The public sector continues to provide the major S & T service in the country by employing 92% of the economically active scientists and engineers and being as well responsible for 93% of the R & D expenditure.

* The number of scientists and engineers engaged in R & D activities amounts to 33% of the economically active scientists and engineers and only 10% of them were engineers and technologists.

* Women comprise only 15% of scientists and engineers.

* At constant 1970 prices (based on GDP deflator), the total direct R & D expenditure increased only marginally from Rs. 25 million in 1975 to Rs. 33.4 million in 1983

* As a percentage of GDP, R & D expenditure had declined from 0.2% in 1975 to 0.14% in 1983.

* Per capita R & D expenditure in 1984 was around US$ 0.40 down 7 cts from the 1975 figure.

* 58% of national R & D expenditure was spent on agricultural sciences

* Full-time equivalent R & D scientists and engineers per million population was 79 in 1984, the average for developing countries being 125 in 1980.

* Basic research constitute only 8% of the Gross Expenditure on R & D and the research expenditure was heavily weighted for Applied Research.

* In some state sector employment total emoluments are nearly twice that obtained by scientists in equivalent positions.

3.0 Manpower Resources Available for S & T Activities in Sri Lanka during 1984

The results in this section cover data on -

(a) Total manpower available for S & T activities in all categories of persons Section 3.1

(b) Total economically active natural scientists and engineers only Section 3.2

(c) Natural scientists and engineers engaged in R & D Section 3.3

(d) Social scientists, medical personnel and the supportive technicians. Section 3.4

It should be noted that the term 'scientist' encompass all personnel including social scientists and medical personnel who are engaged in S & T activities as defined by UNESCO (See Annex 1) However, the term 'scientist' in everyday parlance is used to describe those who are engaged in "natural" sciences. Therefore, to avoid confusion,we have five categories of personnel in the survey, namely scientists (engaged in "natural" sciences), medical personnel, (medical doctors) social scientists, engineers and architects The classification is adopted purely on the basis of their academic and professional qualifications.

3.1 Manpower Available in all Scientific and Technical Categories

The availability of total economically active scientists and the number engaged in research is given in Table 3.0. Total scientific and technical manpower excludes secondary school teachers and medical officers in health services identified was 9837 Scientists comprised of 25% of this total, and engineers and architects amounted to 32%, Medical personnel contributed 3% and social scientists contributed 13%, the remaining 27% was technicians More than 60% of the scientific technical manpower was under 30 years of age and 2951 were engaged in R & D activities which represent 30% of the total scientific and technical potential.

Table 3.0

Economically Active Scientists & Engineers in Sri Lanka

All Activities

	Scientists		Engineers		Medical		Soc.Sci.		Techni.		Archi.	
Male	2025 (2432)	82%	2894 (2546)	94% (93)	221 (247)	66% (65)	965 (117)	75% (76)	2229 (2558)	85% (87)	24 (178)	62%
Female	457 ([illegible])	18%	181 (268)	6% (7)	115 (134)	34% (35)	324 (355)	25% (24)	387 ([illegible])	15% (13)	15 (26)	38%
	2482 ([illegible])		3075 ([illegible])		336 (381)		1289 (1472)		2616 (2953)		39 ([illegible])	

Engaged in R & D

	Scientists		Engineers		Medical		Soc.Sci.		Techni.		Archi.	
Male	962 (1102)	73% (76)	224	91%	136 (146)	67%	487 (539)	80% (78)	444 (448)	76%	5	50%
Female	340 (355)	27% (24)	21	9%	66 (73)	33%	124 (152)	20% (22)	144	24%	2	50%
	1302 (1457)		245		202 (219)		611 ([illegible])		588 ([illegible])		7	

	All S & T Activities		All R & D Activities	
Male	8355 (11791)	85% (87%)	2254 ([illegible])	78% ([illegible])
Female	1479 (1713)	15% (13%)	697 ([illegible])	24% ([illegible])
	9834 (13504)		2951 ([illegible])	

Note:- Excludes Secondary School Teachers and Medical Officers in the medical services. According to Ministry of Education Graduate Science Teachers amounts to 2242 and Ministry of Health statistics reveals medical doctors amounts to 1667

3.2 Economically Active Natural Scientists and Engineers, 1984

Table 3.0 covered all disciplines Taking now only two categories we note that economically active natural scientists and engineers in the country comprise a very small percentage (o 13%) of the total employed population in Sri Lanka[3]. Further, they represent only 2% of the professional, technical and related workers

Table 3.1 shows that the national scientific and technical manpower is heavily weighted in favour of state sector institutions.

Table 3.1

Total Number of Economically Active Natural Scientists and Engineers in Sri Lanka During 1984

Sector / Category	State Sector	%	Private Sector	%	Total	%
Scientists-Male	~~1891~~ 229[illegible]		134		~~2025~~ 2[illegible]	82
Female	~~449~~ 537		8		~~457~~ 535	18
Sub-total	~~2340~~ 2825	~~94~~ 95	142	~~6~~ 5	~~2482~~ 2967	100
Engineers-Male	~~2588~~ 3179		~~306~~ 367		~~2894~~ 3546	~~94~~ 93
Female	~~176~~ 263		5		~~181~~ 266	~~6~~ 7
	~~2764~~ 3442	90	~~311~~ 372	10	~~3075~~ 3879	100
Total Scientists and Engineers	~~5104~~ 6267	92	~~453~~ 514	8	~~5557~~ 6781	100

3) Based on latest available census 1981 - Dept of Census and Statistics, Statistical Year Book

A large percentage (59%) of natural scientists and engineers were spread among those institutions conducting general services The institution in the productive & higher sectors were responsible for the employment of 28% and 13% respectively.

Table 3.2 presents the distribution of engineers and scientists according to sector of performances

Table 3.2

Distribution of Natural Scientists and Engineers According to Sector of Performances

Category	Scientists				Engineers			
Sector	Male	Female	Total	%	Male	Female	Total	%
General service sector	~~1034~~ 1333	~~271~~ 332	~~1305~~ 1665	~~53~~ 56	~~1860~~ 2030	~~136~~ 171	~~1996~~ 2201	~~65~~ [illegible]
Productive sector	~~614~~ 689	~~37~~ 42	~~651~~ 731	~~26~~ 25	~~892~~ 1374	~~29~~ 81	~~921~~ 1455	~~30~~ 38
Higher Education sector	~~377~~ 410	149 161	~~526~~ 571	~~21~~ 19	142	16	158	~~5~~ 4
Total	~~2025~~ 2432	~~457~~ 535	~~2482~~ 2767		~~2894~~ 3546	~~181~~ 268	~~3075~~ 3814	100

Most of the scientists and engineers in the survey were employed on a full-time basis. Only 6 out of 2479 scientists were employed on part-time basis and 21 of the 3070 engineers were employed on a part-time basis. There were 17 foreign consultants among the scientists and 52 foreign consultants among the engineers. A significant number (208 scientists and 95 engineers) were on leave abroad from the institutes being on long term specialized training.

According to age distribution, 43% of the scientists - the largest segment - were between 30-39 years old and were senior scientists available in the institutes were low (Table 3 3)

Table 3.3

Distribution of Scientists and Engineers According to Age Categories

Category of Personnel

Age Group	Scientists	%	Engineers	%	Sci & Engi.	%
Up to 29	~~569~~ 684	23	~~760~~ 1041	25	~~1329~~ 1725	24
30-39	~~1071~~ 1290	43	~~1202~~ 1542	~~39~~ 40	2273 [illegible]	41
40-49	~~501~~ 573	20	~~605~~ 668	~~20~~ 17	~~1106~~ [illegible]	20
50-59	~~227~~ 245	9	~~288~~ 326	9	~~515~~ [illegible]	9
60 & over	~~21~~ 26	1	~~41~~ 46	1	~~62~~ 72	1
Age not specified	~~93~~ 149	4	~~179~~ 254	6	~~272~~ [illegible]	5
	~~2482~~ 2967	100	~~3079~~ 3877	100	5557	100

Note:- Age not specified

The distribution of all scientists according to their field of specialization shows a high concentration in agricultural sciences 46%, (Table 3.4) followed by natural sciences (37%) and engineering and technology (12%)

Table 3.4

Distribution of Natural Scientists and Engineers According to Field of Science

Category of Personnel

Field of Science	Scientists Male	%	Scientists Female	%	Scientists Total	%	Engineers Male	%	Engineers Female	%	Engineers Total	%
Natural Sciences	~~679~~ 771		~~236~~ 251		~~915~~ 1022	~~37~~ 34	560		48		608	~~20~~ 16
Agri Sciences	~~958~~ 1177		~~177~~ 212		~~1135~~ 1389	~~46~~ 47	~~113~~ 119		~~1~~ 7		~~111~~ 126	~~4~~ 3
Engi & Techno.	~~289~~ 273		~~22~~ 114		~~311~~ 417	~~12~~ 14	~~2158~~ 2804		~~131~~ 213		~~2289~~ 3017	~~76~~ [illegible]
Medical Sciences	9		5		14	1	1		-		1	-
Social Sciences	~~90~~ 102		~~17~~ 23		~~107~~ 125	4	62		-		62	2
	~~2025~~ 2432	82	~~457~~ 535	18	~~2482~~ 2967	100	~~2894~~ 3546	~~94~~ 73	~~111~~ 268	~~4~~ 7	~~3077~~ 3814	100

Note:- This category refers to natural scientists and engineers (as defined by their basic degree) working in the field of medical sciences and social sciences. For medical scientists and social scientists working in their own field see subsequent section 3.4.

The level of educational attainment of S & T personnel is a partial indicator of the quality of workforce. The number of post-graduates, particularly with doctoral degrees were small in number (Table 3.5)

Table 3.5

Educational Attainment of Scientists and Engineers

Category of Personnel

Educational Quali.	Scientists	%	Engineers	%	Sci. & Engi.	%
Doctoral	302	12	57	2	359	6
Masters	337	14	180	6	517	9
Dip. (Post-graduates)	40	2	99	3	139	2
Bachelor	1369	55	1946	63	3315	60
Other	434	17	793	26	1227	23
	2482	100	3075	100	5557	100

Natural Scientists and Engineers Engaged in Research & Development

A large percentage of natural scientists (52%) were reported to be engaged in research activities. They represent about 44% of all researchers in the country. Among these natural scientists who were engaged in research 41% were agriculturists. Only 8% of the engineers were involved in R & D activities, hence, there was a large reserve of talented engineers available for R & D work. Another important feature of the R & D workforce is the distribution of a large number of researchers in the universities (Table 3.6)

Table 3.6

Scientists and Engineers Available for R & D Activities by Sector of Performance

Category of Personnel	Scientists				Engineers				Sci.&Engl.	%
Sector	Male	Female	Total	%	Male	Female	Total	%		
General Services	~~526~~ 666	~~185~~ 200	~~711~~ 866	~~55~~ 60	98	9	107	44	818	53
Productive	80	10	90	~~7~~ 6	14	1	15	6	105	7
Higher Education	358	140	~~503~~ 498	~~38~~ 34	112	11	123	50	626	40
	~~964~~ 1104 (~~74~~ 76)	~~340~~ 350 (~~26~~ 24)	~~1304~~ 1454	100	224 (91)	21 (9)	245	100	1549	100

It is important to note that although the number involved in R & D work in the Higher Education sector is relatively large in magnitude, the actual full-time equivalent personnel would be small in number as they are involved in the dual function of teaching and research, teaching being the predominant activity. It is beyond the scope of this study to make a detailed estimation of these separate activities by the university staff. However, some estimates are given in the University Statistics published by the University Grants Commission (UGC, 1982).

It should be noted that only the major research institutions are employing full-time researchers. The total of scientists and engineers in major research institutions who are predominantly involved in R & D amounts to 635 and the remaining researchers can be considered as part-time.

Distribution of scientists and engineers according to field of activities shows that a large number of research personnel are concentrated in Agricultural Sciences. A wide range of specialities of these personnel are reported and it is not possible to list all of them. However, Table 3.7 and 3.8 list some of the major groupings according to field of science and specialities.

Table 3.7

R & D Natural Scientists and Engineers
According to Major Fields of Sciences

	Scientists				Engineers				Sci.& Engi.	%
	Male	Female	Total	%	Male	Female	Total	%		
Natural Science	489	188	677	~~52~~ 46	102	11	113	46	790	51
Agri. Science	~~400~~ 535	~~133~~ 148	~~533~~ 683	~~41~~ 47	15	2	17	7	~~550~~ 698	36
Engi. & Tech.	46	8	54	4	107	8	115	47	169	10
Medical * Science	~~10~~ 14	4	~~14~~ 18	1	-	-	-	-	~~14~~ 18	1
Social * Science	~~19~~ 20	7	~~26~~ 27	2	-	-	-	-	~~26~~ 27	2
	~~964~~ 1104	~~340~~ 355	~~1304~~ 1459	100	224	21	245	100	~~1549~~ 1702	100

* See note on page 12

Table 3.8

Number of Scientists & Engineers in top 10 specialities

Scientists

Natural Science

Chemistry - 272 (Analytical chemists 34
Bio chemists 19)

Botanists - 115 (Micro biologists 24
Bio chemists 14)

Mathematicians - 98

Geologists - 67

Zoologists - 62 (Marine Biologists 14)

Physicists - 61

Surveyors - 40

Meterologists - 24

Engineers

Civil Engineers	- 1,160
Mechanical Engi.	- 544
Electrical Engi.	- 398
Electronic Engi.	- 192
Sanitary Engi.	- 150
Chemical Engi.	- 102
Production Engi.	- 20
Mining Engi.	- 13
Telecommunication	- 11
Structural Engi.	- 10
Industrial Engi.	- 9

Agricultural Science

Agronomists	- 246
Dairy Technologists	-88
Entronologists	- 45
Food Scientists	- 32
Agri. Statisticians	- 32
Plant Breeders	- 31
Agri Economists	- 28
Horticulture	- 25
Soil Scientists	- 19
Pathologists	- 17

In the case of scientists in particular, post-graduate qualifications are important indicators of the extent of specialized training. Speciality of engineers is often indicated by the professional qualifications. Table 3.10 shows the distribution of scientists and engineers according to academic qualifications. It is observed that a large percentage of highly qualified manpower is concentrated in the higher education sector.

Table 3.9.

Number of Post-graduate qualified R & D scientists and Engineers by Sector of Performance

Category of Person	Dip. (Post-Gr.)				M.Sc.				Ph.D.			
	Engi.	Sci.	Total	%	Engi.	Sci.	Total	%	Eng.	Sci.	Tota	
General Service Sector	3	~~15~~ 22	~~18~~ 25	~~85~~ 89	9	~~175~~ 197	~~184~~ 206	~~67~~ 69	4	~~107~~ 114	~~111~~ 118	36
Productive Sector	2	-	2	~~10~~ 7	15	3	18	~~7~~ 6	6	-	6	2
Higher Education	1	-	1	~~5~~ 4	20	53	73	~~26~~ 25	31	175	206	62
	6	~~15~~ 22	~~21~~ 28	100	44	~~231~~ 253	~~275~~ 297	100	41	~~282~~ 289	~~323~~ 330	1

Table 3.10 illustrates the age distribution of S & T manpower for R & D activities in the country.

Table 3.10

Distribution of R & D scientists & engineers according to age categories

Age Group	Under 29	%	30 - 39	%	40 -49	%	50 -59	%	60 & over	%	Total	
Scientists	~~395~~ 447		~~557~~ 620		~~237~~ 266		~~103~~ 110		~~12~~ 14		~~1304~~ 1457	8
Engineers	83		103		45		9		5		245	1
Total	~~478~~ 530	31	~~660~~ 725	43	~~282~~ 311	18	~~112~~ 119	7	~~17~~ 19	1	~~1549~~ 1702	10

The results show that a large percentage of scientists and engineers in R & D are distributed in the age group below 40 years.

An acute shortage of senior personnel was noted, particularly in the Higher Education Sector.

Availability of Medical and Social Scientists and Technicians for S & T Activities During 1984

According to the Health Ministry Statistics there were 1667 medical officers in the health services of the Ministry in 1984. This study, however, did not attempt to include those medical officers in the health services due to resource and time constraints. In addition to these medical officers, a number of State and Private Sector institutions employed medical scientists for various S & T activities. Such medical scientists were included in this survey and this numbers amounted to 336 medical scientists, most of them were found in the State Sector (95%). The women medical scientists accounted for 34% of the total medical scientists Social scientists engaged in S & T activities were mostly employed by the State Sector (98%) and the women social scientists comprised of 25% of the total. The technicians engaged in S & T activities were 2616 personnel of which 15% were women technicians.

Table 3.11

Distribution of Medical and Social Scientists and Technicians by General Sector of Employment and by Sex

Category Sector		Medical Sci.	%	Social Sci.	%	Technician	%
State	Male	231 ~~205~~	63 (~~64~~)	990 ~~838~~	74 (~~73~~)	2276 ~~2045~~	85 (~~84~~)
	Female	133 ~~114~~	37 (~~36~~)	347 ~~316~~	26 (~~27~~)	391 ~~383~~	15 (~~14~~)
		364 ~~319~~	(100)	1337 ~~1152~~	(100)	2667 ~~2428~~	
Private	Male	16	(94)	128	(95)	282 ~~184~~	99 (98)
	Female	1	(6)	7	(5)	4	1 (~~[illegible]~~)
		17	(100)	135	(100)	286 ~~188~~	(100)
	Total	381 ~~336~~		1472 ~~1289~~		2953 ~~2616~~	

The distribution of these categories of personnel according to the sector of performance is given in Table 5 13 A high percentage (57%) of the medical scientists were employed in the Higher Education Sector.

Table 3.12

Distribution of Medical and Social Scientists and Technicians engaged in S & T Activities by Sector

Category/ Sector of performance	Medical Sci.	%	Social Sci.	%	Technician	%
General Service	126 ~~93~~	33 ~~28~~	749 ~~625~~	51 ~~48~~	1845 ~~1702~~	63 ~~65~~
Productive	51 ~~50~~	13 ~~15~~	269	18 ~~21~~	868 ~~674~~	29 ~~26~~
Higher Education	204 ~~193~~	54 ~~57~~	454 ~~395~~	31	237	8 ~~9~~
Total	381 ~~336~~	100	1472 ~~1289~~	100	2950 ~~2616~~	100

Those who were engaged in research and development activities is presented in Table 3 15 The percentages of medical and social scientists engaged in R & D activities are 60 and 47 percent respectively. The technicians involved in R & D work was 22% of the total S & T technicians.

Table 3.15

Availability of medical, social scientists and technicians for R & D work - 1984

	Medical Sci.	%	Social Sci.	%	Technicians	%
Government	~~198~~ 215	98	~~596~~ 676	~~97~~ 98	~~584~~ 568	99
Private	4	2	15	~~3~~ 2	4	1
Total	~~202~~ 219	100	~~611~~ 691	100	~~588~~ 572	100

Financial Resources Incurred on Research and Experimental Development During 1983

Research and development activities undertaken in private and public sector institutions varied from occasional to regular for the 130 institutions surveyed. Of this number 80 institutions conducted R & D activity regularly, whilst 36 institutions had a separate R & D budget The identification of R & D expenditure was very difficult in institutions where R & D activity was carried out only occasionally It was only in 54 institutions that R & D expenditure could be accurately identified Therefore, unlike in the manpower statistics, R & D expenditure statistics were difficult to compile

Even in major research institutes a considerable amount of resources were spent not on research purposes but on "related scientific activities" such as routine testing, extension service, information services, seminars and consultancy work.

The expenditure incurred on such activities was difficult to separate from R & D activities Moreover in the Higher Education Sector the actual R & D expenditure was very difficult to identify from the University budgets

There were also some difficulties in measuring R & D expenditure within institutes of research. Research and development activities are often understood and interpreted differently by different individuals. The accounting procedure for R & D expenditure also varied from institution to institution. Although the Institute of Chartered Accountants in Sri Lanka has recognized this problem and adopted standards for treating research and development since 1980[5], only a few institutions have strictly followed these procedures.

4.1 R & D Expenditure by Sectors of Performance

The total R & D expenditure during 1983 as reported was Rs. 162.65 million of which 93% was accounted for by the state sector (Table 4.1).

Table 4.1

Gross National R & D Expenditure in Sri Lanka During 1983 by State & Private Sectors (in Rs.'000)

Sector	Recurrent	Capital	Total
State	141,420 ~~110441.2~~ (73%)	[illegible] ~~40944.3~~ (27%)	207381 ~~151385.0~~ (93%) 95%
Private	7491 ~~6898.7~~ (61%)	[illegible] ~~4367.3~~ (39%)	10227 ~~11266.0~~ (5%)
	148971 ~~117339.9~~	68637 ~~45311.6~~	217608 ~~162651.0~~

5) See Sri Lanka Accounting Standard No. 11 of the Institute of Chartered Accountants, Sri Lanka.

In the private sectors the ratio between recurrent and capital expenditure was slightly higher than the state sector

Table 4.2

R & D Expenditure by Sector of Performance

(Rs. '000)

	Recurrent				Capital					
	Salary		Others		Equip.		Others		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
General Service Sector	60721.8	71	22803.4	73	12128.7	75	27253.5	93	122907.4	76
Productive Sector	9917.2	11	5069.5	16	3358.7	21	1914.0	7	20259.4	12
Higher education sector	15284.5	18	3542.9	11	644.4	4	12.4	-	19484.2	12
	85923.5	100	31415.8	100	16131.8	100	29179.9	100	162651.0	1

Note:- The proportion of academic services attributable to R & D in the University was calculated using the statistics of University Grants Commissions (UGC 1982)

According to the sector of performance (Table 4.2) R & D expenditure is largely concentrated (76%) in the general services sector (see definition in Annex 1). Both the Productive Sector and Higher Education Sector in Sri Lanka had more or less similar expenditure level. Notably the R & D inputs in the Productive Sector has declined in comparison with earlier surveys. In the Higher Education Sector, the R & D expenditure constitutes directly identifiable expenditure from the university budget and a component of estimated academic services directed to R & D In some rare occasions, university staff receive individual grants direct from foreign agencies which have not been identified here

4.2 R & D Expenditure According to Field of Science

R & D expenditure according to field of science is given in Table 4.3. Agricultural research received the highest percentage in expenditure, whereas medical research had the lowest. This trend was very much similar to the findings of the previous surveys.

Table 4.3

R & D Expenditure by Field of Science

(Nearest '000)

	Recurrent				Capital				Total	%
	Salary	%	Other	%	Equip.	%	Other	%		
Natural Science	13493.8	16	4025.8	13	4904.1	30	1648.8	[illegible]	24039.5	[illegible]
Agricultural Science	47589.2	55	18324.8	58	8791.2	55	19969.3	68	94674.5	58
Engineering & Tech.	6724.4	8	3989.0	13	1829.8	11	7560.9	26	20404.1	12
Medical Science	5518.2	6	2702.8	9	463.6	3	3.4		8688.0	5
Social Science	12598.0	15	2373.4	7	173.1	1	0.4		15144.9	10
	85923.6	100	31415.8	100	[illegible]	100	29152.8	100	162651.0	

4.3 Related R & D Expenditure Reported by R & D Performing Institutions

There are a number of institutions which reported "Related" scientific activities (see Annex 1 for definitions) as shown in Table 4.4.

Table 4.4

Expenditure on Related S & T Activities Reported by the Institution conducting R & D Activities (nearest Rs. '000)

Field of Science	Recurrent			Capital				Total	
	Salary	%	Other	Equip.	%	Other	%		%
Natural Science	20343.4	66	12793.0	2658.8	30	417.1	3	36212.3	50
Agricultural Science *	1782.3	6	824.7	275.9	3	19.9		2902.8	4
Engineering & Technology	1381.3	4	356.5	5608.0	64	11940.0	97	19285.8	27
Medical Science	3885.2	13	199.8	105.5	1	--		4190.5	6
Social Science	3572.5	11	5468.2	132.9	2	--		9173.6	13
	30964.6	100	19642.2	8781.0	100	12377.0	100	71765.0	100

* Note: This expenditure does not represent the extension services of the Department of Agriculture.

One of the striking features of the related S & T activities is the low expenditure allocated to it by the private industries. The private sector institutions we found on interview were largely involved in R & D activities mainly in relation to specific problems and in minor modification to processes and products development. This may indicate low investments by private institutions on past R & D activities.

.4 Extramural R & D Expenditure by Field of Science

The extent of contracted research from some institution to research agencies, research institutes and universities is presented in Table 4.5.

Table 4.5

Extramural Research and Development Expenditure

	Recurrent				Capital				Total	
	Salary	%	Other	%	Equip.	%	Other	%		%
Natural Science	587.2	72	2404.2	35	1848.1	36	367.6	99	5207.1	39
Agricultural Science	-		954.9	14	134.1	3	-		1089.0	8
Engineering & Technology			56.9	1	2740.9	52	-		2797.8	21
Medical Science	225.0	28	2943.3	43	463.6	9	3.4		3635.3	28
Social Science										

The recepients of most of the contracted research have been state sector institutions and the funding bodies are also in the State Sector. There were hardly any private research agencies and estimations to undertake contract research in natural sciences, although such associations do exist for social science research.

4.5 Sources of Funds for R & D Activities

Source of funding R & D activities is given in Table 4.6. A large part being generated from government institutions. Foreign funds also constitute asignificant 12% share of funding.

Table 4.6

R & D Expenditure by source of fund (nearest '000)

	Nat.Sc.	%	Agri.Sc.	%	Eng. & Tec.	%	Medical	%	Social Sc.	%	Total
Local funds	~~21328.6~~ 27657	~~89~~ 91	~~88445.0~~ 122576	~~93~~ 95	~~13091.6~~ 21283	~~65~~ 75	~~6052.3~~ 5816	~~70~~ 69	~~14462.4~~ 21103	~~96~~ 97	198435
Foreign funds	~~2710.9~~ 2714	~~11~~ 9	~~6229.5~~ [illegible]	~~7~~ 5	~~7012.5~~ 7013	~~35~~ 25	~~2635.7~~ 2636	~~30~~ 31	~~682.5~~ 583	~~4~~ 3	19173
	~~24039.5~~ 30268	100	~~94674.5~~ 128806	100	~~20104.1~~ 28296	100	~~8688.0~~ 8452	100	~~15144.9~~ [illegible]	100	[illegible]

4.6 R & D Expenditure by Type of Activity

Table 4.7 gives a breakdown of R & D expenditure according to type of activities such as basic, applied, experimental development activities. The commitment to basic research in generally low, and a large part of the support came from state sector institutions. Most of the general service sector tends to undertake more experimental development type of research. Medical sciences reported very high percentage of basic research which was mainly supported by the Higher Education Sector.

Table 4.7

R & D Expenditure by Type of Activity
and by Field of Science
(nearest Rs '000)

Type of Activity/ Field of Science	Basic	Applied	Exp. development
Natural Science	~~1247.9~~ [illegible] (5%)	~~18735.2~~ 23687 (78%)	~~4056.4~~ 5163 (17%)
Agricultural Science	~~5697.2~~ 7728 (6%)	~~68957.0~~ 94028 (73%)	~~20019.9~~ 27050 (21%)
Engineering & Technology	~~1076.8~~ 1415 (5%)	~~12708.0~~ 18109 (64%)	~~6319.1~~ 8772 (31%)
Medical Science	~~4348.8~~ [illegible] (50%)	~~4101.7~~ 3972 (47%)	~~238.1~~ 254 (3%)
Social Science	~~474.8~~ 651 (3%)	~~14670.1~~ 21035 (97%)	-
Total	~~12845.5~~ 17409 (8%)	~~119172.0~~ 158854 (73%)	~~30633.5~~ 41345 (19%)

Historical statistics on S & T activities in Sri Lanka

Growth of science and technology as measured by inputs to such activities may be taken as one indicators to describe the state of science and technology in Sri Lanka.4)The development of indicators require historical statistics which are comparable. Unfortunately, S & T statistics available in Sri Lanka do not permit such long term comparisons. The only surveys which can be compared with the present study in terms of coverage, scope and definitions was the 1977/78 surveys of S & T Manpower of the National Science Council, and the 1977 study of R & D Expenditure by the same organization.

Table 5.1 presents the growth of scientists and engineers (including medical personnel in S & T institutes and social scientists for 1984) during 1977/78 to 1984. The annual average growth rate excluding social sciences for the period shows 3.6% increasein total S & T manpower and 7% increase in full-time equivalent R & D manpower.

Table 5.1 - Growth of Economically Active Scientists and Engineers by Field of Sciences from 1977/78 to 1984

Year / Field of Science	1977/78 No.	1977/78 %	1984 No.	1984 %	Annual Average percentage increase
Natural Sciences	1074	24	~~1523~~ 1620	~~21~~ 18	~~6.0%~~ 7.1%
Agricultural Sciences	869	19	~~1250~~ 1515	~~18~~ 17	~~6.3%~~ 9.2
Engineering & Technology	2420	53	2642 3638	~~36~~ 41	~~1%~~ 6.3%
Medical Sciences	204	4	~~351~~ 296	~~5~~ 4	~~10.3%~~ 11.8%
Social Science			~~1455~~ 1659	~~20~~ 20%	
Total	4567	100	7221	100	

It is important to note that the full-time equivalent researchers in engineering and technology only amounts to 3% of the economically active engineers and technologists in the country. The agriculture sector was responsible for the highest percentage of researchers (42%) of the total economically active agriculturists in the country. Table 5.2 presents the growth of research scientists and engineers by field of sciences from 1977/78 to 1984.

4) For a further discussion on this subject see Johnson, R and Liyanage, S (1983), Australian Science and Technology Indicators, Feasibility Study - Higher Education, Department of Science and Technology, Canberra.

Table 5.2 - Growth of all Research Scientists and Engineers by Field of Science from 1977/78 to 1984

Year Field of Science	1977/78 Total (FTE)	1984 Total (FTE)	Annual Average % growth of total scientists
Natural Science	340 (161)	790 (306)	18.9
Agricultural Science	463 (362)	550 (531)	2.7
Engineering & Technology	155 (61)	169 (78)	1.2
Medical Science	181 (78)	216 (85)	2.3
Social Science	n.a	638 (212)	
	1139 (662)	2363 (1212)	

Note: - FTE refers to Full-time Equivalent Researchers. FTE is calculated on the basis of UNESCO recommendation to count 3 researchers equivalent to 1 FTE.

Natural Sciences show the highest growth and excluding social sciences the average annual growth of all research scientists and engineers was 7% which is nearly double the amount of increase in all economically active scientists and engineers (3.6%). Therefore rate of increase of research personnel is higher than the rate of all working scientists which is a healthy phenomenon. Growth of R & D expenditure at current prices show that the levels of R & D expenditure had grown considerably although not in proportion with economic activities as indicated in Table 5.3.

Table 5.3 - Growth of R & D expenditure from 1951/52 to 1983 (in rupees)

Year	R & D expenditure at current prices	at constant prices	% of G.D.P.
1951/52	8.2 million	8.2 mil.	0.17%
1959/60	18.8 million	18.2 mil.	0.29%
1965/66	19.8 million	17.6 mil.	0.23%
1970	21.5 million	15.6 mil.	0.18%
1975	45.1 million	22.7 mil.	0.21%
1983	~~162.6~~ million 217.6	~~28.9~~ mil.	0.14%

* 1952 = 100

Source: R & D expenditure for financial years 1950/51, 1955/59 and 1965/66 were reported in Cooray N (1970). Current Expenditure on Scientific Research and Development in Ceylon, CISIR, Colombo. Expenditure for 1970 and 1975 from S. Liyanage et al. (1977). A Survey of Expenditure on Research and Experimental Development in Sri Lanka, 1966 - 1975, N.S.C. Colombo.

Cautionary Note: The figures given before 1970 may not be comparable with later ones due to different definitions etc.

Agricultural Research contributed a large percentage to the total national R & D expenditure. In 1966 expenditure on agricultural research was 74% of the total R & D expenditure and it had dropped respectively to 53% in 1975 and [illegible]% in 1983.

The proportion of capital expenditure also has increased from 22% in 1966 to 28% in 1975 to 37% in 1983. The proportion of the recurrent expenditure incurred on personnel emoluments changed from 60% in 1966 and 65% in 1975 to 44% in 1983.

6.0 Partial Indicators for the growth of S & T Activities in Sri Lanka

Based on input statistics of expenditure and manpower, a number of input indicators can be developed. The historical trends have shown that the R & D expenditure at constant prices as well as S & T manpower has grown steadily.

A comparison of R & D expenditure per capita and R & D expenditure as a percentage of GDP are considered as common indicators for comparison of growth in different field of sciences. These indicators are given in Table 6.1.

Table 6.1

R & D Expenditure Per Researchers And As A Percentage of GDP by field of Science (1983/84)

	R & D Exp/Researcher (Rs.'000)	R & D Exp.as a % of GDP
Natural Science	30.4	0.085
Agricultural Science	172.1	0.21
Engineering & Technology	118.9	0.018
Medical Science	40.2	0.006
Social Science & Humanities	23.0	0.014
Average -	69.0	0.146

A series of other indicators also can be constructed. However, in the absence of detail historical statistics it is possible to compare these indicators with previous years.

Table 6.2 provides a series of indicators constructed to describe the growth of science and technology in Sri Lanka. The institutional support per researcher is expressed by these indicators.

Table 6.2

Input Growth Indicators of S & T - 1983

Indicators	Per equipment Exp. (Rs. '000)	Maintenance Exp. per researchers (Rs.'000)	R & D technici per Researcher
Natural Science	6.2	5.1	0.37
Agric. Science	15.9	33.3	0.44
Engi. & Technology	10.8	23.6	0.25
Medical Science	2.1	12.5	n.a.
Social Science	0.3	3.6	0.01
Average	7.4	13.3	0.25

7.0 International Comparisons of R & D Resources

To put the Sri Lankan figures in international perspective it would be useful to work some international comparisons. In 1980, only 10.6% of the total R & D scientists and engineers and 6.0% of the R & D expenditure in the world were available in developing countries for research and development activities (UNESCO, 1984). The average number of R & D scientists and engineers per million population was 2954 for developed countries compared with 125 for developing countries in 1980. R & D expenditure as a percentage of GNP was 2.24% in developed countries as against 0.43% in developing countries for the same period.

The status of R & D in Sri Lanka in respect of both manpower and expenditure shows us in a poor light. The number of full time equivalent R & D scientists and engineers was 79 per million population in 1984 and the R & D expenditure as a percentage of Gross Domestic Product was 0.14%. Table 8.1 shows comparative data for selected countries. According to these statistics national financial commitment in Sri Lanka for research and development activities remains at a low level compared to other developing countries such as India, Argentina, Turkey, Brazil, Mauritius and Indonesia. The availability of R & D scientists and engineers per million population is also below most developing country average and in the range of countries such as Pakistan, Togo, Thailand, Philippines and Seychelles.

Table 8.1

Number of R & D Scientists and Engineers per million population and R & D expenditure as a percentage of GNP for selected developing countries

		R & D Exp. as a % of GNP		Scientists per million people
Mauritius	1982	0.5		176
Sudan	1978	0.2		219
Argentina	1980	0.5		351
Guyana	1982	0.2		97
India	1982	0.6	1978	89
Indonesia	1982	0.5		113
Pakistan	1979	0.2	1981	61
Philippines	1982	0.2		101
Singapore	1981	0.3		296
Sri Lanka	1983	0.14	1984	29
Korea	1982	0.9		723

Source:- UNESCO (1984) -Statistics on Science & Technology- UNESCO, Paris.

8.0 Some Major Factors Affecting Science In Sri Lanka

Our Questionnaire 'C' attempted through structured questions to isolate some critical factors in R & D as perceived by senior R & D Managers and researchers. The result of this exercise was a collection of useful comments, observations and opinion based on the experience of the senior scientists and engineers in the country. The responses received were quite diverse depending on the sector they served. Yet, it was possible to extract some common problems through the structured questionnaire.

8.1 Research and Development Intensity of S & T Institutions in Sri Lanka

181 scientific and technical institutions responded to this Questionnaire 'C'. All major R & D performing institutes and major S & T institutes were among the respondents. 137 institutions (76% of the sample) have undertaken research and development activities of some form. However, only 80 institutes were undertaking R & D work on a regular basis. Even among the 80 institutes, only 35 had a separate budget for R & D[6]. The R & D activities are primarily distributed among three major areas. Agriculture, forestry and fisheries (22%), Commerce and Industry (36%), Scientific and Technical Services (15%) and the remainder serve medical services; public utilities such as electricity, gas, water, sanitary, transport; education; finance; accounting and legal services; management and consultancy service; computer service; and military services.

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6) Dept. of Agriculture is counted as one unit for reporting R & D expenditure due to centralized budgeting and its substations are not included in this figure.

These various institutions have utilized S & T knowhow in a variety of ways. Certain institutes felt that the role of science and technology was "vital in all respect" (45%) to carry-out their daily functions, whereas 36% of the institutions responding found it only "moderately useful". A small percentage of institutions (3%) found S & T had no significance in conducting their daily activities.

It is worth noting that although the major R & D institutions in the country did not exceed a total of 80, a wide array of scientific and technical activities were covered by them.

It is also important to note that some major S & T institutions such as the Ceylon Electricity Board, the Irrigation Department, Mahaweli Development Authority, Petroleum Corporation, Geological Survey Department, and Meteorological Department are not as active in research and development activity as would be required by the importance of these institutions. A deep seated tradition of services and production functions of these institutions have apparently suppressed the research and development capabilities of these institutions. A number of scientists and engineers interviewed in some of these institutions have enumerated quite a number of technical problems in their institutions that need researched solutions. However, they were apparently unable to make any significant contribution through research due to lack of recognition for such activities in the institutional functions generating S & T knowledge is through own activities within the institute.

A considerable number of institutions (14%) gained S & T know-how via contract research, which was carried out in universities and research institutes. There are, however, no private research Associations and Institutes except in the field of Social Science to conduct such contract research.

A significant number of institutions (14%) depend on overseas sources for S & T know-how. Other institutions (28% have indicated that they are using a combination of the above three methods (own activities, contract research, borrow overseas know-how) to acquire new knowledge.

8.2 Dependency on Foreign Technology

Most institutions depended to varying degrees on foreign know-how. 56% of the S & T institutions surveyed have indicated that they depended on foreign S & T know-how whereas the remaining institutes indicated that they do not depend on overseas S & T know-how. A large percentage (40%) of the institutions that depend on S & T know- how from overseas was from the private sector, and were involved in industrial and commercial activities. The reasons for this dependency on imported technology are many (Figure 1)

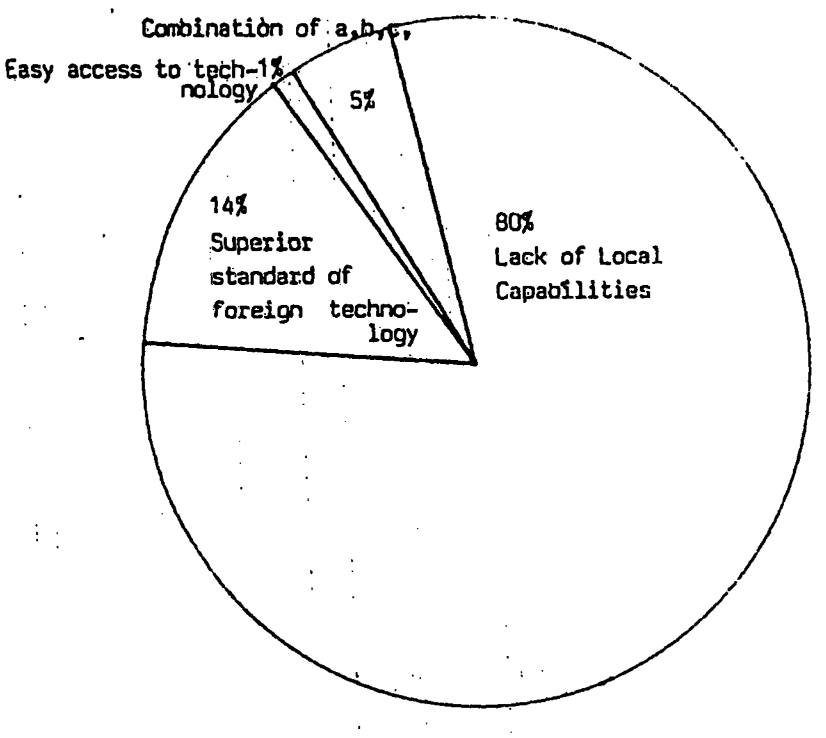


Figure 1 - Major causes for the preference for foreign know-how

The most important reason for the preference of foreign technology was the lack of local capability and expertise to develop such technologies. It is interesting to note that none of the respondents found that the competitive pricing of foreign S & T know-how as a major cause for their preference for foreign S & T, although it was cited by some respondents as a secondary cause. 14% preferred overseas technology due to the superior quality of the foreign technology. Easy access to foreign technology in some fields was the major research for foreign dependency according to our respondents.

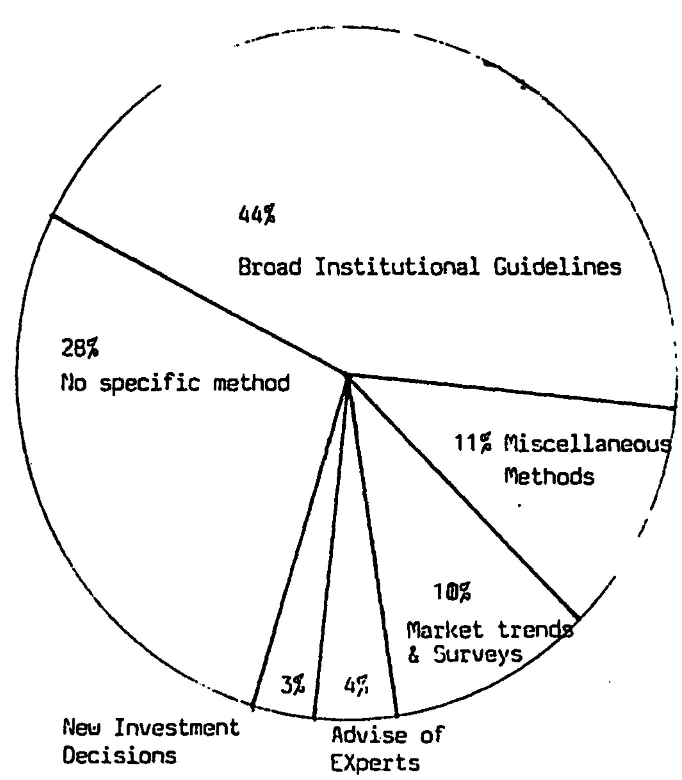
8.3 The Process of R & D Project Selection

The particular direction of scientific research in Sri Lanka depends on the type of R & D projects selected by the R & D institutes. A variety of factors influence the project selection process. Significant among these, are the availability of finance, the urgency of the problem, the d·· ·ation of the project, the technical and economic feasibilities and priorities in national development. In a Third World situation with limited funds for research for research what project is selected becomes very critical. The effectiveness of any R & D program depends on such decisions. The most common method of R & D project selection (38%) according to our respondent was that carried out "partly by management and partly by the individual researchers" themselves. This mode was most prevalent among major R & D institutes such as specialized research institutes. It was also common to find institutes (28% of the total) where R & D project selection was carried out completely by the management of the institution, relegating the execution of such research projects to individual researchers. There were 3 institutes (2%) where R & D project selection was carried out entirely on the decision of individual researchers. Six institutes (4%) reported that they did not follow any specific method for selection of an R & D project.

8.4 Major Criteria for Project Selection

The major criterion used for R & D project selection adopted by most institutions were in accordance to the "broad institutional guidelines" of the institute (44%). Nearly 10% of the Institutes, particularly in the productive sector, used market trends and surveys as the basis of project selection. A small number of institutes (4%) was solely dependent on the advise of experts in the field being researched, and some institutes (3%) indicated the need for new investment decisions as a criterion for project selection. However, 28% of the institutes indicated that there was no one method used for project selection. In the institutions surveyed there was lack of consistency in approach as well as an adequate information base in planning R & D activities, a fact borne out by our interviews.

Figure 2 - Major Criteria for R & D Project Selection.



8.5 Causes for the Failure of R & D Based Innovative Projects

R & D output should in the normal chain of events leads naturally to innovation in industry. Success and failure of innovative projects can be due to several factors. We attempted here to isolate some key factors in the failure of innovative projects. The largest number of institutes (25%) identified market failures as a major cause for the failure of innovative projects. This was a common feature in most private sector institutions. 20% of the institutes found the rapid turnover or the brain-drain of trained personnel as a major cause for the failures. Another 12% of the institutes found that the most frequent causes as the failure of the R & D process itself or the technical infeasibility of the project. The last two reasons were given most frequently in research institutes. A small number of institutes blamed the project failure on pilot plant or proto-type development problems. Among other responses were poor communication and information flow, lack of co-ordination and failures in follow-up action. Thus, a variety of factors had influenced innovative projects.

8.6 Major Constraints for Undertaking R & D

The questionnaire sought to elicit the major causes inhibiting R & D activities. The reasons cited were inadequate funds (32 institutes or 23%), inadequate trained personnel (24 or 17%), inadequate equipment and instruments (4 or 3%) and a combination of the above mentioned three factors (24%). A small number of institutes have indicated that an inadequate support facility and lack of motivation of staff as the major cause. (For example, the Department of Geological Survey had one trained Chemist due to a rapid turnover of personnel in that department and apparently this department is on the verge of coming to a complete halt with a large number of equipment and instruments in this department lying idle).

8.7 Transmission of R & D Know-how

There are several mechanisms available for the diffusion of knowledge in Sri Lanka. Figure 3 shows the method of diffusion of S & T knowledge from producers to users.

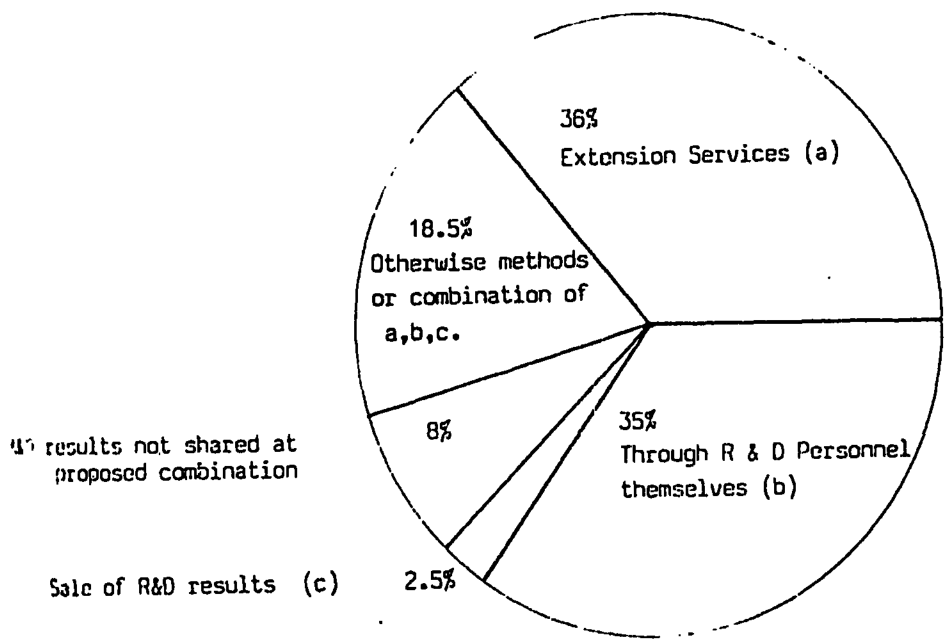


Figure 3 - Major methods of transmission of R & D know-how

Most frequent means through which knowledge is diffused is by extension services and communication among researchers

8.8 Evaluation of R & D Projects

A large number of institutes (86) evaluated their R & D work regularly, and another 43 institutes evaluated their projects occasionally. Some institutes have not evaluated their projects at all. The decision to abandon such projects after evaluation have been taken by nearly 50% of the institutes surveyed. This is important as it may indicate the effectiveness of the evaluating system. Most private industries undertaking R & D had concentrated their efforts in product development, with process development activities undertaken only occasionally.

9.0 General

We would like to put the data presented in the perspective of the general performance of scientists as a whole, as well as the socio-economic restraints to their performance.

A study (Goonatilake et al.1984) done by the General Research Committee of the SLAAS on the output of scientists in Sri Lanka in 10 selected disciplines and three selected institutes indicated that the rate of growth of publications was above 7% per annum. It also brought out significant data on the productivity of scientists indicating that a few scientists working in scientific enterprises in Sri Lanka were in operation. The study also noted some of the problems related to formation of critical masses in some subjects arising from both an internal and external brain-drain.

The brain-drain in Sri Lanka is important for our study here too, because it governs the entry of scientific personnel into scientific activity. Although we have recorded a steady increase in scientific personnel, this has to be muted by the fact that there has been an equal steady, perhaps even more dramatic, exodus of scientific personnel from Sri Lanka. The figures for brain-drain for selected disciplines are given in the table below.

Table 9.1

Trained Personnel who left for Employment Abroad

Occupation Category	May 1971 Apr. 1972	May 1972 Apr. 1973	May 1973 Apr. 1974	May and June 1974	July 1974 June 1975	July 1975 June 1976	July 1976 Dec. 1976	Total
Doctors	108	171	238	41	243	343	110	1,254
Engineers	54	113	94	14	118	498	183	1,074
Accountants	23	41	88	11	86	162	88	499
University Teachers	-	15	24	02	14	54	32	141
Other Teachers	82	55	52	04	70	279	86	628
Lawyers	08	35	13	02	28	49	25	160
Technicians	-	20	27	15	228	176	71	537
Total	275	450	536	89	787	1,561	595	4,293

* Data were obtained by examining Embarkation Cards.

Source: - Migration of trained and skilled manpower and unskilled labour to West Asia, Employment and Manpower Planning Division, Ministry of Plan Implementation, 26.9.78.

In fact these figures related to a period less turbulent than the last couple of years specially 1983 and 1984 where an informal assessment has revealed a haemorrage of scientists occurred. The previous five years also recorded a brain-drain categories, specially to the Middle East.

The brain-drain for economic reasons is directly related to remuneration of scientists. The table below gives the relative remuneration in certain categories of state sector and private sector employment, in comparison with those of scientists It is noted that in certain categories of state sector employment, payment is very much higher than in scientific pursuits. A quick glance at Table 9.2 reveals that remuneration structure is anti-intellectual. This position was further explored in a recent article by Siddeek (1985)

Table 9.2

Comparative Monthly Emoluments

Institute	Post	Qualifications	Total monthly emoluments
Scientists			
NARA-NARESA	(a)Grade V	A Degree (no experience)	2050 (Tax free)
	(b)Grade III	Post-graduate qualifications	2600 (Tax free)
Scientists			
University	(a)Asst.Lecturer	Degree (no experience)	1977 (Tax free)
	(b)Lecturer	Post-graduate	2400 (Tax free)
	(c)Professor Grade II	Post-graduate degree with experience	4125 (Tax free)
	(d)Professor Grade I	Post-graduate degree with experience	4625 (Tax free)
Others			
Private Banks	Trainee Execu.	Degree	5500 (Taxable)
Private Companies	Junior Execu.	SSC/GCE(O.L) or graduate	1500 (Taxable)
State Banks	(a)Messengers	JSC or 8th grade	2800 (Tax free (Equivalent total including loan subsidie

(b)	Junior Executive	SSC/GCE(O.L) or graduate	4800 (Tax free) (Equivalent total including loan subsidies, bonus, etc.)
(c)	General Manager	Minimum Academic SSC or GCE (O.L) qualifications	8600 (Approx) (Equivalent total including loan subsidies, bonus, etc.)

We have also obtained some comparative figures of the brain-drain for the scientific sector and others. A strong impression that we have is that although there is a heavy haemorrage of scientific and technical personnel to foreign countries, it hardly occurs among the highest paid state sector, namely the Banks (and one should add, also in the administrative sector).

Non-monetary reasons for the brain drain have been adduced to the professional isolation of scientists. For example informal interviews among Sri Lankan mathematicians revealed that they, during their graduate studies had researched in very different areas. It is here that allowing academics to meet professional colleagues and thus interact with the "invisible colleges" of their disciplines would be a very useful device for keeping the local scientists in Sri Lanka.

However, we found in our interviews that inspite of the liberalizing policies followed in the case of foreign travel for other sectors - such as private business - there were still, rather long drawn out procedures for scientific personnel, specially in the universities desiring to interact with foreign counterparts. University personnel desiring to meet professional colleagues even during university vacation time have apparently to go through a cumbersome process of approval. Lessening these barriers would we believe, help lessen the brain-drain and increase productivity, as much as would enhancement of other incentives.

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ANNEX - I

1.7 Definitions and concepts used in the study

1.7.1 Scientists & Engineers & Social Scientists - Any person who has received scientific and technical training in the fields of sciences (Natural Sciences, Engineering and Technology, Medical Sciences, Agriculture, Social Sciences and who meets any of the following criteria).

(i) Completed tertiary education leading to an academic degree.

(ii) Completed tertiary non-university education which has been recognized as equivalent to a degree for the purpose of career requirements. Those who qualified in departmental examinations and are classified as engineers or scientists by the institutions may be also included.

(iii) Completed education say with professional experience which is nationally recognized (e.g. Membership of professional institute) as being equivalent to a formal professional education at graduate level.

Technicians - (Please note this category does not include skilled craftsmen).

Any person who has received specialized vocational or technical training in any branch of science or technology as specified below:

(i) One to two years training after completing education at secondary school level, or has received proper and adequate training whether or not leading to a degree or diploma but is nationally identified as a technician.

(ii) Obtain training abroad on short-term or long-term periods and currently working at technicians grade.

(iii) Completed nationally recognized institutional examinations and have received a formal training as a technician.

Scientific and technological activities - (STA) can be defined as all systematic activities which are closely concerned with the generation, advancement, disemination and application of scientific and technical knowledge in all fields of science and technology, that is the natural sciences, engineering and technology, the medical and the agricultural sciences as well as the social sciences and humanities.

Research and Experimental Development - (R & D) can be defined as systematic and creative work undertaken in order to increase the stock of knowledge, including knowledgeof man, culture and society, and the use of this knowledge to devise new applications.

Basic Research can be defined as any experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular or specific application or use in view.

Applied Research - can be defined as any original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.

Experimental Development can be defined as any systematic work drawing an existing knowledge gained from research and/or practical experience that is directed to producing new materials, products and devises, installing new processes, systems and services, and to improving substantially those already produced or installed.

EXPLANATORY NOTES

The percentage of time devoted to R & D activity is taken as a crude measure to separate the R & D component from other related scientific activities such as teaching, consultancy, routine testing, surveys and general purpose data collection, exploration of minerals and oils, scientific information services, etc. It is, however, difficult to keep an exact record of time devoted for R & D work, therefore, subjective judgement may have to be exercised.

Please use this measure to estimate R & D expenditure wherever it is impossible to directly identify research expenditure.

The R & D activities differ from the other related activities in the presence of an appreciable amount of novelty. For an activity to be classified as R & D there should be something innovative, e.g. the introduction of an improved technique. The standard procedure is not classified as R & D.

1.7.2 Sector of Performance can be defined as any sector of the national economy comprising a significant number of institutions carrying out S & T activities (as defined in items 1.1) that present a certain degree of homogeneity with respect to the principal function or service provided irrespective of source of funds, the authority to which such institutions are responsible or the category of STA being carried out. According to these criteria, three major sectors of performance can be distinguished: the productive sector, the higher education sector and the general service sector.

Productive sector comprises:

- domestic and foreign industrial and trading enterprises situated within the country which produce and distribute goods and services for sale, and institutions directly serving them with or without contract whatever their form of ownership (public and private). The S & T activities of these enterprises and institutions closely linked to production are known as "S & T activities integrated with production";
  - governmental, non-governmental and non-profit institutions most or all of whose S & T activities indirectly serve one or more of the categories or classes of activities with a two-or three-digit classification in the ISIC. The S & T activities of these institutions which are only indirectly linked to production are known as "S & T activities not integrated with production". In

countries with a centralized economy, R & D institutes attached to the ministries responsible for the different branches of the national economy should be classified in this category of institutions.

Higher education sector, comprises:
establishments of education at the third level which require as a minimum condition of admission successful completion of education at the second level or evidence of the attainment of an equivalent level of knowledge, together with research institutes, experimental stations, hospitals and other S & T institutions serving such establishments and directly administered by or associated with them.

General service sector, comprises:

- bodies, departments and establishments subordinate to the central, State (in federal systems), provincial, district or county, municipal, town or village authorities that serve the community as a whole and provide a wide range of services such as administration, maintenance and regulation of public order, public health, culture, social services, promotion of economic growth, welfare and technical progress, etc.;
- institutions such as national scientific research and technology councils, academics of science, professional scientific organizations and other institutions which serve the whole of the community;
- institutions whose S & T activities (including R & D) are carried out for the general benefit of agriculture, industry, transport and communications, building and public works or the public electricity, gas and water services - i.e. activities classified under a single-digit reference in the ISIC.

1.7.3 Field of Sciences

(i) Natural Sciences, including : astronomy, bacteriology, biochemistry, biology, botany, chemistry, computer sciences, entomology, geology, geophysics, mathematics, meteorology, mineralogy, physical geography, physics, zoology, other alloed subjects.

(ii) Engineering and technology, including: engineering proper, such as chemical, civil, electrical, and mechanical engineering, and specialized subdivisions of these; forest products; applied sciences such as geodesy, industrial chemistry, etc.; architecture; the science and technology of food production; specialized technologies of inter-disciplinary fields, e.g. systems analysis, metallurgy, mining, textile, technology, other allied subjects.

(iii) Medical Sciences, including: anatomy, dentistry, medicine, nursing, obstetrics, optometry, osteopathy, pharmacy, physiotherapy, public health, other allied subjects.

(iv) Agricultural sciences, including: agronomy, animal husbandry, fisheries, forestry, horticulture, veterinary medicine, other allied subjects.

(v) Social science and humanities, comprising:
Group 1 - Social sciences, including : anthropology (social and cultural) and ethnology, demography, economics, education and training, geography (human, economic and social), law, linguistics (excluding language studies based on set texts, which should be classified in Group II under "Ancient and modern language and literature"), management, political sciences, psychology, sociology, organization and methods, miscellaneous social sciences and interdisciplinary, methodological and historical S & T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified within the natural sciences.

Group II - Humanities, including: arts (history of the arts and art criticism excluding artistic "research" of any kind), languages (ancient and modern languages and literature), philosophy (including the history of science and technology, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, paleography, etc., religion, other fields and subjects pertaining to the humanities and inter-disciplinary, methodological, historical and other S & T activities relating to the subjects in this group.

1.7.4 Expenditure

Intramural Expenditure

Refers to funds used for the performance of R & D within a particular organization or sector of the economy, regardless of the source.

Recurrent Expenditure

This includes wages and salaries and all related elements of labour, including such "fringe benefits" as bonuses, holiday pay, contributions to pension funds, payroll taxes, etc. Also included are expendable supplies and minor equipment and other supporting costs including share of over-heads, for example: rent, maintenance and repair of buildings, replacement of office furniture, water, gas, electricity, administrative expenses such as expenses for security, janitorial and maintenance personnel engaged in general house-keeping activities.

Capital Expenditure

Includes actual expenditure or investment in land, building, major equipment and purchase of books and journals.

Other capital includes the additions during the year for vehicles, books and journals.

Extramural Expenditure

Refers to payments made for the performance of R & D outside a particular organization or sector of performance.

1.7.8 <u>National R & D Coefficient (Manpower)</u>

National coefficient of manpower is defined as number of full-time equivalent S & T personnel for 10,000 population.

1.7.5 Source of Funds

(1) Government funds. This category includes funds provided by the central (federal) State or local authorities and originating from the ordinary or extraordinary budget or from extra-budgetary sources. It also covers funds received from public intermediary institutions established and wholly financed by the State.

(2) Productive enterprise funds and special funds. This category includes funds allocated to S & T activities by institutions classified in the productive sector as productive establishments or enterprises and all sums received from the "Technical and Economic Progress Fund", in countries with a centralized economy, and other similar special funds.

(3) Foreign funds. This category includes funds received from abroad for national S & T activities, including funds received from international organizations, governments or foreign institutions.

(4) Other funds. This category includes funds that cannot be classified under any of the preceding headings, e.g. "own funds" of establishments in the higher education sector, endowments and gifts.

1.7.6 Gross National Expenditure on Research and Experimental Development (GERD)

In accordance with the "Frascati Manual", GERD comprises current and capital R & D expenditures financed by both government and by private sources and undertaken in any facilities within the country, excluding those used and financed by international organizations, but including those facilities abroad which are used to undertake an integral part of the national governmental R & D programme.

1.7.7 National R & D Coefficient (Expenditure)

Country's total expenditure on R & D expressed as a percentage of the Gross National Product.

Telephones—
Minister 25306
20420
27741
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Planimpsec

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MINISTRY OF PLAN IMPLEMENTATION

P. O. Box No. 1348

My No.
Your No.

7th Floor (Northern Tower)
Central Bank Buildi
Colombo 1

29th September, 1984.

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Dear Sir,

His Excellency The President has directed that a document on National Science Plan be prepared by the Ministry of Plan Implementation under the technical guidance of Prof. Cyril Ponnamperuma, the Senior Science Advisor to the President.

A National Science Policy Co-ordinating Committee has been set up for this purpose. One of the serious impediments to the formulation of a science plan and the implementation of it is the absence of a reliable information base on scientific and technological (S & T) resources available in the country. Therefore, it is decided to launch an immediate program to assess the current S & T situation in the country. The Institute of Fundamental Studies (IFS) has agreed to be the focal point of this study.

It is important that this study should be completed before the 31st of November, 1984, and your active co-operation is kindly requested. Please consider this matter with highest priority and attend to the following :

(a) Nominate officers (involved in finance and personnel management) with whom IFS can communicate directly on this matter and inform the Director of the IFS.

(b) Please provide a list of academically and professionally qualified full-time scientists, engineers and technical personnel attached to your institution. (See attached Form A for details required.)

(c) Could you kindly request the finance section to complete the attached Form B ?

(d) Kindly complete Form C by you or by a senior manager of your institution.

(e) Please provide copies of documents prepared by your institution related to finance and manpower planning, forecasting activity in your institution to the Director IFS.

Thanking you for your co-operation in this national endeavour.

Yours faithfully,

Dr.W.S.Weerasooria,
Secretary,
Ministry of Plan Implementation.

FORM A

(To be filled by the Personnel Department)

A STUDY OF NATIONAL SCIENTIFIC AND TECHNICAL MANPOWER POTENTIAL

Please furnish information required to the DIRECTOR, IFS, 380/72, [illegible] MAWATHA, COLOMBO 7 - TELE: 596343

Please respond before the 25 OF OCTOBER, 1984

INSTITUTE:-

NAME & TELEPHONE NO: OF CONTACT PERSON:-

Format - Please list all scientists, engineers, medical doctors, technicians and social scientists (see definition below). Indicate with an asterick (*) those who are on leave abroad and indicate with a cross (x) those who serve your institution as foreign consultants. If a person is employed on part-time basis, please indicate with (P/t) against the name - e.g R. Peterson (P/t).

SCIENTISTS:-

	Name.	Age	Sex	Qualifications	Speciality	Engaged in Research
e.g.	Dr. Richard Peterson (x)	28 yrs	M	B.Sc.(Cey.) Ph.D.(Oxfd.)	Agronomy	Yes
	Dr. P.M. Fernando * (P/t)	35 yrs	F	B.Sc. (Eng.) M.Sc (Lond.)	Micro Biology	No

ENGINEERS:-

	Name	Age	Sex	Qualifications	Speciality	Engaged in Research
e.g.	Mr.D. Silva	47 yrs	M	Dept qualified M.I Eng	Civil	No
	Mr.T. Sivapalan	50 yrs	M	B Sc. (Cey.)	Electronics	Yes

MEDICAL PERSONNEL:-

	Name	Age	Sex	Qualifications	Speciality	Engaged in Research
e.g	Dr. L. Salgado	35 yrs	M	M B B.S M R C P (Lond)	Physician	Yes

...IAL SCIENTISTS:-

	Name	Age	Sex	Qualifications	Speciality	Engaged in Rese...
e g.	Mr. N. Aramb swala	29 yrs	M	M.A (Lond)	Sociologist	Yes

TECHNICIAN:-

	Name	Age	Sex	Qualifications	Speciality	Engaged in rese...
e.g.	Mr. S. Nadesan	27 yrs	M	Diploma (Cey)	Instrument Tech	Yes

DEFINITIONS

Scientists & Engineers

& Social Scientists - Any person who has received scientific and technical training in the fields of sciences (Natural Sciences, Engineering and Technology, Medical Sciences, Agric... Social Sciences and who meets any of the following criteria)

(i) Completed tertiary education leading to an academic degree.

(ii) Completed tertiary non-university education which has been recognized as equivalent to a degree for the purpose of career requirements Those who qualified in departmental examinations and are classified as engineers or scientists by the institutions may be also included.

(iii) Completed education say with professional experience which is nationally recognized (e g. Membership of professional institute) as being equivalent to a formal professional education at graduate level.

Technicians - (Please note this category does not include skilled craftsmen.)

Any person who has received specialized vocational or technical training in any branch of science or technology as specified below:

(i) One to two years training after completing education at secondary school level, or has received proper and adequate training whether or not leading to a degree or diploma but is nationally identified as a technician

(ii) Obtain training abroad on short-term or long-term periods and currently working at technicians grade.

(iii) Completed nationally recognized institutional examinations and have received a formal training as a technician.

FORM B

(To be filled by the Finance Section)

A STUDY OF NATIONAL EXPENDITURE ON RESEARCH AND EXPERIMENTAL DEVELOPMENT

Please furnish the information required to the DIRECTOR, IFS, 380/72, BAUDDHALOKA MAWATHA, COLOMBO 7.

Please respond before the 15 TH OF OCTOBER, 1984

INSTITUTE:-

NAME & TELEPHONE NO:OF CONTACT PERSON:-

The objective of this study is to quantity actual expenditure involved on research and experimental development (see definition) If your Institution does not undertake research and experimental development, please indicate No R & D and return the form to us. In the case of research institutions and institutions which have a R & D budget, please provide the actual expenditure for most recent year (1983) according to the following format. If your institution does not have a separate R & D Division and a separate budget for R & D, please attempt to identify the expenditure items directed at R & D activity as described in the explanatory note.

Question 1 - Do you have a separate budget for R & D YES/NO

Question 2 - What is the expenditure incurred in 1983 for R & D by different R & D divisions in the Institute "

Year - 1983	Current Expenditure		Capital Expenditure		Total
Division	Salary	Other	Equipment	Other	
e.g. Plant Pathology					

Question 3 - Has any part of the above expenditure used for res[...] commissioned outside your institution ? YES/NO

If so, what is the amount spent for such extramural activ[...]

Year - 1983	Current Expenditure		Capital Expenditure	
Division	Salary	Other	Equipment	Other
Total Institute				

Question 4 - Has any component of expenditure given in Question 2 being used for related scientific activity such as seminars, conferences, teaching, consultancy, test and quality control, vaccine production, information and library services and extension services ? YES/NO

If so, could you indicate the amount spent on such activ[...]

Division	Related R & D Expenditure	% of time spent on related R & D work by the staff

Question 5 - Please identify the research and development expenditure in terms of foreign grants received (either by the institution or by individuals).

Foreign Funds 1983	Current	Capital	Total

Question 6 - Could you partition the R & D expenditure according to basic/applied/experimental development research projects by your institution.

1983	Basic Research	Applied Research	Experimental Deve[...]

DEFINITIONS

Research and Experimental Development (R & D) can be defined as systematic and creative work undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications.

Basic Research can be defined as any experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular or specific application or use in view

Applied Research can be defined as any original investigation undertaken in order to acquire new knowledge It is, however, directed primarily towards a specific practical aim or objective

Experimental Development can be defined as any systematic wor drawing an existing knowledge gained from research and/or practical experience that is directed to producing new materials, products and devises, to installing new processes, systems and services, and to improving substantially those already produced or installed.

EXPLANATORY NOTES

The percentage of time devoted to R & D activity is taken as a crude measure to separate the R & D component from other related scientific activities such as teaching, consultancy, routine testing, surveys and general purpose data collection, exploration of minerals and oils, scientific information services, etc It is, however, difficult to keep an exact record of time devoted for R & D work, therefore, subjective judgement may have to be exercised.

Please use this measure to estimate R & D expenditure wherever it is impossible to directly identify research expenditure.

FORM C

(To be filled by the Head of the Institute)

Please return this form to the DIRECTOR, IFS, 380/72, BAUDDHALOKA MAWATHA, COLOMBO 7, not later than 25 OCTOBER, 1984.

INSTITUTE:- ....

....

Please circle the appropriate answer.

Question 1 - What is the major area of activity in your institution ?

(a)	Agriculture, Forestry & Fisheries	1
(b)	Commerce & Industry	2
(c)	Medical Services	3
(d)	Public Utilities	4
	Electricity	5
	Gas	6
	Water	7
	Sanitary	8
	Transport	9
(e)	Education	10
(f)	Finance, Accounting & Legal	11
(g)	Scientific and Technical Services	12
(h)	Management & Consultancy	13
(i)	Computer Services	14
(j)	Military Services	15
(k)	Other (Please specify)	

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Comments and explanations if any :-

Question 2 - Do you perform research and development (R & D) in your institution ?

1)	Yes - as a regular activity	1
2)	Yes - occasionally	2
3)	Never	3
4)	Other (Please specify)	4

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Comments and explanations if any:-

Question 3 - What is the role of science and technology (S & T) in daily activities of your institution ?

a) Vital in all respect 1
b) Vital for some activities 2
c) Moderately useful 3
d) Rarely useful 4
e) No use 5

Comments and explanations if any:-

Question 4 - When you need new S & T knowledge, where do you mainly look for such knowledge ?

a) Generation within the institute 1
b) Contracting out to a research institute/university 2
c) Purchase from abroad 3
d) Others (please specify) 4

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Comments and explanations if any :-

Question 5 - Do you depend on foreign S & T know-how ?

a) Yes
b) No

Comments and explanations if any:-

Question 6 - If the answer is Yes for Question 5, why do you prefer purchase of foreign know-how ?

a) Lack of local capability and expertise
b) Competitive pricing of foreign S & T know-how
c) Superior standards & quality of foreign technology
d) Others (please specify)

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Comments and explanations if any :-

Question 7 - If you have an R & D department, who selects the R & D projects ?

a) Entirely by the Management of the institution 1
b) Entirely by the individual Researchers themselves 2
c) Partly by Management of the Institution and partly by the individual Researchers 3
d) No specific method for selection 4
e) Others (please specify) 5

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Comments and explanations if any :-

Question 8 - R & D projects in the institute are selected primarily according to -

a) Advise of experts in the field being researched 1
b) The broad objectives and guidelines of the institution 2
c) Market trends and surveys 3
d) The need of new investment decisions 4
e) No single method 5
f) Others (please specify) 6

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Comments and explanations if any:-

Question 9 - In your opinion what is the most common cause leading to failures of an innovative project ?

a) Failures of the R & D process itself 1

b) Pilot plant and prototype development failures 2

c) Market failures 3

d) Rapid turnover of trained personnel 4

e) Others (please specify) 5

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Comments and explanations if any:-

Question 10 - What in your opinion is the major constraint for undertaking R & D in your institution ?

a) Inadequate funds 1

b) Inadequate trained personnel

c) Inadequate equipment and instruments 3

d) Inadequate support facility 4

e) Lack of motivation of staff 5

f) Others (please specify) 6

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Comments and explanations if any :-

Question 11 - What in your opinion is the major incentive available for undertaking R & D by the staff of your institution ?

a) Financial rewards 1

b) Promotional prospects 2

c) Recognition of their work 3

d) Other material incentives such as vehicles,housing 4

e) Others (please specify) 5

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Comments and explanations if any :-

Question 12 - What are the Government incentives that you are aware of, available for post R & D development ?

a)	Assistance for prototype development	1
b)	Assistance for pilot plant development	2
c)	Manufacturing and tooling incentives	3
d)	Provision for market research	4
e)	Protection policies for products	5
f)	No incentives at present time	6
g)	Others (please specify)	7

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Comments and explanations if any :-

Question 13 - What is the most common problem in the development of pilot plants and prototypes ?

a)	Absence of vital components in the local market	1
b)	Lack of certain specific technological skills	2
c)	Poor quality material and/or components available locally	3
d)	High costs.	4
e)	Investment in pilot plant financially risky	5
f)	Others (please specify)	6

Comments and explanations if any:-

Question 14 - If you do not have an R & D programe, in your opinion what should be the most preferred incentive for developing R & D activity in your institution ?

a)	R & D project grants from outside institutions	1
b)	Taxation incentives	2
c)	Tarift protection (to protect new products emerging from R & D)	3
d)	Capital grants and credit facilities	4
e)	Protection of R & D knowhow(patents)	5
f)	Others (please specify)	6

Comments and explanations if any:-

Question 15 - What is the major vehicle in your institution for the transmission and diffusion of S & T knowledge from R & D to actual practice?

a) Extension services 1
b) Through R & D personnel themselves 2
c) Sale of R & D results(of technology) to outside customers 3
d) R & D results are strictly confidential 4
e) Others (please specify) 5

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Comments and explanations if any:-

Question 16 - Do you have a formal mechanism for periodic review or evaluation of the progress of a project ?

a) Projects are never evaluated 1
b) Projects are evaluated occasionally 2
c) Evaluated regularly 1
d) Others (please specify) 4

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Comments and explanations if any:-

Question 17 - After project evaluation, have you at any stage abandoned the project ?

a) Yes 1
b) No 2
c) Others (please specify) 3

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Comments and explanations if any:-

Question 18 - If your institution is involved in production, what is the approximate proportion of financial resources directed to products and process development ?

a) More than 75% product and 25% process 1
b) 50% product and 50% process 2
c) 25% product and 75% process 3
d) 100% product 4
e) 100% process 5
f) Others (please specify) 6

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Comments and explanations if any:-

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EXECUTIVE SUMMARY

INPUTS INTO SCIENTIFIC RESEARCH IN SRI LANKA

MANPOWER - 1984 and FINANCE - 1983

Table 1 Personnel Available for S & T Activities

	All S & T Activities	R & D Activities	No. of Ph.D.	No. in University (PhD holders)
Natural Scientists	2482	1340	301	526 (179)
Engineers & Architects	3114	169	56	169 (35)
Medical Scientists	336	216	4*	193 -
Social Scientists	2613	638	143	384 (125)

Note :- * Medical Scientists possess other post-doctoral qualifications equivalent or higher than Ph.D.

The above data do not include medical officers (1667) engaged in Health Services in the Ministry of Health and Secondary School teachers - estimated as 2242 science graduates and 15379 arts and commerce graduates for 1984 by the Department of Education.

Table 2 Expenditure Incurred on R & D

(Million Rupees)

	Recurrent Exp.	Capital Exp.	Total Exp.
Current prices	117.34 (72%)	45.31 (28%)	162.65
Constant prices	24.05	9.35	33.04

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Distribution of Expenditure according to the objectives of :-

Natural Sciences	15%
Agricultural Sciences	58%
Engineering & Technology	12%
Medical Sciences	5%
Social Sciences & Humanities	10%

Situation Analysis with respect to High Turnover of Manpower and Problems of Developing Science in Sri Lanka.

Underdevelopment of science and technology in Sri Lanka is attributed to a large number of causes as described in this study. Some of the most profound factors are as follows :-

a) inadequate funds for research

b) unavailability of trained and experienced S & T Workforce and under utilisation of local talents

c) inadequate equipment, facilities and incentives for S & T activities.

It is important to note that a large number of S & T manpower is not utilised for research and development activities (nearly 46% of natural scientists and 95% of engineers). Most of the available S & T manpower is relatively young and the number of senior and post-doctoral S & T personnel available in the country is small.

There were only 12% of natural scientists with doctoral degrees and 60% of them were in the universities. This would mean that any depletion of senior and qualified personnel will severely hamper the training of young scientists and jeopardise the development of existing R & D structures.

Brain-Drain

Both internal and external brain-drain is adequately recognised as a major problem for the development of science in all circles. In 1974, a cabinet committee was set up to inquire into the problem of Technologically, Professionally and Academically qualified personnel leaving Sri Lanka. (Sessional paper No. 18 of 1974). This report enumerated various constraints that affects brain-drain and made several important recommendations. However, these recommendations were not fully implemented and it is worth reviewing these recommendations to take necessary steps for their implementation.

In their study, major causes for brain-drain were as follows :-

a) inadequate remuneration for scientists compared with other professionals (it is worth noting that the present salary structure is anti-intellectual. A messenger in a State Bank receives higher remunerations, and enjoy other privileges than a lecturer in an University).

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b) lack of recognition of scientific work by politicians and sometimes by their peers. A considerable degree of inconsistency in the evaluation of scientific work was noted. Another striking feature is the inadequate incentives to undertake doctoral work as the remuneration structures change only marginally with post-doctoral qualifications.

Major Constraints for Research Work

The constraints for R & D work noted in this study varies according to field of sciences and according to different institutions. Certain institutions such as Medical Research Institute, Metereological Department, Geological Survey Department was not in a position to carry out their routine activities due to inadequate funds and lack of equipment.

Some of the major constraints noted are as follows :-

a) Inadequate funds and lack of trained personnel
b) Difficulties in the formation of "critical masses" and lack of effective communication among local scientists and scientists abroad.
c) Inadequate funds for Journals, Books and equipment
d) Inadequate rewarding schemes for performance of scientists.
e) "Institutional violence" and rigid administrative procedures.
f) Absence of incentives for post - R & D development

INTERNATIONAL COMPARISONS OF R & D RESOURCES

To put the Sri Lankan figures in international perspective it would be useful to work some international comparisons. In 1980, only 10.6% of the total R & D scientists and engineers and 6.0% of the R & D expenditure in the world were available in developing countries for research and development activities (UNESCO, 1984). The average number of R & D scientists and engineers per million population was 2954 for developed countries compared with 125 for developing countries in 1980. R & D expenditure as a percentage of GNP was 2.24% in developed countries as against 0.43% in developing countries for the same period.

The status of R & D in Sri Lanka in respect of both manpower and expenditure shows us in a poor light. The number of full time equivalent R & D scientists and engineers was 79 per million population in 1984 and the R & D expenditure as a percentage of Gross Domestic Product was 0.14%. Table 8.1 shows comparative data for selected countries. According to these statistics national financial commitments in Sri Lanka for research and development activities remains at a low level compared to other developing countries such as India, Argentina, Turkey, Brazil, Mauritius and Indonesia. The availability of R & D scientists and engineers per

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million population is also below most developing country average and in the range of countries such as Pakistan, Togo, Thailand, Philippines and Seychelles.

Table 8.1

Number of R & D Scientists and Engineers per million population and R & D expenditure as a percentage of GNP for selected developing countries.

		R & D Exp. as a % of GNP		Scientists per million people
Mauritius	1982	0.5		176
Sudan	1978	0.2		219
Argentina	1980	0.5		351
Guyana	1982	0.2		97
India	1982	0.6	1978	89
Indonesia	1982	0.5		113
Pakistan	1979	0.2	1981	61
Philippines	1982	0.2		101
Singapore	1981	0.3		296
Sri Lanka	1983	0.14	1984	79
Korea	1982	0.9		723

Source:- UNESCO (1984) - Statistics on Science & Technology UNESCO, Paris.

SUMMARY OF HIGHLIGHTS

1. The total economically active scientists engaged in S & T activities reported in the study was 7221. Natural scientists comprised of 34% of the total, engineers and technologists were 43%, medical scientists 5% and social scientists 18%.

2. Economically active natural scientists and engineers amount to 5557 in 1984 compared with 4567 personnel in 1978. This corresponds to an average annual increase of 2.5 percent (141 persons per year). This is compared with the annual average output of 645 scientists and engineers from the universities from 1977 to 1982.

3. The public sector continues to provide the major S & T service in the country by employing 92% of the economically active scientists and engineers and being as well responsible for 93% of the R & D expenditure.

4. The number of scientists and engineers engaged in R & D activities amounts to 33% of the economically active scientists and engineers and only 10% of them were engineers and technologists.

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5. Women comprise only 15% of scientists and engineers.

6. At constant 1970 prices (based on GDP deflator), the total direct R & D expenditure increased only marginally from Rs. 25 million in 1975 to Rs. 33.4 million in 1983.

7. As a percentage of GDP, R & D expenditure had declined from 0.2% in 1975 to 0.14% in 1983.

8. Per capita R & D expenditure in 1984 was around US$ 0.40 down 7 cts from the 1975 figure.

9. 58% of national R & D expenditure was spent on agricultural sciences.

10. Full-time equivalent R & D scientists and engineers per million population was 79 in 1984, the average for developing countries being 125 in 1980.

11. Basic research constitute only 6% of the Gross Expenditure on R & D and the research expenditure was heavily weighted for Applied Research.

12. In some state sector employment total emoluments are nearly twice that obtained by scientists in equivalent positions.