

1. INTRODUCTION, METHODOLOGY AND SUMMARY

1.1 Introduction

1.1.1 Technological upgradation, modernisation and scientific advances in production processes constitute some of the leading factors in growth of productivity, whether it be in organised industry, agriculture or small industry. In order to keep pace with speedy Technological developments within the country and out side it was realised fairly early by the planners that India needs development of a suitable infrastructure and adequate Scientific and Technical manpower equipped with up-to-date technical knowledge and skills. Accordingly, efforts have been made for expansion in the field of academic instructions and training in Science and Technology ever since the launching of the first Five Year Plan.

1.1.2 As scientific and technical manpower plays a crucial role in developmental process, it is necessary to formulate a data base in regard to availability of scientific and technical manpower according to qualifications, specialisation, age, employment, activity status, nature of Work performed etc. Simultaneously, it is also necessary to know the demand for scientific and technical personnel by qualifications, discipline, specialisation etc. over future years in order to maintain a balance between demand and supply.

1.1.3 The need for collection of data in regard to technical and scientific manpower in different disciplines as well as conditions of work and service obtaining among scientific and technical personnel was felt as early as 1947. In August 1947, Government of India appointed a Scientific Manpower committee to advise on the best methods of utilising and augmenting the scientific manpower resources of the country. On the recommendation of this committee, regarding preparation of a roster of scientific and technical talent available in the country, the Council of Scientific & Industrial Research was asked to compile a National Register of Scientific & Technical personnel. In

this context, the then Prime Minister (Late) Pt. Jawahar Lal Nehru issued frequent appeals to the scientists and technicians of the nation to send complete information about themselves such as age, address, scientific qualifications, research and industrial experience, their present occupation, the nature of research work done, if any etc. However, since the registration was voluntary, the response of the registrants was not satisfactory. With passage of time the registration diminished and it became only a partial reflection of the S & T manpower situation of the country.

1.1.4 Considering the need of the correct update information on S & T manpower, census of technical manpower was conducted in 1961 Census as an ancillary enquiry linked integrally to the Census count in close collaboration with the CSIR. The studies based on the data of S & T personnel collected at the time of 1961 Census proved to be useful in educational and manpower planning. It was, therefore, planned to have a wider coverage during 1971 Census including all degree holders and technical personnel. The studies carried out by CSIR on the above data proved to be useful in the assessment of S & T manpower situation in the country and was considered helpful for Manpower Planning.

1.1.5 The survey of Degree Holders and Technical Personnel (DHTP) was again taken up along with 1981 Census. But, considering the heavy requirement of schedules and difficulty of collecting and handling bio-data for such a huge population, it was decided to collect the data on 20 percent sample in 12 States and complete enumeration in the remaining States and Union Territories. Since Census was not conducted in Assam in 1981, DHTP survey was also not carried out in that State. The post Census non-response survey conducted by CSIR in Delhi and Calcutta revealed that the non-response was as high as 58

percent and 52 percent respectively. The non-response of this order has obviously affected the estimates of various characteristics computed on the basis of survey data and hence could be used only with necessary caution.

1.1.6 Although the total resource of S & T manpower in the country, in relation to the population and magnitude of the task, is rather small as compared to industrially advanced economies yet we have to face twin problems of (i) employment and (ii) emigration. As regards the first problem, this is mainly because of the fact that the economy has not progressed as planned though the outturn of S & T personnel has increased. The current rate of unemployment of S & T personnel is around 9 percent, 6 percent for degree holders and 14.6 percent for Diploma holders in Engineering & Technology and 6 percent for medical doctors. This however, does not imply that there are no shortages of manpower, particularly in specialised areas. Another reason is that S & T has so far not been made an integrated part of the major socio-economic sectors e.g rural development, ecology, production and scientific/industrial research. As regards the second problem, the exodus is generally of better than average persons either because of higher expectations or inadequacy of facilities for research or lack of research environment and this hampers the pace of development. No doubt, efforts to check brain drain have been made, for example by creating a 'Scientists Pool, to provide temporary placement to highly qualified scientists trained in India/Abroad, visit of UPSC selection committee in other countries for recruitment and through Govt. Policy of extending offers to outstanding individual scientists. However, it appears that we have to live with brain drain the main reasons being the differentials in emoluments and the work culture in the developed and developing countries

1.1.7 The manpower system, which is now being developed, has to ensure that no plan project/programme suffers from manpower shortage and there are no surpluses which imply wastage of scarce manpower resources. In spite of macro surpluses, there is a problem of critical manpower shortages which warrant analysis at the disaggregate level, discipline wise and by skill levels. Thereafter, appropriate action, at periodic intervals, may have to be taken to re-organise/restructure the courses to attune these to the new environment.

1.1.8 Keeping the above in view, the Ministry of Science and Technology desired to prepare a Perspective Plan for Science and Technology Manpower in India upto 2000 AD and accordingly the present study was carried out by the Centre for Research, Planning & Action in 1988-89 with a view to prepare the Perspective Plan.

1.1.9 **Main Objectives** of the present Study are as Under:-

- (1) Assessment of the current availability (supply) of S & T Manpower by category (field of specialisation) such as Agriculture and Veterinary science manpower, Engineering & Technology manpower, Medical and para-medical personnel and General Science personnel.
- (2) Discipline wise break-down of supply of each category of manpower alongwith appropriate break down by age/sex/activity status and employment.
- (3) Projection of likely availability (supply) by category/discipline upto the turn of the century which inter alia implies projection of total stock at five yearly intervals.

- (4) The present and projected demand of S & T manpower by category/discipline in relation to Planned/indicative Programmes of development at five yearly intervals upto the end of the century.
- (5) Preparation of Manpower balance and an assessment of the likely shortages/surpluses at disaggregate level upto 2000 AD and various intermediate points so as to take appropriate steps to ensure adequate supply of S & T Manpower as per need and also avoid wastage by avoiding mismatches.
- (6) To estimate the differentials in emoluments, age, qualifications, etc.

1.2 Definition of S & T Manpower

1.2.1 S & T manpower may be taken to refer to the category of manpower which has an add-on effect in terms of either vocationalisation or training. Hence this manpower will be at all levels viz. intermediate, middle or higher level. The categories of manpower included as S & T manpower are all types of degree and diploma holders including Ph.Ds., Post-graduates, Graduates and under graduates in Engineering & Technology and graduates, post-graduates and Ph.Ds. in Science/ Agriculture/ Medicine.

1.2.2 Realising that the above definition is rather vague, S & T manpower has been defined in terms of occupations i.e. type of work performed. Generally degree and diploma holders are covered under Occupation Division Code 0 and 1, of the National Classification of Occupation (NCO). Division Codes 3, 7, 8 and 9, called production related workers are by and large having no formal education/training. Skilled technicians under codes 7 to 9 comprise those who have (a) formal training in trade at the Industrial Training Institute (ITI)

or (b) have formal in-house/in plant training and (c) are occupying technical occupations because of on job training; and (d) have risen to hold these positions by virtue of experience.

1.3 Methodology

1.3.1 Base Line Stock

1.3.1.1 Base line stock of Agricultural and veterinary scientists at the beginning of 1981 for urban areas has been taken from C series tables of 1981 Census. Rural Stock has been estimated on the basis of 1981 B series tables. Stock of employed Agriculture and Veterinary Scientists was estimated from 1981 Census B Series tables.

1.3.1.2 Base line stock of Engineering and Technology manpower at the beginning of 1981 has been built up as the sum total of two components viz (i) employed S & T personnel as per 1981 Census; and (ii) unemployed S & T Personnel estimated on the basis of DHTP(1981) survey and the employment exchange statistics.

1.3.1.3 Stock of Registered Allopathic medical manpower at the end of 1980 has been taken from Medical Council and that of Indian System of Medicine (ISM) Practitioners and Nurses from respective Councils/Examination Boards. Stock of employed Medical and Para-medical personnel has been estimated from Census 1981 B Series tables.

1.3.1.4 Stock of degree holders in Science at the end of 1980 has been generated on the basis of annual outturn of different categories of degree holders from 1950 to 1980 as available from U.G.C reports and corresponding stock of employed degree holders in Science has been estimated from B.Series tables of 1981 Census.

1.3.2 Updated Stock : 1985

1.3.2.1 Updated stock of Agriculture and veterinary scientists at the end of 1985 has been generated with the help of base

line stock, annual enrolment figures in respective disciplines during the intervening years, enrolment / outturn ratio realised in the recent past and attrition rate on account of death, disability etc.

1.3.2.2 Updated Stock of Engineering & Technology manpower for 1985 has been generated from the base year (1981 beginning) stock taking into account the outturn/estimated outturn of degree and diploma holders during the intervening years and attrition rate for depletion.

1.3.2.3 Updated stock of registered Medical and Para-Medical manpower has been taken from respective Medical Councils, Nurses Councils/Examination Boards. Stock of employed manpower has been estimated on the basis of employed stock ratio as observed in 1980.

1.3.2.4 The stock of degree holders in science for the year 1985 has been estimated taking into account base line stock, outturn/estimated outturn of degree holders during the intervening period and attrition rate for depletion.

1.3.3 Projected Stock for future years upto 2000 AD

1.3.3.1 Projected stock of S & T Manpower for future years have been estimated taking into consideration updated stock of 1985 and latest enrolment figures in different disciplines and respective enrolment outturn ratio.

1.3.4 Future Requirements of S & T Manpower upto 2000 AD

1.3.4.1 Requirements of S & T Manpower relating to Agriculture and veterinary Science, Engineering and Technology as also General Science, was estimated at three different scenarios by adopting three different methods viz (a) Output method, (b) Manpower method and (c) Investment method and average of these three estimates was taken as more realistic estimate of requirement.

1.3.4.2 Requirements of Medical and

Para-medical personnel for future years have been estimated on the basis of health needs as per national goal of "Health for All" by 2000 A.D.

1.3.4.3 In order to project future requirements by investment and output methods future Investment/output have been estimated by loglinear method.

1.3.4.4 In order to estimate requirement of medical manpower, future population has been estimated at moderate growth rate expected due to increase in couple protection rates owing to Family Planning Programmes.

1.4 Agriculture Science Manpower

1.4.1 Total stock of degree holders in Agriculture Science at the beginning of 1981 was of order of 1.03 lakh. Around 37.24 percent of them were in Maharashtra and U.P. Another 36.58 percent were in other six major States namely Andhra Pradesh, Bihar, Gujarat, Karnataka, Madhya Pradesh and Tamil Nadu.

1.4.2 78 percent of the stock of degree holders in Agriculture Science manpower were economically active and unemployment rate among them was 11.41 percent. Out of the stock, 2.95 percent were having doctorate degree, 20.57 percent having post-graduate degree and the remaining 76.48 percent having Graduate degree. Among employed, 3.22 percent were Ph.Ds, 20.95 percent were M.Sc.s, and 75.83 percent were B.Sc.s. in Agriculture Science.

1.4.3 Availability of Agriculture Scientists which in 1981 was 6.76 per 10 thousand hectares of cultivated area improved to 9.11 per 10 thousand hectares of cultivated area in 1985.

1.4.4 Future stocks of degree holders in Agriculture Science for 1990, 1995 and 2000 have been estimated as 175.6 thousand, 204.6 thousand and 229.4 thousand respectively showing a growth rate of 3.2 percent per annum by 2000-01.

1.4.5 Requirements of Agriculture Science degree holders have been estimated as 106.6 thousand in 1990-91, 128.9 thousand in 1995-96 and 158.3 thousand in 2000-01 showing a growth rate of 3.9 percent per annum during 1990-95 and 4.2 percent per annum during 1995-2000.

1.4.6 The rate of unemployment, which was of the order of 19.68 percent in 1985-86 and is expected to be of the order of 22.26 percent in 1990-91 will show a declining trend thereafter and by 2000-01 will decline to 11.51 percent only.

1.4.7 Agronomy is the most popular branch of Agriculture Science accounting for 75 percent of the Agriculture Scientists in 1981. Agro-Chemistry, Dairying and Fishing each accounting for around 2 percent of them are relatively less popular.

1.5 Veterinary Science Manpower

1.5.1 Total stock of Veterinary Scientists was 20.9 thousand in 1981. Out of which 83.12 percent were B.VSc., 14.25 percent M.VSc. and remaining 2.63 percent Ph.D degree holders. Out of total stock 30 percent were in the States of Tamil Nadu and Andhra Pradesh alone. Another 41.9 percent were in the States of Bihar, Karnataka, Madhya Pradesh, Maharashtra, Orissa and U.P.

1.5.2 About 87 percent of the total stock of veterinary scientists were economically active and amongst them only 0.02 percent were unemployed.

1.5.3 Updated stock in 1985 was 25.5 thousand. Future stock of veterinary scientists have been estimated as 30.1 thousand in 1990, 34 thousand in 1995 and 37.4 thousand in 2000.

1.5.4 Out of total stock of Veterinary Science degree holders available in 1985, 3.68 percent were Ph.Ds 15.04 percent M.VSc and 81.28 percent B.VScs. By 2000 AD, their respective proportions will be 4.87 percent for Ph.Ds, 16.32 percent for M.VScs. and 78.81 percent B.VSc degree holders in Veterinary Science.

1.5.5 Total estimated requirement of Veterinary Scientists in 1985-86 was 22.5 thousand. Future requirements for the years 1990-91, 1995-96 and 2000-01 have been estimated as 27 thousand, 32.5 thousand and 39.4 thousand respectively showing an overall growth rate of 3.8 percent during 1985-86 to 2000-01.

1.5.6 Already there was a shortage of Veterinary Scientists to the tune of 1.24 percent of the requirement. This shortage is expected to increase further to 2.93 percent by 1990-91, 9.07 percent by 1995-96 and rise as high as 17.5 percent by 2000-01.

1.5.5 There is a need of augmentation of the capacity of teaching in Veterinary Science in all the existing institutions and also opening of new departments/Colleges having such facilities so that economic planning may not suffer due to shortage of manpower.

1.6 Engineering & Technology Manpower

1.6.1 The stock of economically active degree holders in E&T, in 1981 was 311.3 thousand which has increased to 374.5 thousand by 1985. Future stock of E&T degree holders is expected to be 467 thousand in 1990, 573 thousand in 1995 and 693 thousand in 2000. As against this, their requirement is expected to be 453.9 thousand in 1990-91, 606.2 thousand in 1995-96 and 746.9 thousand in 2000-01. Thus, although a surplus of the E&T degree holders is expected in 1990-91 to the tune of about 3 percent of the stock, by 1995-96 a shortage is expected to the tune of 5.5 percent of the requirement and by 2000-01 the shortage will be by over 7 percent. Thus there is a need to augment the enrolment capacity of E&T disciplines to meet their prospective need.

1.6.2 Stock of economically active diploma holders in E&T in 1981 was 527.2 thousand which increased to 637.8 thousand by 1985. Future stock of E&T diploma holders has been estimated as 804 thousand in 1990, 998 thousand in 1995 and 1220 thousand in 2000. Future expected requirement of diploma holders has been estimated as 739.8 thousand in

1990-91, 967.9 thousand in 1995-96 and 1210 thousand in 2000-01. Thus, a surplus of about 8 percent of supply has been estimated for the year 1990-91. This surplus is showing declining trend owing to which by 2000 AD the surplus will decline to 2 thousand against the supply of 1220 thousand which is only marginal.

1.6.3 Gaps in Supply of E & T manpower in relation to demand are also expected to emerge in some frontier areas. Large number of new installations that are being established in the area of electronics and telecommunications will be in need of properly trained manpower to maintain and keep the industry productive. In the energy sector for new technologies which have been developed for rural sector sufficient E & T manpower of good talent is needed to meet the requirement.

1.6.4 Some more specific requirements have been mentioned for technical persons for Servo-control system, Cryogenics, bio-technology and application & maintenance engineering.

1.6.5 Keeping in view the future need of technical manpower in these specific areas there is a need for greater linkage between industry and technical education.

1.6.6 Out of total technical manpower engaged in E & T education during 1987-88, only 13.5 percent were female.

1.6.7 The average age of technical personnel engaged in education was 41.3 years. Average age of females is marginally less than that of males. Relatively more females are engaged in the age groups of 31-35 years and 41-45 years.

1.6.8 The average income per month of technical personnel (both male and female combined) in 1987-88 was Rs.3037 that of female being Rs.2964 per month and of male being Rs.3048 per month.

1.6.9 The average age of Technical personnel engaged in Industry in 1987-88 was 37 years. Around 49.6 percent of them were in the lower age group of upto

35 years. The average age of Technical personnel engaged in service sectors was 45 years for Health education, 43 years for Transport & Communication, 42 years each for Electricity, Gas & Water and Education, 41 years for Hospital and. 38 years for R & D.

1.6.10 Average income of Technical Personnel engaged in Industry was Rs. 2395 per month and that of personnel engaged in service sector of different sub-sector was Rs.1732 to Rs.2978 per month.

1.7 Medical & Para-medical manpower

1.7.1 Stock of medical manpower in 1980 consisted of 255.5 thousand Allopathic doctors, 224.9 thousand Ayurvedic doctors, 145.0 thousand Homeopathic Doctors, 26 thousand Unani doctors and 8.4 thousand Dental Surgeons. As against this, employed medical manpower was 207.6 thousand Allopathic doctors, 107.5 thousand Ayurvedic doctors, 50.1 thousand Homeopathic doctors, 6.7 thousand Unani doctors and 8 thousand Dental Surgeons.

1.7.2 Medical manpower per million in 1981 works out as 312 Allopathic doctors, 162 Ayurvedic doctors, 75 Homeopathic doctors, 10 Unani doctors and 12 Dental Surgeons. Stock per million population in Rural area was 113 Allopathic and 132 Non-Allopathic doctors and that in urban areas 932 Allopathic doctors and 333 Non-Allopathic doctors.

1.7.3 Stock of nurses in 1981 was 166.9 thousand and stock of Para-medical staff was 527.7 thousand.

1.7.4 Out of total medical manpower in 1981 female doctors accounted for 10.9 percent. Maximum share (15.7 percent of females) was among Allopathic doctors. For other categories female doctors share was between 4.2 to 5 percent. For Dental Surgeons it was 8.7 percent.

1.7.5 Stock of medical manpower in 1985 consisted of 298.3 thousand Allopathic doctors, 272.2 thousand Ayurvedic doctors, 28.7 thousand Unani doctors and 130 thousand Homeopathic doctors. Accordingly, estimated employed medical personnel in 1985-86 has been

estimated as 242.2 thousand Allopathic doctors, 130.2 thousand Ayurvedic doctors, 7.4 thousand Unani doctors and 50.3 thousand Homeopathic doctors.

1.7.6 Estimated medical manpower per million population for the year 1985-86 has been worked out as 592 of which 341 were of Allopathic, 172 of Ayurvedic, 11 of Unani and 68 of Homeopathic systems. Thus availability of doctors in 1985-86 in relation to population was about 6 percent higher than that of 1980-81.

1.7.7 Stock of economically active Allopathic doctors for future years has been estimated as 309.6 thousand in 1990, 345.8 thousand in 1995 and 378.9 thousand in 2000 AD. Stock of economically active Non-Allopathic doctors would be 160.3 thousand Ayurvedic, 8.0 thousand Unani and 40.7 thousand Homeopathic doctors in 1990 and 177.6 thousand Ayurvedic, 8.6 thousand Unani and 36.9 thousand Homeopathic doctors in 1995 and 193.3 thousand Ayurvedic, 9.2 thousand Unani and 33.5 thousand Homeopathic doctors in 2000. The stock of dental surgeons would be 10.7 thousand in 1990, 11.9 thousand in 1995 and 12.9 thousand in 2000.

1.7.8 Future stock of Nurses is expected to be 242.9 thousand in 1990, 284.9 thousand in 1995 and 322.0 thousand in 2000.

1.7.9 Future requirements of Allopathic doctors have been estimated as 305.4 thousand in 1990-91, 360.3 thousand in 1995-96 and 422.2 thousand in 2000-01. Requirements of Ayurvedic doctors during the corresponding years would be 145.2 thousand, 165.7 thousand and 187.2 thousand respectively. For Unani doctors the requirement would be 9.0 thousand in 1990-91, 10.3 thousand in 1995-96 and 11.7 thousand in 2000-01 and for Homeopathic doctors requirement during corresponding years is expected to be 67.6 thousand, 77.3 thousand and 87.2 thousand respectively.

1.7.10 Future requirements of staff nurses have been estimated as 397.3 thousand in 1990-91, 506.4 thousand in 1995-96 and 645.3 thousand in 2000-01.

1.7.11 Stock of economically active Allopathic doctors is estimated to be marginally surplus in 1990-91. But, present trend of demand supply shows that by 2000-01 shortage to the tune of 43.3 thousand i.e about 10 percent of the requirement is apprehended.

1.7.12 Ayurvedic doctors will be marginally surplus through out the period. But, for Unani doctors there will be shortage throughout the period and by 2000-01, the shortage will be by 21.4 percent of the requirement. Thus there is immediate need for augmenting the enrolment capacity in Unani system of medical education by about 5 percent per annum.

1.7.13 Presently there is a surplus of Homeopathic doctors to the extent of 12 percent of the stock. But the present trend of demand and supply of Homeopathic doctors shows that from 1995-96 onwards there will be shortage and by 2000-01, the shortage will increase to 26 percent of the requirement.

1.7.14 Demand-Supply analysis of Nurses and Para Medical Manpower shows that there would be huge shortage of Nurses by 2000 Ad., Health Educators, Lab-Technicians, Nurse-Midwives, Health Assistants (male) and Health Assistants (female). The existing situation can only be improved significantly if organisational structures responsible for Health Manpower Development are further strengthened with speed.

1.7.15 During 1987-88, in most medical Institutions, females were about one third of the total personnel in all the disciplines excepting nursing where share of females was about 85 percent.

1.7.16 The female medical personnel had a higher share of 53 percent among those below 30 years. This share gradually declined till age group 41-45 years when their share was 18.9 percent but increased again for higher age groups.

1.7.17 The share of women was higher than that of males in the salary slab of

1501-2000. In all other salary slabs their share was lower. The share of women was much less (11.5 percent) for salary slab of above 3500.

1.8 General Science Manpower

1.8.1 Estimated stock of degree holders in science in 1980 was 1268.5 thousand which increased to 1637.9 thousand by 1985. Their projected stock is estimated as 2073.2 thousand in 1990, 2591.7 thousand in 1995 and 3214.3 thousand in 2000. Out of the total stock, 78 percent will be economically active.

1.8.2 The stock of economically active B.Sc degree holders is expected to rise from 1071.9 thousand in 1985 to 2188.1 thousand in 2000 AD. That of M.Sc degree holders will rise from 181.8 thousand to 255.2 thousand and of Ph.D degree holders from 23.8 thousand to 63.8 thousand during the same period.

1.8.3 Estimated requirement of degree holders in Science during 1985-86 was 1012.7 thousand which increased to 1295.5 thousand in 1990-91, 1679.6 thousand in 1995-96 and 2204.7 thousand in 2000-01. Requirement of degree holders in Science by level of degree is expected to rise from 830.7 thousand in 1985-86 to 1897.7 thousand in 2000-01 for B.Sc degree holders, 160.8 thousand in 1985-86 to 243.3 thousand in 2000-01 for M.Sc degree holders and 21.2 thousand in 1985-86 to 65.6 thousand in 2000-01 for Ph.D degree holders.

1.8.4 Analysis of future estimated demand and supply of combined degree holders in Science shows that Unemployment of degree holders which is of the level of around 20 percent of the availability is showing a declining trend and by 2000-01 it will decline to 12 percent. At dis-aggregate level unemployment rate for B.Sc degree holders will decline from 22.5 percent to 13.27 percent, that for M.Sc degree holders will decline from 11.55 percent to 4.62 percent and for Ph.Ds from 10.92 percent to only 0.31 percent during the same period.

1.8.5 In 1980-81, around two-third of employed B.Sc. degree holders were in the lower group of upto 35 years, while amongst M.Sc degree holders about 53 percent were in this age group and amongst Ph.D degree holders only 35.7 percent were in this age group.

1.8.6 Average income of B.Sc degree holders was Rs.2350, that of M.Sc degree holders was Rs. 3454 and that of Ph.D degree holders was Rs. 4097 per month.

1.8.7 About 49 percent of degree holders in Science were engaged in Teaching and R & D and 30 % in Administrative work. In Industry also a sizeable percentage(12.4%)of them were engaged.

1.9 Combined S & T Manpower

1.9.1 With a view to assess the Demand. Supply situation of combined S & T Manpower by 2000 AD, the estimates of economically active S & T manpower and their requirements in regard to different categories of S & T manpower, as presented in chapters 2 to 5 of this report have been consolidated here. Overall situation shows that economically active S & T manpower which was 24.75 lakh in 1980 has increased to 30.32 lakh by 1985 and is expected to increase to 55.8 lakh by year 2000. As against this, the requirements of S & T personnel by 2000-01 would be about 57 lakh. Thus shortage of S & T manpower of the order 1.2 lakh is expected to be experienced by the turn of the century.

1.9.2 The estimated distribution of stock of different categories of S & T manpower for Selected States/UT in 1981 has been presented in table 1.1. The statement reveals that, at the national level, there were 35.87 lakh S & T manpower in 1981. Out of this, medical and para-medical manpower accounted for 37.8 percent, degree holders in Science for 35.3 percent, degree and diploma holders in Engineering & Technology for 23.4 percent and the degree holders in Agriculture and Veterinary Science for 3.5 percent.

1.1 Distribution of S & T Manpower by Discipline in Selected States:1981

(in percent)

Sl. No.	State/UT	Agriculture & Veterinary Science			E & T	General Science	Medical & Para-medical	Total	N ('000)
		Agri.	Vet.	Total					
1.	Andhra Pradesh	2.7	1.3	4.0	29.1	31.7	35.2	100.0	221.6
2.	Bihar	2.2	0.4	2.6	18.2	31.7	47.5	100.0	302.5
3.	Karnataka	2.5	0.7	3.2	26.3	47.9	22.6	100.0	281.6
4.	Kerala	1.4	0.4	1.8	14.0	55.5	28.7	100.0	218.0
5.	Madhya Pradesh	3.3	0.5	3.8	22.7	34.4	39.1	100.0	227.8
6.	Maharashtra	3.9	0.4	4.3	33.7	29.6	32.4	100.0	486.4
7.	Tamil Nadu	1.7	1.0	2.7	21.4	43.4	32.5	100.0	351.4
8.	Uttar Pradesh	5.4	0.3	5.7	12.8	36.2	45.3	100.0	371.6
9.	West Bengal	1.0	0.2	1.2	19.8	40.0	39.0	100.0	344.4
10.	Other States/UTs	3.4	0.7	4.1	26.5	25.6	43.8	100.0	782.0
Total		2.9	0.6	3.5	23.4	35.3	37.8	100.0	3587.3

1.9.3 State-wise distribution of S & T manpower in 1981 have been presented in table 1.1(a). The statement shows that Maharashtra has the maximum share of S & T manpower having 13.6 percent of the total. Other major States in regard to stock of S & T personnel are

Uttar Pradesh, Tamil Nadu, West Bengal, Bihar, Karnataka, Madhya Pradesh, Andhra Pradesh and Kerala in that order. The above nine major States together accounted for 78.2 percent of the total S & T manpower in the country.

1.1 (a) Distribution Of S&T Manpower by States:1981

(in percent)

Sl. No.	State/UT	Agriculture & Veterinary Science			E & T	General Science	Medical & Para-medical	Total
		Agri.	Vet.	Total				
1.	Andhra Pradesh	5.7	13.4	7.0	7.7	5.5	5.8	6.2
2.	Bihar	6.3	6.2	6.3	6.6	7.6	10.6	8.4
3.	Karnataka	6.8	8.6	7.1	8.8	10.6	4.7	7.8
4.	Kerala	2.8	4.3	3.0	3.7	9.5	4.6	6.1
5.	Madhya Pradesh	7.1	5.8	6.9	6.2	6.2	6.6	6.3
6.	Maharashtra	18.2	9.1	16.7	19.4	11.3	11.7	13.6
7.	Tamil Nadu	5.7	16.8	7.5	9.0	12.0	8.4	9.8
8.	Uttar Pradesh	19.1	6.2	16.9	5.7	10.6	12.4	10.4
9.	West Bengal	3.1	3.8	3.3	8.1	10.9	9.9	9.6
10.	Other States/UTs	25.2	25.8	25.3	24.8	15.8	25.3	21.8
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0
(N'000)		(105.0)	(20.9)	(125.9)	(838.5)	(1268.5)	(1354.4)	(3587.3)

1.9.4 Stock & Distribution of economically active S & T manpower having degree and diploma as in 1981 for selected States and for the country as a whole has been presented in table 1.2 & 1.2(a). It would be seen that in 1981 there were 24.75 lakh economically

active S&T manpower having degree or diploma in the country. Out of this 40.0 percent were of General Science, 33.9 percent of E & T, 22.1 percent of medical and nursing and remaining 4.0 percent of Agricultural and Veterinary Science.

1.2 Stock of Economically active S & T Manpower having Degree and Diploma:1981(in'000)

Sl. No.	State/UT	Agriculture & Veterinary Science			E & T	General Science	Medical & Nursing	Total
		Agri.	Vet.	Total				
1.	Andhra Pradesh	4.7	2.4	7.1	64.5	54.8	43.8	170.2
2.	Bihar	5.1	1.1	6.2	55.1	74.8	34.5	170.6
3.	Karnataka	5.5	1.6	7.1	74.1	105.3	28.9	215.4
4.	Kerala	2.3	0.8	3.1	30.6	94.4	36.0	164.1
5.	Madhya Pradesh	5.9	1.1	7.0	51.7	61.2	34.4	154.3
6.	Maharashtra	14.9	1.7	16.6	63.9	112.1	69.3	361.9
7.	Tamil Nadu	4.7	3.0	7.7	75.3	118.8	45.7	247.5
8.	Uttar Pradesh	15.6	1.1	16.7	47.5	104.8	66.1	235.1
9.	West Bengal	2.6	0.7	3.3	68.2	107.3	36.3	215.1
10.	Other States/UTs	20.6	4.7	25.3	207.6	156.0	151.8	540.7
	Total	81.9	18.2	100.1	838.5	989.5	546.8	2474.9

1.9.5 Distribution of S & T personnel by category shows that maximum share was of degree holders in Science in the States of Bihar, Karnataka, Kerala, Madhya Pradesh, Tamil Nadu, Uttar Pradesh and West Bengal. The share of E & T

personnel was maximum in Maharashtra Andhra Pradesh & Others States/UTs. Manpower having degree in Agricultural Science and Veterinary Science was minimum in all the States/UTs ranging from 1.2 to 6.6 percent.

1.2(a) Distribution of Economically Active S & T Manpower Having Degree and Diploma by Discipline : 1981 (in percent)

Sl. No.	State/UT	Agriculture & Veterinary Science			E & T	General Science	Medical & Nursing	Total	N ('000)
		Agri.	Vet.	Total					
1.	Andhra Pradesh	2.8	1.4	4.2	37.9	32.2	25.7	100.0	170.2
2.	Bihar	3.0	0.6	3.6	32.3	43.8	20.3	100.0	170.6
3.	Karnataka	2.6	0.7	3.3	34.4	48.9	13.4	100.0	215.4
4.	Kerala	1.4	0.5	1.9	18.6	57.6	21.9	100.0	164.1
5.	Madhya Pradesh	3.8	0.7	4.5	33.5	39.7	22.3	100.0	154.3
6.	Maharashtra	4.1	0.5	4.6	45.3	31.0	19.1	100.0	361.9
7.	Tamil Nadu	1.9	1.2	3.1	30.4	48.0	18.5	100.0	247.5
8.	Uttar Pradesh	6.6	0.5	7.1	20.2	44.6	28.1	100.0	235.1
9.	West Bengal	1.2	0.3	1.5	31.7	49.9	16.9	100.0	215.1
10.	Other States/UTs	3.9	0.9	4.7	38.4	28.8	28.1	100.0	540.7
	Total	3.3	0.7	4.0	33.9	40.0	22.1	100.0	2474.9

1.9.6 Stock of economically active S & T manpower having degree and diploma in 1985 for the major states and for the country as a whole has been presented in table 1.3. The statement reveals that during 1985-86 there were 30.32 lakh of economically active S & T manpower (having degree & diploma) in the country out of which 42.1 percent were having degree/diploma in general science, 32.5 percent in E & T, 21.0 percent in medical and nursing and the remaining 4.4 percent in Agricultural and Veterinary Science.

1.3 Stock of Economically active S & T manpower having Degree and Diploma:1985

(in '000)

Sl. State/UT No.	Agriculture & Veterinary Science			E & T	General Science	Medical & Nursing	Total
	Agri.	Vet.	Total				
1. Andhra Pradesh	6.0	2.6	8.6	70.5	80.7	46.5	206.3
2. Bihar	5.6	1.4	7.0	71.8	102.4	32.4	213.6
3. Karnataka	7.7	1.9	9.6	84.1	127.7	32.4	253.8
4. Kerala	2.7	0.9	3.6	38.9	119.0	58.9	220.4
5. Madhya Pradesh	7.5	1.4	8.9	67.3	83.7	36.6	196.5
6. Maharashtra	17.9	2.3	20.2	181.4	141.3	78.7	421.6
7. Tamil Nadu	5.9	3.3	9.2	82.0	158.5	60.5	310.2
8. Uttar Pradesh	27.2	1.7	28.9	72.4	134.8	76.4	312.5
9. West Bengal	3.8	1.1	4.9	80.5	133.6	52.8	271.8
10. Other States/UTs	26.5	5.6	32.1	235.7	195.8	161.8	625.4
Total	110.8	22.2	133.0	984.6	1277.5	637.0	3032.1

1.3(a) Distribution of Economically Active S & T Manpower Having Degree and Diploma by Discipline :1985

(in percent)

Sl. State/UT No.	Agriculture & Veterinary Science			E & T	General Science	Medical & Nursing	Total	N ('000)
	Agri.	Vet.	Total					
1. Andhra Pradesh	2.9	1.3	4.2	34.2	39.1	22.5	100.0	206.3
2. Bihar	2.6	0.7	3.3	33.6	47.9	15.2	100.0	213.6
3. Karnataka	3.0	0.8	3.8	33.1	50.3	12.8	100.0	253.8
4. Kerala	1.2	0.4	1.6	17.6	54.0	26.7	100.0	220.4
5. Madhya Pradesh	3.8	0.7	4.5	34.2	42.6	18.7	100.0	196.5
6. Maharashtra	4.2	0.6	4.8	43.0	33.5	18.7	100.0	421.6
7. Tamil Nadu	1.9	1.1	3.0	26.4	51.1	19.5	100.0	310.2
8. Uttar Pradesh	8.7	0.5	9.2	23.2	43.1	24.5	100.0	312.5
9. West Bengal	1.4	0.4	1.8	29.6	49.2	19.4	100.0	271.8
10. Other States/UTs	4.2	0.9	5.1	37.7	31.3	25.9	100.0	625.4
Total	3.7	0.7	4.4	32.5	42.1	21.0	100.0	3032.1

1.9.7 Projected stock of economically active S & T manpower during 1990-2000 at all India level has been presented in table 1.4. The statement shows that total S & T manpower having degree and diploma will be around 38.20 lakh in 1990, 46.44 lakh in 1995 and 55.80 lakh by 2000 AD. The growth rate during 1985-1990, 1990-1995 and 1995-

2000 works out to be 4.67, 3.98 and 3.74 percent respectively.

1.9.8 It is worth mentioning here, that the stock of economically active S & T manpower presented in table 1.2 to 1.4 refers to domestic stock only. Stock of S & T manpower of Indian Origin has not been included here.

**1.4 Projected Stock of Economically active Personnel
with Degree and Diploma in S & T by Discipline (in '000)**

Year	Agriculture & Veterinary Science			E & T	General Science	Medical & Nursing	Total
	Agri.	Vet.	Total				
1990	137.0	26.2	163.2	1271.0	1617.0	769.5	3820.7
1995	159.6	29.6	189.2	1571.0	2021.6	861.9	4643.7
2000	178.9	32.5	211.4	1913.0	2507.1	948.6	5580.1

**1.4(a) Distribution of Projected Stock of Economically Active Personnel
with Degree and Diploma in S & T by Discipline (in percent)**

Year	Agriculture & Veterinary Science			E & T	General Science	Medical & Nursing	Total	N ('000)
	Agri.	Vet.	Total					
1990	3.6	0.7	4.3	33.3	42.3	20.1	100.0	3820.7
1995	3.4	0.7	4.1	33.8	43.5	18.6	100.0	4643.7
2000	3.2	0.6	3.8	34.3	44.9	17.0	100.0	5580.1

1.10 Future Requirements

1.10.1 Estimated requirement of S & T manpower during 1990 to 2000 at all India level has been presented in table 1.5 for different categories. It would be seen from this statement that by 1990-91 requirements of S & T personnel having degree and diploma will be 35.3 lakh, by 1995-96, 45.32 lakh and by 2000-01, 57 lakh showing a growth rate of 5.12 percent during 1990-95 and 4.69 percent during 1995-2000.

**1.5 Requirement of S & T Personnel
having Degree and Diploma
during 1990-91 to 2000-01
(in '000)**

Year	Agri- cul- ture	E & T	General Science	Medical and Nursing	Total
1990-91	133.5 (3.8)	1193.7 (33.8)	1295.5 (36.7)	908.0 (25.7)	3530.7 (100.0)
1995-96	161.4 (3.6)	1574.1 (34.7)	1679.6 (37.0)	1117.3 (24.7)	4532.4 (100.0)
2000-01	197.2 (3.5)	1964.6 (34.5)	2204.7 (38.6)	1333.7 (23.4)	5700.2 (100.0)

Note: Figures in brackets are percentage to total.

1.10.2 It is worth mentioning here that the estimated requirement of S & T personnel having degree and diploma, presented in table 1.5 is inclusive of R & D requirements in different sectors of the economy.

1.11 Expected Shortage/Surplus

1.11.1 Expected shortage/surplus of different categories of S & T manpower during 1990-91, 1995-96 and 2000-01 have been presented in table 1.6 from which it will be seen that even in 1990-91 S & T manpower on the whole is expected to be in surplus. However, for medical and nursing shortage is expected to the tune of 138.5 thousand. This shortage is expected to increase to 255.4 thousand by 1995-96 and 385.1 thousand by 2000-01. By 1995 for E & T also there will be marginal shortage which will increase to 51.6 thousand by 2000-01. On totality also the shortage is expected to be around 120.6 thousand.

1.6 Expected Shortage(-)/Surplus(+) of S&T Manpower during 1990-2000(in'000)

Category of Manpower	1990-91	1995-96	2000-01
Agriculture & Veterinary	+ 29.7	+ 27.8	+ 13.7
E & T	+ 77.3	- 3.1	- 51.6
Medical & Nursing	- 138.5	- 255.4	- 385.1
General Sc.	+ 321.5	+ 342.0	+ 302.4
Total	+ 290.0	+ 111.3	- 120.6

1.6(a) Percentage of Shortage(-)/ Surplus(+) of S&T Manpower to Requirement /Stock (in percent)

Category of Manpower	1990-91	1995-96	2000-01
Agriculture & Veterinary	+ 18.2	+ 14.7	+ 6.5
E & T	+ 6.1	- 0.2	- 3.3
Medical & Nursing	- 15.3	- 22.9	- 28.9
General Sc.	+ 19.9	+ 16.9	+ 12.1
Total	+ 7.6	+ 2.4	- 2.1

1.12 Suggestions and Recommendations

1.12.1 Owing to greater emphasis given to S & T since Independence, a massive infrastructure covering a broad spectrum of disciplines and capabilities has been built up in educational and research institutions. However, it has often been felt that S & T has not made the kind of impact it ought to have, possibly because the crucial role that S & T can play in planning for growth was not realised fully. It is thus necessary to integrate more systematically Science and Technology in the process of economic Planning in setting targets.

1.12.2 Agricultural & Veterinary Science

1.12.2.1 Considering that manpower having degree in Agricultural Science is already in surplus by 21.8 thousand in 1985-86 in relation to corresponding demand and this situation will persist in 2000-01 after reaching a peak of surplus by 30.5 thousand during 1990-1995, it is felt that present educational institutions for agriculture will be adequate to meet the demand upto 2000-01. However, more stress in the conversion of intake towards higher education i.e, Post graduates and Ph.Ds in Agricultural Science is to be given to meet the challenges of changing scene towards R & D and Science oriented agriculture in the future. Further adequate employment opportunities are required to be generated where present unemployed manpower is absorbed.

1.12.2.2 Agricultural extension is required to be strengthened in all future plans and decision on the nature and size of the extension organisation would determine the size of the demand for technical manpower at the block and district level from time to time.

1.12.3 Engineering & Technology

1.12.3.1 Technological advancement and expansion of activities in various sectors on the economy have led to manpower shortage in specialised

disciplines, which are bound to increase in future. Due to this reason, the shortage of E & T Degree holders has been apprehended by 33.2 thousand even in 1995-96. By 2000-01, this shortage is expected to increase to 53.6 thousand. In this context, the Seventh Five Year Plan has laid emphasis on the need for giving special attention to technical manpower needs in the new emerging areas like electronics, computer systems, nuclear science, satellite communication, bio-engineering, ocean engineering etc. Further, the increasing pace of development of knowledge all over the world is making the utility of traditional disciplines like civil, mechanical, electrical etc. more and more inadequate. Therefore, we are at a stage when further development is linked to our capability on catching up with the world in emerging areas with special reference to high technology sectors.

1.12.3.2 The educational system in electronics has so far been able to provide good graduates with adequate theoretical background but lacking in hands-on-experience. The primary lacunae in electronics education at the bachelor's level are inadequate laboratory facilities. These are too inadequate in small engineering colleges and private institutes. Also there is a wide gap in the quality of education between bachelor's degree programme and a technician's diploma programme. Post graduate programmes are small or non-existing and educational institutes are unable to attract the best talents in the field who generally go abroad. Since fresh engineers do not have enough hand-on-experience to provide adequate support at the middle level, one finds Ph.Ds sometimes doing trouble shooting repair just to keep system going. There is an urgent need to correct this deficiency in our premier institutions. The system should be modified so that greater stress is laid on practice. The degree should be given only after completion of a project that would take a year.

1.12.3.3 In telecommunication also need for augmentation of resources and

training facilities is called for in the premier institutions. Simultaneously, improvement and upgradation of skills of the existing personnel to improve their performance is also needed.

1.12.3.4 The ocean Science and Technology Board had emphasised the need for increasing the technical manpower particularly for the off shore and deep sea mining, remote sensing, ocean data processing, management of resources etc. In this connection it is necessary to create regular positions in different institutions and organisations instead of research fellowships. Permanent infrastructure could be created in the educational institutions for continuous development of manpower need for the the ocean sector.

1.12.3.5 There is need for development of manpower to design, erect, operate and maintain super-thermal power projects. The initial training of personnel has to be supplemented by in-house training to the employed personnel with a view to upgrading their skills on a continuous basis. There is an urgent need to evolve strategy for development of skilled personnel required in large numbers to man power stations. Trained manpower is required in oil refining and R & D work under the new energy sources programme pertaining to solar energy development, geo-thermal, tidal and wind energy. For atomic energy also heavy demand of skilled manpower is expected for the proposed expansion programme.

1.12.3.6 The vocational education and training courses should have adequate skill component so as to be of help to students in procuring employment in industries. There is a need for diversification into new fields in vocational training in urban and semi-urban areas. In rural areas, it has to be oriented specially to trades which have relevance like agro-based industries, rural based energy system and small industries with rural bias

1.12.4 **Medical & Para-medical**

1.12.4.1 If the existing enrolment capacity for Medical and Nursing teaching is not augmented the programme of "Health for all" by 2000 AD cannot be achieved. It is thus suggested that more stress should be given towards creation of additional capacity of enrolment in medical and nursing in general and nursing in particular.

1.12.4.2 Availability of medical and nursing services in rural areas is not at all adequate, even after creation of CHCs, PHCs and SHCs as Private practitioners are mostly urban biased. It is thus suggested that Medical Practitioners and nurses may be encouraged to set up their practice in rural areas by providing them suitable incentive like proper facilities etc.

1.12.4.3 For Para-medical teaching also, augmentation is necessary to cope up with the need.

1.12.4.4 Indian System of Medicine (ISM) and Homeopathy may be suitably developed and popularised, specially in rural area so that ISM is considered by the people as alternate source of medical facilities.

1.12.5 **General Science**

1.12.5.1 The present growth of education in general science is adequate to meet the demand of this category of personnel upto 2000 AD.

1.12.5.2 Considering the ever increasing tendency of imbalance between States in regard to the manpower need and availability of B.Sc. degree holders there is a need to augment the educational system in various States. In Gujarat, Karnataka and smaller States/UTs enrolment capacity at degree level of science is required to be augmented. In other States more stress is needed to be given to qualitative improvement ensuring properly trained manpower to cope with the technological advancement. Besides, economic planning of the States may be reoriented in such a way that the wastage of trai-

ned manpower is avoided.

1.12.5.3 For M.Sc. also enrolment capacity is needed to be increased in Gujarat, Karnataka and smaller States & UTs. Besides, educational system of M.Sc. is required to be reoriented so that demand in specialised disciplines, which is bound to increase in future, is fully met. Such specialised disciplines are Geology, Marine Biology, Genetics and Plant Breeding, Bio-Chemistry, Geophysics, Applied Physics and Applied Mathematics.

1.12.5.4 In regard to Ph.D (Science), Shortage is expected in six major States namely Bihar, Gujarat, Karnataka, Kerala, Madhya Pradesh and Maharashtra as also smaller States/UTs while in Andhra Pradesh, Orissa and Uttar Pradesh surplus of manpower is expected. Considering the above, facilities of Ph.D (science) Research may be augmented in almost all the States excepting Andhra Pradesh, Orissa and Uttar Pradesh.

1.12.6 **Research & Development**

1.12.6.1 Currently India's expenditure on R & D and related S & T activities is about 1 percent of G.N.P. The rapid growth of expenditure in recent past reveals that it may grow to 2 to 3 percent of GNP by 2000-01. Considering a moderately higher growth rate of economy, (5.5 percent in 1995-96 and 6 percent in 2000-01) R & D activity is expected to provide employment to around 68.2 thousand Ph.Ds, 111.0 thousand of post graduates, 81.7 thousand graduates and 31.9 thousand Diploma holders by 2000-01.

1.12.6.2 The growth rate of expenditure on R & D in Private Sector Industries is much lower (one fourth) than that of Public Sector Industries even after providing some incentive like tax incentives in Income Tax Act, and liberalised import policies on import of equipment, Component and raw materials for the use of in house R & D in the industrial units. Although the provisional expenditure in 1986-87 shows much improvement in private sector

investment, no inference can be drawn till final figures on expenditure for 1986-87 is available.

1.12.6.3 In order to promote R & D activity in Private Sector industries, establishment of in-house R & D activity may be made compulsory for units having production valued Rs.2 crores and above and minimum allocation of funds for R & D may be fixed at 0.5 percent of the sales turnover.

1.12.6.4 Incentives may also be provided to those industrial units whose R&D achievement in terms of number of papers published or seminars attended exceeds certain minimum norms to be fixed by the Govt.

1.12.7 **Managing Brain Drain**

1.12.7.1 Since Brain Drain is considered to be a source of national loss, it will be useful to manage it in the best possible manner, both in national and international interest. Brain Drain is also in some quarters described as brain bank because this is one important way by which technologies permeate and percolate into the Indian economy. A number of those, receiving training abroad, set out enterprises in India or help other enterprises in technology transfer etc. Thus a meaningful balance has to be created between need for highly skilled Manpower in India and meeting this need by controlling emigration.

1.12.7.2 The task requires a thorough analysis of emigrants by type of skills they carry with them. Also to monitor skills available with Indians abroad so that selective reverse flows are organised.

1.12.7.3 In selective areas emigration can be restricted as has been done in case of medical personnel.

1.12.7.4 Further, greater indigenisation of professional training system in skills should be attempted so that there is greater scope for use of higher skills within the country.

1.12.7.5 Some useful schemes have been set into motion for reversing Brain Drain. These need to be strengthened. The schemes included are Scientists Pool and the Super-numerary post schemes.

1.12.7.6 A scheme for interviewing scientists abroad for possible absorption into the Indian economy has also been established with the help of UPSC. But its success is yet to be established.

* 1.12.7.7 A tax on foreign exchange release can be devised which can be varied depending upon the nature of training. The tax will be high and prohibitive if similar training is available within the country and low or nil if similar training is not available in India.

* 1.12.7.8 Arrangements can also be made with receiving countries to coordinate with India in regard to their needs for skilled and technical manpower so that sufficient number of such manpower is produced and made available to developing countries for which they can provide a subsidy to selected educational institutions.

1.12.7.9 Some of these transfers of manpower can be organised under an International Labour Compensatory facility or International Fund for Educational Training.

1.12.7.10 But before specific measures are taken in this area, considerable need for further information is felt not only in terms of number of persons emigrating or emigrated but also their qualifications, their intentions and similar other qualitative parameters. These need to be established through a number of studies in the area of skilled manpower.

1.12.7.11 Inflow and outflow of manpower phenomenon is influenced by several factors working in the world system on day to day basis. It is very important to monitor these flows on continuous basis so that necessary realignments between supply and demand are brought about as early as possible.