Dr. V.G. Panse Memorial Lecture

Prof. P.K. Bose was requested to deliver this memorial lecture. The manuscript of the lecture was sent by him on 8 December, 1993, but unfortunately, his sad demise occured on 10 December, 1993. As a mark of tribute to him, the text of his lecture was read during the 47th Annual Conference of the Society at S.V. Agricultural College (APAU Campus), Tirupati on 16 December, 1993.

Chairman,
Editorial Board

Energy Strategies and population problem in India

P.K. Bose

The General President of 21st Session of the Indian Science Congress Prof. M.N. Saha said in 1938 —

"If we desire to fight successfully the scourge of poverty and want from which 90 per cent of our population are suffering, if we wish to remodel our society and renew the springs of our civilization and culture, and lay the foundations of a strong and progressive national life, we must make the fullest use of the power which a knowledge of Nature has given us. We must rebuild our economic system by utilizing the resources of our land, harvesting the energy of our rivers, prospecting for the riches hidden under bowels of the earth, reclaiming deserts and swamps, conquering the barriers of distance."

The growing world population is a major threat to human civilisation as well as stability and progress. Problems of natural resources and protection of the environment would only get accentuated with rapid population increase. Deprivation of large numbers of people would also result in social and political problems. For instance, it is inconceivable that large slum areas and urban masses unable to find fuel supplies to cook two square meals a day would remain passive and immobilised politically. Nor can one expect to bridge a growing gap between urban and rural areas, where the very livelihood of farmers depends on use of larger quantities of energy to attain higher agriculture yields, today more than ever before. Those who are still deficient in energy supplies for the basic needs of cooking and lighting would not continue to accept their lot silently and unagitated. Even in aggregate terms it can be seen that if the 5.3 billion people who lived on this planet in 1990 were to be supplied 2.5 KW per capita, a total of 13.2 TW would have been required for the world's population. In essence, therefore, we have to find options which would require investments in alternatives not fully tapped thus far. If we were to fuel the world with available resources of energy, it would be seen that this planet has a large resource of diverse energy forms which can be tapped if the technology to provide energy for a wide range of end uses could be developed effectively. An estimate of world energy resources is provided in Table 1.

Table 1. Stock Resources (Non-renewables)

Resource	Probable remaining recoverable resources (terawatt-years)	
	United States	World
Petroleum	40	600
Natural gas (conventional)	40	400
Coal	1,000	5,000
Heavy oils, tar sands, unconventional gas	200?	1,000?
Oil share	5,000	30,000
Uranium (in conventional reactors)	200	2,500
Uranium (in breeder reactors)	200,000	3,000,000
Lithium (for kst generation fusion)	140,000,000 (oceans)	
Deuterium (for 2nd generation fusion)	250,000,000,000 (oceans)	

The challenge really is of mobilisation of capital, both human and financial on an unprecedented scale. Here again one runs into a serious problem of constraints in the ability of poor countries to mobilise savings on a large enough scale to bring about investment in R and D, demonstration projects as well as in large scale expansion of energy supply systems.

Energy strategies in the developing countries have to deal with a totally different set of challenges than in the developed world. Energy developments in the Third World have to be viewed as an instrument of economic development. On the other hand, in several developed countries, the problem is really one of bringing about an adjustment as a state of mal-development, implying a pattern of consumption of goods and services which in the net imposes major burdens globally on our ecosystems and natural resources.

Yet if we have to worry about the future of humanity and sustainable development for all communities living on this planet, then we have to be concerned with the future scenarios of energy production and use in different parts of the world. The World Energy Conference in the recent study dealing with global energy perspectives for the period 2000–2020, points to the changing share of energy consumption in different parts of the world. Whereas the developed countries of the North accounted for over 75 per cent of the world's total energy consumed in 1960, this share had changed to a little over 70 percent by 1985, and is expected to reduce further to less than 60 per cent by the year 2020, based on both the scenarios considered in the WEC study. This distribution must be seen in the context of the distribution of population in the world with almost three quarters of humanity living in the developing countries, and the prospect of this ratio changing to four-fifths by the year 2020. Even the most optimistic forecasts of a more egalitarian distribution of energy use throughout the world would still leave a per capita energy consumption level substantially higher in the countries of the North than in those of the South. In fact, the gap in per capita consumption levels is likely to grow as brought out by the WEC report, even if we assume a higher growth scenerio for the developing than for the developed countries.

The economic and social compulsions favouring a larger share of electricity for rural populations are also very strong. Tables 2(a) (b) and (c) show standard of living indicators for a number of countries in the world. These merely provide aggregate indicators of what is already known qualitatively in terms of large disparties in food intake between developed country and developing country populations. For instance, as against a calorie intake of 3,682 in the US, the per capita calorie intake in Bangladesh is only 1,804. Higher food production, therefore, represents the most important challenge facing developing country governments and policy-makers. Major increases in agricultural productivity are to be brought about for two reasons, *viz.*

1. A large section of the population in developing countries has still not benefited from the Green Revolution, and rural income and agricultural productivity, therefore, remain very low. Consequently, returns from higher productivity, are substantial, and the availability of fertilisers, energy for groundwater irrigation, larger use of tractors, etc., are, therefore, critical.

2. Several countries in the Third World have limited land areas for agricultural production. Any further increases in land under cultivation would only take place through greater deforestation, which is already a serious problem. In fact, one important strategy for afforestation lies in the adoption of tree growing by farmers, which would involve some diversion of land from agriculture to forestry. Consequently, productivity increases in agriculture are the only means by which pressure on land under forests can be reduced and by which afforestation measures can be accelerated.

The progress of energy use in rural areas is constrained by a number of infrastructural and economic limitations in the developing countries. Consequently, the extension of electricity grids and power lines does not immediately result in increases in electricity consumption. In the initial stages it is the innovators, the rich farmers and those with other advantages that essentially are able to benefit from the supply of electricity. It is the low income and small farmers who generally come on stream subsequently. These potential consumers are constrained not by attitudinal barriers but because of a lack of credit and other inputs, and consequently, inability to make the initial investments necessary to use electricity. In fact, the popular belief that small farmers are slow in accepting new agricultural technologies has no basis. A survey carried out in the early eighties clearly established that the small farmer is as receptive to technology changes as his larger counterpart. It is, therefore, to be expected that the demand for electricity would grow as credit facilities are extended to smaller farmers, crop insurance benefits are universalised and the availability of chemical fertilisers is increased.

The fear of large energy demand increases in the developing countries in the future based on their projected growth of population is, of course, fully justified. Often this leads to a clamour for strong population control policies, which in any case are in the interests of the developing countries themselves and the economic welfare of their societies. Effective population control programmes, however, imply a change in the fertility behaviour of the societies concerned. Such change can only come about with the extension of health care and methods for ensuring child survival, increase in income, spread of education and literacy and the growth of employment opportunities. Of course, all these would materialise through a larger use of energy, whether one is concerned with adult literacy programmes requiring lighting and illumination, or provision of medicines and vaccines, etc., involving refrigeration and extension of health care services, which would require greater transportation, communications, infrastructure and consequently energy use.

Population and Energy – The Indian scene

More than 150 years from now Malthus propounded a doctrine which states that increase in population in a given area beyond a certain point entails increase of poverty and ultimately reaches a maximum beyond which further increase is rendered impossible by starvation. We should admit that it is in part true especially for India, although it is necessary to disentangle the true and false parts, therefore the question of revalidation arises.

If we look at the direct linkages between population and energy in India, one is confronted by three sets of concerns. The first set deals with sheer increase of population as a whole and the macro implications that these would have for total consumption and supply of energy , as well as the resources that would have to be found to ensure the requisite level of supply. The second set of concerns, which is a sub-set of the first, but it is by far the most frightening in terms of social and political implications, is the future scenario of urbanisation that India is facing. The third set which qualifies for separate treatment, only by virtue of its very specific nature, is the problem of meeting the very basic energy needs of a growing rural population, much of which would remain outside the market, relying heavily on supply of biomass energy.

Nature and implications of population in India

The growth in Indian population gathered momentum in the last few decades. It can be seen from Table 4.1 that natural growth rate during the decade 1941–51 was only 1.25 per cent per annum, and had remained at much lower levels during the earlier decades of this century. The growth rate started increasing rather fast after 1951 and reached a peak of 2.22 percent during the decade 1971–81. It is tempting to think that if only India had succeeded in containing her population growth rate after 1951 to around 1 percent per annum *i.e.*, the rate China has achieved, how much difference this factors alone would have meant in terms of per capita income, consumption and levels of living.

On the assumption that the family planning efforts will be turned into an effective people's movement during the Eighth and the Ninth Plan, the Standing committee of Experts on population Projection has estimated that the annual growth rate of population during the period 1991–96 would be 1.81 per cent which will further come down to 1.65 per cent during 1996–2001. The 8th Plan (1992–97) envisages a population growth rate of 1.78 per cent per annum. As per these projections the Indian population will grow from 844 million in 1991 to 925 million in 1996, 1006 million in the year 2001 and 1102 million in 2007 (Table 4.2). The net Reproduction Rate (NRR) will equal unity only during 2011 to 2016, that is 5 years later than was expected at the time of presenting the Seventh Plan. The goal of stabilising population (Zero population growth, ZPG) has thus shifted further in time. India's fertility and mortality levels and the age distribution of the population are such that even after attaining NRR=1 by the year 2011–2016, the population would stabilise (*i.e.*, achieve ZPG) only towards the end of the 21st Century.

The major states of India may be arranged into four groups according to the probable stage of demographic transition indicated by the trend in the growth rate since interstate migration is negligible compared to the growth of population. Group–A states are in the earliest stage of transition with possibly stable fertility and declining mortality and therefore increasing growth rates over the decades. Group–B states are in the next stage of transition with possible declines of both fertility and mortality leading to a slight increase of growth rate. Group-C states are further advanced in the transition, the decline in fertility has possibly caught up with the decline in mortality resulting in decline of growth rate. The Group-D states are foremost in the transition, possibly with large mortality and compensating fertility resulting in a declining growth rate below 2.00 per cent.

Based on this approach, the following objectives will be accorded priority :

(i) Generation of adequate employment to achieve near full employment level by the turn of the century.

(ii) Containment of population growth through active peoples co-operation and an effective scheme of incentives and disincentives.

(iii) Universalisation of elementary education and complete eradication of illiteracy among the people in the age group of 15–35 years.

(iv) Provision of safe drinking water and primary health care facilities, including immunisation, accessible to all the villages and the entire population, and complete elimination of scavanging.

(v) Growth and diversification of agriculture to achieve self sufficiency in food and generate surpluses for exports. And the last but not the least,

(vi) Strengthing structures of infracture energy, transport, communication, irrigation in order to support the growth process on sustainable basis. Here in the article we shall come on energy because we feel that it is an important component.

Energy Pools of Earth

The principal energy pools of the earth from which we draw energy, originate from the sun and the earth acting separately and in conjunction. The nuclear fuels – uranium and thorium are found in earth's crust. In some regions of the earth there are other sources of energy which are classed as geothermal energy (volcanoes, hot rocks and hot springs). The earth, in conjunction with the moon, produces tides and tidal currents. The atmosphere of the earth heated by solar radiation generates winds, which also have served the energy needs of man. In the materials deep within the earth, man has looked for fuels. We are searching for a technology to liberate energy out of earth's water by the fusion process and also for a technology for cheap production of hydrogen, the emerging fuel. But in the immediate past, far more important were the pools created by the sun. We have seen how nature has worked out wonderful conversion mechanisms to store solar energy in the living bodies. The living bodies, after death and passage of millions f years, are converted under suitable conditions into the fossil fuels, which have been our main energy source so far. We are considering also how we can ourselves transform solar energy to a form directly and immediately useful to us. Some of the pools – the pools of fossil fuels and the nuclear fuels, are of limited dimension and therefore of limited duration. The biological pools like those derived from the forests and the vegetables and the animal wastes are replenishable. Other pools, which depend on earth's internal heat and sun's radiated energy, are eternal for all practical purposes.

In India coal occurs in two stratigraphic horizons– (1) the lower Gondwanas of the permian age, and (2) the coal and lignites of the Tertiary age. The Gondwana coals are set in the basin like depressions of older formations and are aligned along four main river valleys : (i) Damodar-Koel, (ii) Sone-Mahanadi, (iii) Pranhita-Godavari and (iv) Satpura basin. Outside these river basins are the coal fields of Rajmahal Hills and the Deoghar group. All these are found in the golden triangle defined by the 24°N latitude line, 78°E longitude line to 16°N latitude and then to 88°E. These are the basic processes, and many production methods are on the trial or in course of development. The idea is to enrich the methane content of the gas produced, or alternatively to extract the hydrogen itself as the output fuel. The main systems are (1) hydrogasifier systems, (2) steam-iron systems and (3) electrothermal systems. There are three basic ways to liquify coal : (1) addition of hydrogen, (2) depletion of carbon (pyrolysis), and (3) breaking coal down to individual carbon atoms and resynthesising to the desired liquid fuel. In this area intense global R and D work is going on, and in India also we must immediately intensify the research already started. Sri J.C. Ghosh had initiated a number of studies on this subject by a number of committees of the Government. We may mention some projects which are going on abroad; coal gasification Atgas, Bigas, Cogas, Hygas, Hydrane, Synthane, coal liquefaction, COED, CONSOL, H-coal process, Hydrosulphurisation, Meyers process, solvent refined coal process, Synthoil.

Oil and Natural Gas : Petroleum is the general name of the liquid form of fossil fuels. Decay of plants and animal matter in ancient marine environments in course of million of years gave rise to oil and natural gas.

Oil prospecting technology is very sophisticated, employing sesmic and magnetic measurements for detection of rock structure formations, which arre capable of bearing oil deposits. The technology is so well developed, that it is possible to prospect and extract oil from the deposits on the continental shelves and deep oceans. Recently satellites like Landsat are being used for oil prospecting by remote sensing methods.

In India the petroleum geologists have marked 27 basins on land and offshore- a sedimentary area of about 1.41 M Km^2 on land, and 0.26 M Km^2 laying within 100 m isobath of offshore shelf zone. Most successful has been the exploration and oil extraction in Assam-Arkan area and the Cambay basin. In the later basin, the recently discovered oil deposits in Gujarat and the Bombay high structure are well known. The rate of discovery of new oil deposits seems encouraging.

Oil recovery technology is very well developed. In the primary method, oil is driven out of the well by the pressure of the deposits inside the well. Other methods are : (1) stimulation by fluid injection, (2) reduction of viscosity of oil by mixing with gases and surfactants, (3) thermal stimulation by steam injection, (4) underground ignition and (5) acidisation. Nuclear stimulation has been tried in USA to fracture oil bearing rocks, but public opinion, there, is against this technology.

Products from oil refineries are vital in the economy : liquid petroleum gas (LPG), gasoline, kerosene and air turbine fuels, gas oils, high speed diesels (HSD), light diesel oil (LDO), fuel/furnace oils, lubricating oils and greases, and petroleum coke are some of the petroleum products. Because of the convenience of use and easy and cheap availability prior to the OPEC embargo in 1974, there was a dramatic global switch over from coal to oil in the sixties, and India also followed suit. In absence of oil all these products must be substituted by coal derived products.

According to an estimate by ONGC made in 1978 the total resources of oil and natural gas, including the reserves, the submarginals and the inferred resource are shown below :

Indian Oil and Natural Gas

Oil (GBbl)	*Natural gas (Tft)*
2.06 GBbl = 282 MT	3.4

WAES[2] gives the global reserve of oil as follows

Global Oil and Natural Gas

Oil	*Natural gas*
Proven reserve	Proven reserve
(GBbl)	(Tft)
658	2352

Energy is an essential input for economic development and improving quality of life. India's per capita consumption of commercial energy (viz., coal, petroleum and electricity) is only one–eighth of global average and will increase with growth in Gross Domestic Production (GDP) and improve the standard of living.

Government has formulated an energy policy with objectives of ensuring adequate energy supply at minimum cost, achieving self- sufficiency in energy supplies and protecting environment from adverse impact of utilising energy resources in an injudicious manner. Main elements of the policy are :

(i) accelerated exploitation of domestic convenitional energy resources – oil, coal, hydro and nuclear power,

(ii) intensification of exploration to increase indigenous production of oil and gas,

(iii) management of demand for oil and other forms of energy,

(iv) energy conservation and management,

(v) optimisation of utilisation of existing capacity in the country,

(vi) development and exploitation of renewable sources of energy to meet energy requirements of rural communities,

(vii) intensification of research and development activities in new and renewable energy sources, and

(viii) organisation of training for personnel engaged at various levels in energy sector.

Development of conventional forms of energy for meeting the growing energy needs of society at a reasonable cost is the responsibility of Government *viz.*, Departments of Power, Coal, Petroleum and Natural Gas Development and promotion of non- conventional/alternate/new and renewable sources of energy such as solar, wind and bio-energy, etc., are also getting sustained attention. Nuclear energy development is being geared up by the development of Atomic Energy to contribute significantly to overall energy availability in the country.

The problem of energy now dominates all our thoughts and actions. We know that much of the energy pools from which we have been drawing our sustenance are of finite dimensions and would perish very soon. Hence the problem of energy needs multidisciplinary treatment.

The Eighth Plan (1992–97) is being launched at a time which marks a turning point in both international and domestic environment.

Infrastructure

Among the main components of infrastructure, energy needs particular attention during the Eighth Plan mainly because of the fast growing demand, the limits of our internal sources of energy and implications for balances of payments. The medium form energy plan has to be seen only as a component of a long term plan. It is only in the perspective of such a long term plan that a view about priorities and relative emphasis on use of petroleum based energy vis-a-vis coal and hydro based energy will emerge and will have to be pursued right from now through the Eighth Plan. While planning for energy development equal emphasis will have to be given to improve the performance of the existing plants by enforcing higher efficiency norms.

The goals in the energy sector, inter alia, envisage elimination of power shortages in different parts of the country, achievement of a minimum hydel share of 40 per cent in the total installed capacity by the end of the Ninth Plan, restraining the growth in consumption of petroleum products.

Energy Planning

Efficient use of resources and long-term sustainability are the two important objectives of economic planning. The short and medium term strategies of energy planning will have to reckon with the available resources and the technological constraints that are prevalent in the system.

Seventh Plan Outlay on Energy

(Rs. Crore)

	Energy	Seventh Plan outlay 1985-90	Annual Plan 1985-86 Actuals	Annual Plan 1986-87 Actuals	Annual Plan 1987-88 R.E.	Annual Plan 1988-89 outlay
1.	Power	34,273.46	5,615.53	6,701.45	7,437.70	9,584.08
2.	Petroleum	12,935.37	2,935.64	3,382.03	3,414.99	3,394.56
3.	Coal and Lignite	7,400.58	995.04	1,233.05	1,280.97	1,733.00
4.	Non-conventional sources of Energy	519.55	132.76	141.87	118.87	135.68
	Total	55,128.96	9,678.97	11,458.40	12,252.53	14,847.32

Source – India 1988-89, p.337.

The demand for energy in the economy arises mainly from the requirements of lighting and cooking in the household sector, irrigation and other agricultural operations, transport of passengers and freight, fuel and feedstock requirements in the industry and from the energy input needs of various other related activities of the services sector. A sizeable share of these requirements is met from non-commercial sources, especially those of the rural household sector. The traditional sources of energy include fuelwood, crop residue and animal waste. The levels of efficiency at which useful energy is presently being realised from the resources are very low, varying between 10 to 15 per cent. However, non-commercial energy resources are steadily getting replaced by coal, oil, and electricity which provide energy of a much higher quality and efficiency and involve at the same time high capital cost.

Energy Strategy for the Future

Against the above background, it is desirable to adopt a long- term energy strategy which is consistent with sustainable development. Such a strategy should ensure that the highest priority is accorded to meeting fully the basic energy needs of the rural and the urban poor in the immediate future. It should also ensure gradual shift from non-renewable resources to renewable ones with increasing emphasis on demand management, conservation and efficiency. The short-term, medium-term and long term priorities should accordingly be as follows.

Short-Term

1. Maximise returns from the assets already created in the energy sector.
2. Initiate measures for reducing technical losses in production, transportation and end-use of all forms of energy.
3. Initiate action to reduce the energy intensity of the different energy consuming sectors of the economy and promote conservation, demand management through appropriate organisational and fiscal policies.
4. Initiate steps meeting fully the basic energy needs of the rural and the urban households, so as to reduce the existing inequities in energy use.
5. Maximise satisfaction of demand for energy from indigenous resources.

Medium-term

6. Initiate steps towards progressive substitution of petroleum products by coal, lignite, natural gas and electricity so as to restrict the quantum of oil imports to the current level.
7. Initiate action for accelerated development of all renewable energy resources, especially the available hydro-electric potential.
8. Promote programmes to achieve self-reliance in the energy sector.
9. Promote R and D effort on decentralised energy technologies based on renewable resources.
10. Initiate appropriate organisational changes in the case of different energy sub-sectors consistent with the overall energy strategy.

Long-term

11. Promote an energy supply system based largely on renewable sources of energy.
12. Promote technologies of production, transportation and end-use of energy that are environmentally benign and cost efficient.

The Eighth Plan programme of energy development will be so oriented as to be consistent with this strategy.

Table 2 (a)[2]
Standard of Living Indicators

Country	Per Capita GNP 1986 (US $)	Per Capita daily intake		
		Fats (grams)	Proteins (grams)	Calories
India	290	36	54	2,126
Australia	11,920	137	101	3,302
Bangladesh	160	19	41	1,804
Brazil	1,810	58	61	2,567
Burma	200	44	70	2,508
Canada	11,120	154	96	3,443
China	300	41	62	2,620
Egypt	760	81	81	3,275
France	10,720	136	111	3,358
Germany (W)	12,080	149	101	3,519
Iran	n.a.	n.a.	n.a	3,115
Israel	6,210	114	99	3,019
Italy	8,550	137	108	3,493
Japan	12,840	85	88	2,695
Kenya	300	36	59	2,214
Korea, Republic of	2,370	50	78	2,806
Mexico	1,860	87	82	3,126
Pakistan	350	53	59	2,180
Philippines	560	33	53	2,260
Singapore	7,410	77	79	2,696
Sri Lanka	400	51	48	2,485
Sweden	3,160	126	99	3,007
UK	8,870	143	88	3,148
USA	17,480	164	107	3,682
USSR	4,550	102	106	3,332

Source : Statistical Outline of India, 1989–90. Department of Economics & Statistics, Tata Services Limited, Bombay, India, 1989.

Table 2 (b)[2]
Standard of Living Indicators

Country	Per capita annual consumption (kg.)				Enrolment ratio in primary school***
	Sugar*	Energy*	Crude steel	News-print	
India	11.2	208	17	0.5	92
Australia	48.2	4,710	370	41.5	106
Bangladesh	2.4	46	4	0.4	60
Brazil	47.2	830	70	2.2	104
Burma	2.3	76	1	0.2	102
Canada	42.6	8,945	525	28.2	105
China	5.2	532	55	0.7	124
Egypt	33.9	577	53	0.8	85
France	@	3,610	276	10.4	114
Germany (W)	@	4,464	489	23.1	96
Iran	28.8	958	86	0.4	112
Israel	71.6	1,944	130	11.7	99
Italy	@	2,539	366	6.7	98
Japan	23.0	3,186	569	23.5	102
Kenya	19.4	100	11	0.5	94
Korea, Republic of	13.0	1,408	193	5.6	96
Mexico	44.6	1,235	113	3.8	115
Pakistan	13.9	205	7	0.4	47
Philippines	24.1	180	12	1.1	106
Singapore	49.6	1,851	789	22.2	115
Sri Lanka	16.8	139	5	1.1	103
Sweden	45.8	6,374	439	29.0	98
UK	@	3,802	255	27.3	101
USA	32.7	7,193	479	51.8	101
USSR	48.0	4,919	n.a.	4.3	106

* Centrigugal sugar expressed in raw value.
** Oil equivalent.
*** In several countries it is more than 100% becaus the actual number of primary students exceed the population in the age group 6-11 years to which it is relatd.
@ Combined EEC countries 39.3 kg.
Source : Statistical Outline of India, 1989-90, Department of Economics & Statistics, Tata Services Limited, Bombay, India, 1989.

Table 2 (c)[2]
Standard of Living Indicators

Country	Population			
	Passenger	TV set	Telephone	Physician
India	53.3	154	250	3,700
Australia	.2	2.1	2	520
Bangladesh	2,065	323	n.a.	9,690
Brazil	14	5.3	13	1,300
Burma	751	1,250.0	n.a.	1,930
Canada	2	1.8	1.5	550
China	4,189	102	200	1,730
Egypt	53	12	67	760
France	3	2.5	2	460
Germany (W)	2	2.6	2	420
Iran	467	18	19	2,900
Israel	7	3,8	3	400
Italy	3	2.6	2	750
Japan	4	1.7	2	710
Kenya	160	185	77	10,120
Korea, Republic of	87	5.3	6	1,390
Mexico	15	8.5	11	1,210
Pakistan	266	67	167	2,910
Philippines	148	28	67	6,850
Singapore	11	4.7	3	1,100
Sri Lanka	110	36	143	7,460
Sweden	3	2.5	1.1	410
UK	3	1.9	2	680
USA	2	1.2	1.3	500
USSR	28	3.1	10	270

Note : Data relate to the latest available year which may not be the same for all the countries and for all the columns. In most cases they relate to years between 1982 and 1986. Figures for India, as for other countries, are taken from publications of the United Nations and the World Bank, and may not tally with those shown elsewhere.
Source : Statistical Outline of India, 1989-90, Department of Economics & Statistics, Tata

Table 3[2]
Agricultural Indicators — An International Comparison

Country	Economically active population in agriculture as % of total	Arable lands (million hectares)	Per capita arable land* (hectares)	Fertisiler consumption per hectare of arable land* (kg)
India	61	169.5	0.21	39.4
Bangladesh	83	9.1	0.10	59.6
China	57	100.9	0.10	180.6
Pakistan	52	20.3	0.22	58.6
Sri Lanka	52	2.2	0.14	71.3
Burma	50	10.1	0.27	16.7
Egypt	49	2.5	0.06	360.5
Philippines	44	11.8	0.23	32.0
Brazil	36	74.7	0.58	36.5
Iran	36	13.7	0.34	65.6
Korea, Republic of	35	2.2	0.05	345.2
Mexico	34	23.5	0.32	61.2
USSR	15	232.3	0.86	98.7
Italy	10	12.4	0.22	168.9
Japan	9	4.8	0.04	137.0
France	8	18.6	0.34	311.6
Israel	6	0.4	0.10	183.1
Canada	4	46.2	1.87	48.7
Germany (W)	3	7.5	0.12	421.1
UK	2	7.0	0.12	374.6
USA	2	190.6	0.82	104.5

* Including area under permanent crops.
** Data relate to 1982 to 1983.
Source : Department of Economics & Statistics (Tata Services Ltd.), *Statistical Outlines of India*, 1986–87, June 1986.

Table 4.1. Dynamics of Population Growth : 1901–1991.

Period	Population at the end of the period (as on 1st March)		Growth Rate 9%		Vital Rates per 1000 Population		
	Total (million)	Urban (%)	Decadal	Annual (Exponential)	Birth Rate	Death Rate	Natural Growth Rate
1	2	3	4	5	6	7	8
1901–11	252.09	10.29	5.75	0.56	49.20	42.60	6.60
1911–21	251.32	11.18	–0.31	–0.31	48.10	43.60	–0.50
1921–31	278.98	11.99	11.00	1.04	46.40	36.30	10.10
1931–41	318.66	13.86	14.22	1.33	45.20	31.20	14.00
1941–51	361.09	17.29	13.31	1.25	39.50	27.40	12.50
1951–61	439.23	17.97	21.51	1.96	41.70	22.80	18.90
1961–71	548.16	19.91	24.80	2.20	41.20	19.00	22.20
1971–81	683.33	23.34	24.66	2.22	37.20	15.00	22.20
1981–91	844.32	25.72	23.56	2.12	32.50	11.40	21.10

Note : (1) The 1981 Census Population total has been revised in the light of the 1991 Census results.

(2) The 1991 Census figure includes projected population of Jammu & Kashmir.

(3) The Vital Rates except for 1981–91 have been calculated from the Census of India data by Reverse Survival Method.

(4) Vital Rates for 1981-91 have been calculated using Sample Registration System data.

Table 4.2 Population Projections.

Period	Population at the end of the period (as on 1st March)			Average Expectation of the birth		Birth Rate	Death Rate	Growth Rate	General Marital Fertility Rate (Per 1000 Married Women
	Total (millions)	Urban (millions)	Urban popln. as % of total popln.	Male	Female	(per 1000 persons)			
1	2	3	4	5	6	7	8	9	10
1991–96	925.13	257.36	27.82	60.60	61.70	27.50	9.40	18.10	160.80
1991–97	941.37	266.57	28.32	61.05	62.20	27.00	9.20	17.80	157.50
1996–2001	1006.98	306.87	30.50	62.80	4.20	24.90	8.40	16.50	144.50
2001–2006	1085.98	363.64	33.48	64.80	65.80	23.00	7.80	15.20	132.30
2006–2011	1164.25	425.73	36.57	67.05	68.30	20.90	7.10	13.80	120.90

Source– Report of the Standing Committee of Experts on Population Projections (1989).

Notes (1) The projections have been adjusted in the light of the 1991 Census results, particularly in case of Urban Population.

(2) For 1992-97, 2006-2011 : projections are based on similar assumptions as adopted by Standing of Experts Population Projections (1989).

Table 5. World Population and Energy, 1850–1990.

Year	World population (billions)	Energy use per person (KW)		World energy use (TW)		Total	Commu-lative use of industrial energy forms since 1850 (TWy)
		Industrial forms	Traditional forms	Industrial forms	Traditional forms		
1850	1.13	0.10	0.50	0.11	0.57	0.68	0.0
1870	1.30	0.16	0.45	0.21	0.59	0.79	3.2
1890	1.49	0.32	0.35	0.48	0.52	1.00	10.1
1910	1.70	0.64	0.30	1.09	0.51	1.60	25.7
1930	2.02	0.85	0.28	1.71	0.56	2.28	53.7
1950	2.51	1.03	0.27	2.58	0.68	3.26	96.6
1970	3.62	2.04	0.27	7.38	0.68	8.36	196.3
1990	5.32	2.19	0.29	11.66	1.54	13.20	386.7

PROCEEDINGS OF THE SYMPOSIUM ON "STATISTICAL ASPECTS OF DIFFERENT CROPPING SYSTEMS"

Chairman : Shri J.S. Sarma*

Convenor : Dr. P.R. Sreenath¤

At the outset, Prof. Prem Narain, Secretary, Indian Society of Agricultural Statistics welcomed the participants and the speakers. He requested Shri. J.S. Sarma, former Economic and Statistical Advisor, Ministry of Agriculture, Government of India to chair the session. Having introduced the Chairman and the Convenor to the participants Prof. Prem Narain highlighted the imprtance of the topic for the symposium for meeting the requirements of the recent priorities in the Agricultural Research.

The Chairman, in his opening remarks, dwelt on the complexities of the cropping systems research including the collection of data and its statistical analysis for arriving at sound results taking into account the sustainability of the system, its effect on the environment and several other related issues. The invited speakers were then requested to present their papers.

In all, seven speakers i.e, Dr. G. Nageswara Rao, Dr. P.R. Sreenath, Dr. D.M. Hegde, Dr. N. M. Patel, Dr. P.B. Parthasarathy, Shri. C.K. Ramanatha Chetty and Shri. U.M. Bhaskara Rao presented their papers in this sequence. Abstract of the paper received from Shri. P.N. Soni was circulated. While the first two presentations related to intercropping system, the next three dealt with problems relating to multiple cropping and rotation experiments. The last two presentations were on Agroforestry system. Presentations of each group of papers was followed by brief discussions with the participants taking keen interest.

The following recommendations emanated from the presentations, discussions and the Chairman's observations.

There is no single standard method available for the analysis of data from cropping systems and hence such data need to be subjected to several analyses.

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