Population and Economic Growth as Drivers of Future Land Use in India

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Neeraj Sharma[1]

INTRODUCTION

With the world moving into a new millennium, the focus, concerns and confabulations across the globe centre on the direction of various components of well being in the next few decades. This includes development, production, as well as the environment we live in. This is so because we have just one 'World' and by the most conservative estimates the countdown to finality may already have been set in motion by man or to put mildly by the 'dynamic forces of Nature'.

This chapter presents a perspective on the challenges facing India in terms of population and economic growth and future land use patterns. It argues that, for a developing country like India, the future land use patterns are likely to be decided by the growth in population and economy over the next few generations. Climate change, agriculture and land use are so much interdependent that, in our context, a change in one of them would have effects on the other two parameters. These changes are likely to result in a transition to the next level of development. In this chapter, we shall discuss the present status of India's population, projections for selected years up to 2050. Then we shall discuss the current state of food availability and projections of demand and supply of food grains up to 2050. And finally, an attempt has been made to see whether the food supply would be able to keep pace with increasing population and economic growth. In the last sections the implications of change in climate, future land use patterns and agriculture is examined.

The background

In today's global scenario India accounts for nearly one sixth of the world's six billion people and only about 2% of the world's area. Over the last five and a half decades, since India gained independence, its population has increased at a very rapid pace – growing nearly two and a half times since 1947. India's investment

[1] The views expressed in the chapter are the author's alone. Usual disclaimers apply.

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in agricultural research and development coupled with contributions from international scientific collaborations especially in agriculture in the early sixties and also trade, to a limited extent, has helped it feed the burgeoning population. On a macro scale, India is self sufficient in food grain production However, such self sufficiency may not necessarily continue into the future. A growing population and economy exert pressures on production inputs - the most critical of them being land. New agricultural technologies and increased rural incomes are likely to change food demand and rural living patterns in the coming decades. Food demand will be determined by population distribution in different income groups. This in turn, would affect land use patterns and demand for agricultural resources. There has already been a shift in cropping and consumption patterns since the mid-sixties. The chapter, as stated earlier, examines trends in food demand, cropping patterns, and trade in terms of resulting land use, food production, and environmental attributes. The analysis is done for India, which will support nearly one sixth of world population by 2050.

POPULATION GROWTH

India was the first country in the world to adopt a programme to reduce birth rates aimed at stabilizing population 'consistent with the requirement of the national economy.' Ironically the programme could not achieve the desired results in the early decades of its implementation. Replacement level fertility is estimated to be achieved by 2026. Yet, because of population momentum, the population will continue to grow for some more time. Mukhopadhyaya (2000) observed that during 1901-1921, the population of India increased from 238 to 251 millions, in subsequent three decades the annual exponential growth rates were above 1%. After 1951 the population exhibited an average annual growth rate of around 2%. The second half of the twentieth century witnessed India's population increasing from 361 million in 1951 to 964 million in 1998.

While global population has increased threefold during this century, from 2 billion to 6 billion, the population of India has increased nearly five fold. India's current annual average 15.5 million people population increase is large enough to neutralize efforts to conserve the resource endowment and environment (Government of India, 2001) and most of the increase in food grain production has been absorbed by population growth. The growth rate of population has slowed down from 2.1% per annum in 1980s to 1.7% in the 1990s.

As India could not reduce its population growth to desired levels, the National Health Policy, 1983, set more specific goals. It stated the long-term goal of Net Reproduction Rate of unity (NRR = 1.0) by the year 2000 AD. This goal corresponds to a family size of 2.1, crude birth rate of 21, crude death rate of 9 and natural rate of population growth of 1.2% per annum. It would require a contraceptive prevalence rate of 60%.[2]

India's population was 361.6 million in 1950-51, which increased to 683.3 million in 1980-81 and to one billion in May 2000. The birth rate and death rate

[2] United Nations Fund for Population Activities, (www.unfpa.org.in/Publications/FOOD/populationpress.htm)

were 39.9 and 27.4 in 1950-51, which came down to 33.9 and 12.5 respectively in 1980-81 and to 26.4 and 8.8 respectively in 1998-99. The fall in death rate is explained by better availability and access to medical facilities coupled with increased availability of food grains. If current trends continue, India will overtake China by 2045 to become the most populous country in the world.

Population projections

India's population growth rate has continued to decline since 1971. It came down from a high of 2.25% per annum in the 1970s to 1.69% in the late 1990s. The growth rate is expected to decline further with projections it will approach 0.92% by 2020. Numerous attempts have been made to estimate population at different points in the future. The India Vision 2020 Document considered two alternate scenarios for achieving population stabilization. In their optimistic scenario, based on achieving the demographic goals of National Population Policy 2000, life expectancy is assumed to rise to 71 for males and 74 for females by 2020. Under their realistic scenario, life expectancy is assumed to reach 65 for males and 69 for females by 2020. Under either scenario India's population would exceed 1.3 billion by 2020.

The growth rate of population is expected to be positive (0.33%) even in 2051 (Kulkarni, 2000) compared to growth rates of nearly 2% during 1980s and 1990s. The projected size of the population in 2051 is 1,646 million, an increase of nearly 95% over that in 1991. This makes the doubling interval about 60 years. Lower fertility rates would mean that the rate of growth of population shall be lower.

Projections for different age groups (Table 8.1) show that the 15-64 year age group will have expanded by 46% by 2020. The dependency ratios of the population shall also change and shall be lower at 46% than 67% which prevailed in the year 2000. Dependency ratio is a measure of the portion of population which is dependent (either because they are too young or too old to work) on the working population. The dependency ratio is equal to the number of individuals aged below 15 or above 64 (economically dependent) divided by the number of individuals aged between 15 and 64 (economically productive), expressed as a percentage. The World Development Report (1984) projects population to reach 1,522 million by the year 2050. The population growth rate during 1991-2000 was calculated using the figures of 846.6 and 1,000 million respectively which came to 1.85[3]. It was then assumed that there shall be a reduction in this rate of growth by 0.3% in every decade. This gave a population size of 1168.2 million in the year 2010. The background paper for the Tenth Plan states that the population of the country is expected to grow from 1,027 million in 2001 to 1,409 million in 2026 and to 1,628 million by 2051 (Srinivasan and Shastri, 2002).

The difficulty is that depending on the requirements and objectives of their studies, different researchers have estimated population size for different years in future. For simplicity the target years taken in this study are 2020 and 2050. The population estimates in this chapter have been assessed more from the point of

[3] Natural rate of growth was calculated using the formula $a=be^{it}$ where i=growth rate and t=time period.

view of getting a reasonably good idea of its possible size rather than very accurate mathematical precision as long term projections for such a variable will be influenced by numerous factors difficult to assess and measure. Factors like education, per capita GDP etc. are themselves dependent on other variables.

Table 8.1 Distribution of population by age category for 2000 and 2020 (million inhabitants)

Age category	2000	2020
<15	45	76
15-64	604	882
>65	361	373
Total	1,010	1,331

Source: Bhat (2001).

Srinivasan and Shastri (2002) projected that the population of India would be around 1.4 billion in 2025. He goes on to state that the population size is expected to reach this mark whether India attains the goals of the National Population Policy for 2010 or not, by 2051, India's population would almost be equal to that of China's. But India's population would still be growing at a rate of 1% per annum, even though the level of fertility required for long-run population stabilization would have been achieved by then (Bhatt, 2001). The trends of population growth in India has been broadly in tune with the classical theory of demographic transition into four phases and India is supposed to have entered now in the fifth phase, of rapidly declining fertility. The point of concern is that this growing population shall exert pressure on the economy of the country as well as the environment. It is with this view that the productivity of agriculture is discussed in the following section.

Table 8.2 Projection of India's population up to the year 2050 (million)

Year	Average annual growth rate (%)	Author's projection
2010	1.55	1,168
2020	1.25	1,324
2030	0.95	1,457
2040	0.65	1,555
2050	0.35	1,611

PRODUCTIVITY OF AGRICULTURE

During the last 30 years, India's food grain production nearly doubled from 102 million tons in the triennium ending 1973 to nearly 200 million tons by 1999 (Table 8.3). Virtually all of the increase in the production resulted from yield gains rather than expansion of cultivated area. Availability of food grains per capita increased from 452 gm/person/day to over 476 gm/person/day, even as the country's population almost doubled, swelling from 548 million to nearly 1000 million (Singh, 2002b).

Table 8.3 Production of food grain between 1950 and 2002

Year	Area (million ha)	Production (million tons)	Yield (kg/ha)	% area under irrigation
1950-51	97.32	50.82	522	18.1
1960-61	115.58	82.02	710	19.1
1970-71	124.32	108.42	872	24.1
1980-81	126.67	129.59	1,023	29.7
1990-91	127.84	176.39	1,380	35.1
1998-99	125.17	203.61	1,627	42.4
1999-00	123.10	209.80	1,704	43.9
2000-01	121.50	196.81	1,626	NA
2001-02	121.91	212.03	1,739	NA
2002-03	113.13	182.87	1,614	NA

NA = not available.
Source: Government of India (2003).

The area under food grains has hovered around 125 million ha since 1970-71. This indicates that the limit to increasing production through area expansion may have been reached as far as the cultivable land is concerned.

During the period 2002-05 GDP of the country was expected to grow at a rate of about 6.5% and the population at the rate of 1.7% per annum. The demand for food grains would grow at a rate of 2.5-3%. Under such a case the observed rate of growth of agriculture production would be just enough to feed the growing population. However, to make the country hunger free the food grain production will have to be accelerated at a compound rate of 4% per annum.

Taking the above evidence into account various scenarios estimations were made (Paroda and Kumar 2000) for the year 2020. These are presented in Table 8.4. In addition, taking the set of population projections in Table 8.4, an attempt was made to work out the food grains requirements for various decades until the year 2050. This has been worked out using the assumption that with 201.56 million tons of food grains India is able to feed its population of one billion and that this ratio of production to population would feed the population at any point in the future and that consumption will not fall below this level. The present daily caloric intake in has been taken at 2,500. With increase in incomes as a result of development, this intake has been assumed to increase to 3,500 in 2050 - an increase of 40% (over the base level daily consumption of 2,500 calories) in next fifty years. This would generate additional demand for food grains as a result of better nutritional intake. The present share of animal products in daily calorie intake is about 7%. It has been assumed that over the next fifty years the share of animal products in daily calorie intake would increase to 15%. The results are presented in Table 8.5.

Table 8.4 Projected demand for agricultural commodities in 2020

Item	Average 1997-99			Demand in 2020 (million tons)	
	Area (million ha)	Production (million tons)	Yield (kg/ha)	Low growth (3.5% per capita growth of GDP)	High growth (5.5% per capita growth of GDP)
Food grains	120.8	199	1,595	255.9	252.8
Edible oil	28.6	6.4	269	10.8	11.4
Potatoes	1.2	21.6	17,188	27.8	30.6
Vegetables	5.3	74.5	14,204	135.6	168
Fruits	3.2	43	13,437	77	93.6
Sugarcane/ gur	3.7	26.9	7,006	32.6	33.7
Milk	-	71.2	-	115.8	137.3
Meat	-	5	-	8.8	11.4
Eggs	-	2,873	-	7,750	10,000
Fish	-	5.3	-	10.1	12.8

Based on Paroda and Kumar (2000).

Table 8.5 Population and food grain requirements during the period 2010–2050

Year	Population (million)	Food grain requirements (million tons)
2010	1,168	268
2020	1,324	344
2030	1,457	425
2040	1,555	506
2050	1,611	582

Bhalla et al. (1999) took the official figures for population projection for 2020 as base and considering different determinants of demand such as rate of urbanization, rise in per capita income, changes in consumption behaviour and expenditure elasticities estimated the demand for food grains. The projections are presented in Table 8.6.

Table 8.6 Estimation of food demand in India for the year 2020 (in million tons)

Year/Source	Food	Feed	Total	Average (kg/ capita/day)
1993 (actual)	147.12	3.71	150.83	0.47
For 2020				
GDP growth rate (%)				
2.0	231.51	25.75	257.26	0.53
3.7	246.08	50.11	296.19	0.61
6.0	267.21	107.52	374.73	0.77

Source: Bhalla et al. (1999).

The supply side

Given that the demand for cereals will be around 350 million tons, we now examine whether this demand is likely to be fulfilled. India has high population pressure on land and other resources to meet its food and development needs. The natural resource base of land, water and biodiversity is under severe pressure. Food demand challenges ahead are formidable considering the non-availability of favourable factors of past growth, fast declining factor productivity in major cropping systems and rapidly shrinking resource base.

Future increases in the production of cereals and non-cereal agricultural commodities will have to be achieved mainly through increases in productivity, as the possibilities of expansion of area and livestock population are minimal. Average yields of most crops in India are still rather low (Singh, 2002a). To meet the projected demand in 2020, the Indian Agricultural Research Institute estimates that yields must attain per hectare levels of 2.7 tons for rice, 3.1 tons for wheat, 2.1 tons for maize, 1.3 tons for coarse cereals, 2.4 tons for cereal, 1.3 tons for pulses, 22.3 tons for potato, 25.7 for vegetables, and 24.1 tons for fruits. The production of livestock and poultry products must be improved by 61% for milk, 76% for meat, 91% for fish, and 169% for eggs relative to 1997-9 yields.

Virtually no productive land remains uncultivated in India today, so there is little scope for increasing the area cultivated. The remaining land is relatively unproductive and bringing it under cultivation would entail high environmental costs, including deforestation and soil erosion. Future growth will therefore have to continue to depend on yield and this will require the spread of yield-enhancing technologies, improved natural resource management, and greater technical efficiency (Bhalla et al., 1999). Taking into account the constraints and likely progress being made in production, processing and storage technologies it is estimated that India would be able to meet its food requirements. However, in the estimates arrived at by Bhalla et al. (1999) there is a gap between the demand and supply of cereals in India in 2020. Their estimates are presented in Table 8.7. This effectively means that even in the case where the country's GDP grows by a modest rate of 3.7% per annum there shall be a shortage of food grains in India. This gap widens as the country's growth rate increases. An increasing population along with increasing incomes would exert pressure on the available resources.

Table 8.7 Projected demand and supply of food and feed grains in India for the year 2020 (million tons)

Scenario	Supply scenario	Total supply (net of seed and waste)	Projected demand with growth of per capita income (%)		
			2.0	3.7	6.0
	Total demand		257.3	296.2	374.7
1	1962/65 -1993 trend extrapolated	321.1	63.8	24.9	-53.6
2	Reasonable increase in fertilizer and irrigation use	232.2	-25.1	-64.0	-142.5
3	(2) +genetic and efficiency improvements	259.9	2.6	-36.3	-114.8
4	(3) + additional land degradation	242.1	-15.2	-54.1	-132.6

Source: Bhalla et al. (1999).

Table 8.8 Projections for rice and wheat production using yields from National Demonstrations

Crop	Area (1998-99) (million ha)	Yield based on current practice (kg/ha)	Total production (million tons)	Yield based on demonstration plots (kg/ha)	Total production (million tons)
Rice	44.6	1,928	86.0	3,182	141.9
Wheat	27.4	2,584	70.8	3,500	95.9
Total	72.0	-	156.8	-	237.8

It has been observed that yield potentials of crops have not been realized to the fullest extent possible. For example for rice and wheat, which account for nearly 75% of total food grains in the country, only about 58% and 68% respectively of the yields achieved in the national demonstration plots have been realized (Table 8.8). Only 46% and 82% area under rice and wheat is irrigated. The average yield of rice was 1,851 kg/ha while that on demonstration plots was 3,182 kg/ha. Similarly, for wheat, the average yield was 2,387 kg/ha while that on demonstration plots it was 3,500 kg/ha (Pandey and Sharma, 1996). Thus, if the average yield increased even to the level equal to that achieved on the demonstration plots, India would be able to increase the production of food grains from the existing land base by around 50%. Then, in the second run if the yields of food grains reach the levels attained on research stations, the problem of shortages and pressures on land may be under control.

There is a small surplus in supply to demand in the 'medium' per capita growth scenario with the extrapolated growth rates. This however is wiped out only if moderate progress is made in genetic and technical efficiency in crops production. It would be prudent to assume that such shortfalls would be made good by international trade. Much would depend on international prices of grains as well as the size of their demand. The situation calls for caution well in advance as some steps may still be taken to reduce or mitigate the problems.

TRANSITION IN LAND USE PATTERNS

As in the past, public investment in rural infrastructure, agricultural research and extension, and the education and health of rural people will continue to play a key role in determining the rate of agricultural growth. In fact, the marginal returns to several infrastructure investments are now higher in many rain fed areas, and they also have a potentially greater impact on reducing rural poverty. This suggests the possibility that investment in infrastructure in rain fed areas can offer India a win-win strategy for addressing productivity and poverty problems.

The biggest constraint faced in increasing future supply of cereals would be the magnitude and efficiency of land used for crop production. There are competing uses of finite resource of land within a country's boundaries. Changes in land use and land cover, together with land degradation have adverse impacts on forest resources and biodiversity. Increasing demand for forest resources is of particular concern. In the 'India Vision 2020' report, it is observed that the potential exists for dramatically reversing this pattern of degradation during the next two decades (Table 8.9). The report argues this can be done by a concerted and systematic effort to halt soil erosion, restore precious nutrients and organic material to crop lands, recharge groundwater tables, and re-establish depleted forest lands, together with a holistic approach to land management that combines technologies and policies to integrate ecological, socio-economic, and institutional principles.

It has been estimated by Gupta (2002) that, at present, 40% of the commercial demand for timber and less than 20% of the demand for fuel wood are being met by sustainable supply from the forests. Population growth will result in rising demand for both. Over-grazing and over-extraction of green fodder lead to forest degradation through decreased vegetative regeneration, soil compaction and erosion. The degradation of land and forest is also endangering India's rich biodiversity.

Table 8.9 Projected land use patters for the year 2020

Sector	1997	Business-as-usual	Best case scenario
Agriculture	45.9	45.8	45.3
Forest cover	23.0	23.9	26.6
Pastures	3.5	3.5	3.5
Settlements and industry	6.8	8.5	8.4
Unused land	20.7	18.3	16.2

Source: Gupta (2002).

Ecological consequences of population pressure

The UNCED (United Nations Conference on Environment and Development) from 1992 acknowledged that population growth, rising income levels, changing technologies, and increasing consumption pattern will collectively have adverse impacts on environment. Ensuring that there is no further deterioration depends on choices made by the population about family size, life styles, environmental protection and equity. Availability of appropriate technology and commitment towards ensuring sustainable development is increasing throughout the world. Consequently, it might be possible to initiate steps to see that the natural carrying capacity of the environment is not damaged beyond recovery and that ecological balance is to a large extent maintained. It is imperative that the environmental sustainability of all developmental projects is taken care of by appropriate inputs at the planning, implementation, monitoring and evaluation stages.

Poor land use practices and management are responsible for the rapid land degradation in India. Various strategies need to be developed by the Government including policy intervention, promoting research and stakeholder participation, and technological intervention to control land degradation. The strategies identified by the government are as follows:

- An assessment of the nature and extent of the existing degraded land needs to be carried out.
- The adoption of land use according to the land capability classes (USDA classification modified to suit Indian conditions) will ensure that land is put to appropriate use.
- A balanced use of organic nutrients, chemical fertilizers, bio-fertilizers, and other agrochemicals will ensure sustainability.

- A well-defined integrated land use policy should be developed. Rural fuel wood, grazing and fodder policies also need to be developed.
- A national land use commission should be instituted to lay down such formulate policies, implementation strategies and monitoring guidelines.

The Tenth Five Year Plan (period 2002-2007) adds additional strategies like improving cropping intensity, development of rural infrastructure, and increasing public investments in agriculture. Since considerable investment is planned to go into improving infrastructure especially for irrigation and technology development it will have a beneficial effect on the GHG emission from this sector by reducing energy consumption.

AGRICULTURE, LAND USE AND EMISSIONS OF GREENHOUSE GASES

With emissions of greenhouse gases (GHG) increasing, the only way out is to control and reduce such emissions from different sources. This chapter concentrates only on the aspects of agricultural land use resulting in emissions of greenhouse gases. It is only during the last few years that research in India has started focusing on the vulnerability and assessment of GHGs. Long term time series observations are not readily available and have to be estimated using different assessment methods.

India's share of total world carbon emissions is 4%. This is relatively low compared to the 13% share of China and the 23% share of the US. Patterns of land use in India fased considerable changes during the past fifty years. Most of these changes took place during the period from 1950 to 1971. The changes involve the cropping pattern, diversion of land to non-agricultural uses, changes in the ownership of land and the influence of land reform measures like consolidation of holdings. Large tracts of fertile land have been diverted to urban needs. Since 1970, the net sown area remained more or less stagnant at 125 million ha. More than half of the country's total geographical area is suffering from degradation. More importantly, the extent of degradation is not only increasing over time but also growing at an increasing rate. Land degradation takes place largely in the form of soil erosion from water. In India, with growing population, there is relentless pressure to convert forest lands for agriculture. Several factors increasing considerably, including cattle grazing, collection of fuel and fodder, industrial use of land, irrigation projects, housing and urban development. Up-to the late 1970s, forestland was a prime target for diversion for resettlement, agriculture and industrialization, and this trend was contained only by the Forest (Conservation) Act of 1980. Until 1980, India's forest cover was being lost at the rate of 144,000 ha a year. The average annual costs of this degradation have been estimated to be about 3.5% to 4.9% of the GDP (Table 8.10).

Harasawa et al. (2002) state that the productivity of agricultural land will be greatly influenced by future environmental changes. For example, climate-induced changes are expected to have profound impacts on potential crop yields and influence the distribution of cropping patterns in the Asia-Pacific area. GTAP (Global Trade Analysis Project) was used by Harasawa et al. (2002) to assess the impact of climate change on the economy through changes in crop productivity within each region examining changes in producer prices, agricultural production and social welfare. Comparing the changes in social welfare per capita, India was the country likely to suffer the most damage as the model reflected a significant decline in the productivity of wheat in India and the comparatively large share of agricultural products purchased using private funds.

Table 8.10 Annual costs of environmental degradation in India 1994-1997 (% of GDP)

Resource	Cost range
Air	0.4
Forests	1.1 – 1.6
Soil	0.3 – 0.8
Water	1.7 – 2.1
Total	3.5 – 4.9

Source: Parikh and Parikh (2001).

Impact of climate change on Indian agriculture

The main direct effects on agriculture in India in next 25-30 years will be through changes in factors such as temperature, precipitation, length of growing season, and timing of extreme or critical threshold events relative to crop development, as well as through changes in atmospheric CO_2 concentration (which may have a beneficial effect on the growth of many crop types). According to Shukla et al. (2003) the indirect effects will include potentially detrimental changes in diseases, pests and weeds, the effects of which have not yet been quantified in most available studies. In the tropics where some crops are near their maximum temperature tolerance and where dry land, non-irrigated agriculture predominates, yields are likely to decrease.

The present scenario of GHGs in India

In the GHG emission estimations in the Asia Least-cost Greenhouse Gas Abatement Strategy (ALGAS) project undertaken by the Asian Development Bank, the CH_4 emissions from the agricultural sector were 12,654 Ggs while N_2O, NO_x and CO was 243; 109 and 3038 Ggs respectively. Total emissions were estimated at 1,001,352 Ggs of CO2 Equivalent. Of these estimated emissions from the agricultural sector were 341,064 Ggs. The total CO_2-equivalent emissions from India were estimated to be 1,001,352 Gg, which were about 3% of the total global CO_2-equivalent emissions. Based on this, the per capita CO_2-equivalent emissions for 1990 were estimated to be 1.194 tonnes (325 kg C). The per capita emissions for Japan and USA were 2,400 and 5,400 kg C in 1990. The projections made in the ALGAS Report (ADB, 1998) for 2020 indicated that per capita emissions for India in 2020 would be in the range of 460-485 kg C, a mere one tenth of 1990 per capita emissions in the USA.

Table 8.11 India's greenhouse gas inventory in agriculture in 1990 (in Gg)

	CH_4	N_2O	NO_x	CO	CO_2 equivalent
Enteric fermentation	7,563	-	-	-	158,823
Manure management	905	-	-	-	19,005
Rice cultivation	4,070	-	-	-	85,470
Agricultural soils	-	240	-	-	74,400
Prescribed burning of savannas	-	-	-	-	-
Field burning of agricultural residues	116	3	109	3,038	3,366
Total	12,654	243	109	3,038	341,064

Source: Asian Development Bank (1998).

Projections of green house gas emissions from agricultural sector for the year 2020 have been done by the Tata Energy Research Institute (TERI) as well as the National Physical Laboratory (NPL) New-Delhi. Their findings are summarized in Table 8.12.

Table 8.12 Projections for methane emissions until 2020 (in Gg)

	1900	2000	2010	2020
Enteric fermentation	7,563	8,297	9,102	9,985
Manure management	905	977	1,036	1,099
Rice				
- NPL	4,070	4,560	4,830	5,120
- TERI	3,090	3,260	3,630	4,050
Total	12,538	13,834	14,968	16,204

Source: Asian Development Bank (1998).

The Planning Commission in India has devoted attention to mitigation of GHGs in the coming decades. Figures for projected air emissions, not exclusively of the agricultural sector are presented in Table 8.13.

Table 8.13 Projected air emissions for the year 2020 (million tons)

	1997	2020 (business-as-usual)	2020 (best case scenario)
Sulphur dioxide	1.38	3.57	2.47
Particulate	13.93	8.92	2.83
Nitrogen oxides	1.91	3.84	2.37
Hydrocarbons	0.02	0.07	0.04
Carbon monoxide	11.33	22.32	13.27

Present data for the GHGs emissions from the agricultural sector are still not very precise as the base data for livestock population as well as land use need a long time to collect. However, in the recent years the National Remote Sensing Agency has been conducting extensive surveys to help ascertain land cover and land use besides many other parameters. Satellite image based land use planning would provide more accurate results if long term satellite based land use statistics is readily available.

CONCLUSIONS AND EPILOGUE

A growing population, increasing rural incomes and change in the structure as well as the magnitude of food demand will exert pressure on land and would result in change in crop mix and green cover. The production pressure on land base is evident from soil erosion degradation and even water logging and salinisation.

The conclusions emerge from the analysis:

- India's population has increased rapidly in spite of an operational population control programme since last fifty years.
- This growing population would need additional food as a result of growth in numbers, increase in per capita income and changing consumption patterns.
- Requirement of additional food as well as a resultant change in the cropping pattern would affect the future land use patterns as well as emissions in greenhouse gases from agricultural sector.
- India would be able to meet its food demand.
- All the effects of a transition in agriculture may not be beneficial.
- Population and economic growth shall be the drivers of future land use patterns in India.

The dilemmas faced are very well summed up in the opening lines of Eileen Wilson's report 'Is agriculture part of the problem or part of the solution?' where the opening lines are 'Every year, nearly 17 million hectares of tropical rain forests are destroyed, thousands of irreplaceable plant varieties are lost, and millions of hectares of land turn into deserts. Will increased agricultural production, with its associated use of fertilizers, pesticides, irrigation, and farm machinery only exacerbate these severe global environmental problems? In short, does the goal of meeting the world's future food needs conflict with the goal of protecting the environment? According to researchers, one of the major causes of the environmental stress in the developing world is poverty, and one of the major causes of poverty is environmental stress.'

REFERENCES

Agarwal, C., G.M. Green, J.M. Grove, T.P. Evans and C.M. Schweik (2001) *A Review and Assessment of Land Use Change Models. Dynamics of Space, Time, and Human Choice*. Center for the Study of Institutions, Population, and Environmental Change, Indiana University and USDA Forest Service.

Asian Development Bank (1998) *Asia Least-cost Greenhouse Gas Abatement Strategy (ALGAS)*. India, Asian Development Bank, Manila Philippines.

Bhalla, G.S., P. Hazell and J. Kerr (1999) *Prospects for India's cereal supply and demand to 2020; food, agriculture and the environment*. Discussion Paper 29, International Food Policy Research Institute, Washington.

Bhat, P.N. Mari (2001) Indian Demographic Scenario 2025, Population Research Centre, Institute of Economic Growth, Delhi.

Government of India (2001) *National population policy 2001*. Planning Commission, New Delhi.

Government of India (2003) India's initial national communication to the UNFCCC, www.natcomindia.org/initial_natcom.pdf, accessed 16 Nov 2003.

Gupta, S.P. (2002) *Report of the Committee on India Vision 2020*. Planning Commission, Government of India, New Delhi.

Harasawa, H., Y. Matsuoka, K. Takahashi, Y. Hijioka, Y. Shimada, Y. Munesue and M. Lal (2002) Potential Impacts of Global Climate Change, www.nies.go.jp/social/aim/india0210/presentation/AIM_papers/03_Impact_Global.pdf, accessed 16 Nov 2003.

Kulkarni, P.M. (2000) *Prospective changes in the size and structure of India's [population-implications of PFI projections up to 2051*. Department of Population Studies, Bharathiar University, Coimbatore.

Mukhopadhyay, S.K. (2000) *Population growth and agricultural development in India*. Institute for Studies in Population, Agriculture and Rural Change (INSPARC), University of Kalyani, Kalyani.

Pandey,V.K. and K.C. Sharma (1996) Crop diversification and self-sufficiency in food grains, *Indian Journal of Agricultural Eco*nomics, Vol. 51 (4), pp. 644-651.

Parikh, J. and K. Parikh (2001) Accounting for environmental degradation: A case study of India. SDF-India Project Report. UNU/IAS, Tokyo.

Paroda, R.S. and P. Kumar (2000) Food production and demand in South Asia, *Agricultural Economics Research Review*, Vol. 13 (1), pp.1-24.

Shukla, P.R., R. Nair, M. Kapshe, A. Garg, S. Balasubramaniam, D. Menon and K.K. Sharma (2003) Development and climate - an assessment for India. Indian Institute of Management, Ahmedabad, May.

Singh, P. (2002a) *Agriculture policy: Vision 2020*. Background paper for Committee on Vision 2020 for India, Planning Commission, New Delhi.

Singh, P. (2002b) *Trends in fertility, mortality, nutrition and health indicators*. Background paper for Committee on Vision 2020 for India, Planning Commission, New Delhi.

Srinivasan, K. and V.D. Shastri (2002) A set of population projections of India and the larger states based on 2001 census results, Background Paper Committee on Vision 2020 for India, Planning Commission, New Delhi.