Atlas of the Sustainability of Food Security in India

M S Swaminathan Research Foundation

and

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PREFACE

M. S. Swaminathan Research Foundation (MSSRF) and World Food Programme (WFP) decided, on the basis of detailed discussions in the year 2000, that it would be useful to prepare action- oriented atlases relating to food insecurity in rural and urban India. Accordingly, research teams were assembled to prepare atlases designed to promote public policy and action that will result in achieving the goal of a hunger-free India by 15 August 2007, which marks the 60th anniversary of India's independence. The Food Insecurity Atlas of Rural India was released by the Honourable Prime Minister, Shri. Atal Bihari Vajpayee on 24 April 2001. The Food Insecurity Atlas of Urban India was released by H. E. The President of India, Dr. A.P.J. Abdul Kalam on 23 October 2002. Work on the preparation of these atlases revealed that it would be equally important to examine the sustainability of food security in India based on the management of the ecological foundations of agriculture, namely, land, water (inland and ocean), biodiversity, forests and the atmosphere.

Even in the early years of the green revolution, there was criticism from environmentalists that the seed–fertilizer technology may cause long-term ecological harm. The book *Silent Spring* by Rachel Carson (1962) brought out clearly the dangers of excessive use of chemical pesticides and mineral fertilizers. Even before the term 'green revolution' was coined in late 1968, one of us (M.S. Swaminathan) addressing the Indian Science Congress held at Varanasi on 3 January 1968 made the following observations:

"Exploitative agriculture offers great dangers if carried out with only an immediate profit or production motive. The emerging exploitative farming community in India should become aware of this. Intensive cultivation of land without conservation of soil fertility and soil structure would lead, ultimately, to the springing up of deserts. Irrigation without arrangements for drainage would result in soils getting alkaline or saline. Indiscriminate use of pesticides, fungicides and herbicides could cause adverse changes in biological balance as well as lead to an increase in the incidence of cancer and other diseases, through the toxic residues present in the grains or other edible parts. Unscientific tapping of underground water will lead to the rapid exhaustion of this wonderful capital resource left to us through ages of natural farming. The rapid replacement of numerous locally adapted varieties with one or two high-yielding strains in large contiguous areas would result in the spread of serious diseases capable of wiping out entire crops, as happened prior to the Irish potato famine of 1854 and the Bengal rice famine in 1942. Therefore, the initiation of exploitative agriculture without a proper understanding of the various consequences of every one of the changes introduced into traditional agriculture and without first building up a proper scientific and training base to sustain it, may only lead us, in the long run, into an era of agricultural disaster rather than one of agricultural prosperity."

The Rural Food Insecurity Atlas revealed that the Punjab–Haryana region which is today India's bread basket could lose its production potential within a few decades if the current patterns of groundwater extraction and pollution, soil salinization and monoculture of rice and wheat persist. Therefore, it was decided that an atlas of the Sustainability of Food Security in India should be prepared for promoting ecologically sustainable methods of food production and natural resources management. The present atlas is the outcome of this joint MSSRF–WFP effort.

The three atlases together will help policy makers to promote, in all major farming systems, an ever-green revolution which can help to enhance productivity in perpetuity without associated ecological or social harm. They will also help in initiating steps to ensure economic access to food and will generate awareness on the urgent need to stabilize human and animal population at a level the ecosystem can support in a sustainable manner. A **"Food Security Compact"** has been proposed in the Atlas of Sustainability of Food Security, in order to enable State Governments to formulate and introduce integrated programmes of natural resources conservation and enhancement; augmentation of food production; generation of sustainable livelihood and employment opportunities; and provision of clean drinking water, environmental hygiene, primary health care and primary education. We hope State Governments will undertake a detailed analysis of the situation in their respective States and develop and implement a Sustainable Food Security Compact. The pathway to a sustainable human future was shown by the IUCN (World Conservation Union) General Assembly held at Perth, Australia, in 1990, under the chairmanship of the then President of IUCN, Professor M. S. Swaminathan. This pathway has the following two processes:

"One is to secure a widespread and deeply held commitment to a new ethic, the ethic for sustainable living, and to translate its principles into practice. The other is to integrate conservation and development: conservation to keep our actions within the Earth's capacity and development to enable people everywhere to enjoy long, healthy and fulfilling lives."

We are indebted to the MSSRF team led by Dr. Swarna Sadasivam Vepa and the WFP team headed by Dr. Minnie Mathew for their dedicated work. What is encouraging is the building up of highly dedicated and competent teams of young professionals who will be assets in India's efforts to achieve the following goal set by the Prime Minister, Shri. Atal Bihari Vajpayee when he released the Atlas of Food Insecurity in Rural India in April 2001.

The sacred mission of a Hunger-Free India needs the cooperative efforts of the Central and State Governments, local self-government bodies, non-governmental organizations, international agencies and above all, our citizens. We can indeed banish hunger from our country in a short time. Let us resolve today to make this mission substantially successful by 2007, which will mark the 60th anniversary of our independence.

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Introduction

The Concepts

The origins of the terms Sustainability and Food Security reveal the context in which they were coined. In 1980, The World Conservation Union (IUCN) proposed the concept of sustainable development in its publication *World Conservation Strategy*. This report was released in New Delhi in March 1980 by the then Prime Minister of India, Smt. Indira Gandhi. In 1987, a report titled *Our Common Future*, published by the World Commission on Environment and Development, Chaired by Dr.Gro Harlem Brundtland refined this concept further and defined the word 'sustainability' as "meeting the present need without compromising on the future needs." Later in 1996, the Food and Agricultural Organization, on the occasion of the World Food Summit defined the term 'Food Security' in a report titled *Food for All*.

A Science Academies Summit convened by M.S.Swaminathan Research Foundation in June 1996, prior to the World Food Summit held in Rome later that year, combined these two aspects and expressed the following comprehensive view on Sustainable Food Security (MSSRF 1996).

"...that food originates from efficient and environmentally benign production technologies that conserve and enhance the natural resource base of crops, animal husbandry, forestry, inland and marine fisheries...

"Policies and technologies for Sustainable Food Security should ensure that every individual has the physical, economic, social and environmental access to a balanced diet that includes the necessary macro- and micro-nutrients, safe drinking water, sanitation, environmental hygiene, primary health care and education so as to lead a healthy and productive life."

The above conceptualization adds an ecological dimension to food security, in addition to the physical, economic and social dimensions. The two publications of MSSRF on rural and urban food insecurity adopted a broad definition of Food Security in its three dimensions—Food Availability, Food Access and Food Absorption (MSSRF 2001 and MSSRF 2002). Food availability is a function of food production. Food access is a function of purchasing power. Food absorption is a function of environmental hygiene, clean air and water and primary health care.

There are two facets of food availability, food access and food absorption. The first is Present Security and the second is Future Sustenance. It is important to produce enough food at present without damaging the environment and the natural resources base required for future food production. Such a concept is important for India, since human and farm animal populations have grown substantially since 1947 when the country achieved independence.

The Carrying Capacity of Natural Resources

An interesting feature of Indian agriculture is the very low availability of grazing land despite the very large farm animal population. Figure 1.1 in the first chapter, which details the major land-use pattern in India, shows that only 3.6 per cent of the geographical area is under permanent pastures, though India has the world's largest cattle population.

Most of the farm animals in India are stall-fed. There is a preponderance of large and small ruminants in the population that make crop-residues and agricultural biomass important sources of animal nutrition.

From 1950, when the era of planned development (First Five-Year Plan) started, up to 1968, advances in agricultural production were largely related to an expansion in the cultivated area as well as in irrigated area. Such a horizontal growth in cultivated area resulted in bringing forestland under annual crops, leading to the depletion and degradation of forests.[1]

From 1968, when high-yielding semi-dwarf varieties of wheat started making an impact on yield-based production, there has been a vertical growth in productivity rather than a horizontal expansion of cultivated area. For example, the data on area, production and productivity in wheat and rice, the two major food crops of India, shown below indicate how the green-revolution technologies brought about a paradigm shift from a horizontal to a vertical growth pattern in Indian agriculture.

If the over 80 million tonnes of wheat that is the Indian farmers' current yield had to be grown at the productivity levels existing in 1961, we will need over 80 million hectares of land under wheat, in contrast to the 24 million hectares now under this crop. The same is true in the case of rice and other crops where there has been a substantial increase in productivity per hectare. Thus, the productivity pathway of increasing production can also be termed forest- and land-saving agriculture.

India's population is still growing at a level where the population-supporting capacity of major ecosystems is being exceeded. In the future, we will have no option but to produce more food, fibre, fodder and all other farm commodities under conditions of diminishing per capita availability of arable land and water. Water is becoming a serious limiting factor, not only for agriculture and ecosystem maintenance, but also for domestic consumption. This is why adding an ecological dimension to the concept of food security has become an urgent task.

Even before the term green revolution was coined by Dr.William Gard of USA, Prof. M.S. Swaminathan made the following points in the Presidential Address to the Agricultural Sciences Section of the Indian Science Congress held at Varanasi in January 1968 (Swaminathan 1968).

"...Therefore, the initiation of exploitative agriculture, without a proper understanding of the various consequences by every one of the changes introduced into a traditional agriculture and without first building up of a proper scientific and training base to sustain it, may lead us into an era of agricultural disaster in the long run rather than to an era of agricultural prosperity."

Later, he elaborated the concept of ecological security as a fundamental component of food security in the Aggrey-Fraser-Guggisberg Memorial Lectures delivered at the University of Ghana in 1981 (Swaminathan 1981).

"The steps for achieving ecological security would include measures for protecting the basic assets of agriculture and minimizing the liabilities. This can be achieved through establishment of National Land Use Board, which could foster through appropriate scientific analysis and public policies, land and water use practices, which are

[1] While the Land Utilization Statistics may not show that the net sown area increased at the expense of forests because of under-reporting and misreporting in the early years, there are several case studies

compatible with the concept of sustainable development. Government alone, however, cannot promote ecological security. It has to be a joint sector activity involving the people and government agencies...". In other words, the protection of the environment has to become everybody's business.

Reduced Capacity of Agriculture to Provide Livelihood Access

In India, agriculture, including crop and animal husbandry, fisheries, forestry and agro-processing, is the backbone of the rural livelihood security system. However, the contribution of agriculture to GDP has been steadily declining over the years. But, the share of agriculture in providing employment has been static. Thus, the onus of providing employment and livelihoods to a majority of the population continues to remain with agriculture, in spite of the diversification of economic activity. Agricultural progress is the best safety net against hunger and poverty, as it offers effective social protection. Indian agriculture is, therefore, not just an instrument for producing food for the urban population, but is the major source of livelihood opportunities in the country. Conserving and improving the ecological foundations of agriculture are vital for sustainable food security. While dealing with food security, the fodder and feed needs of the farm animal population need to be kept in view.

The long-term sustainability of food production and security in India is, therefore, essential for elimination of endemic hunger, to strengthen livelihoods in both the on-farm and off-farm sectors and for national sovereignty. Sustainability was considered for too long only from an economic perspective. Later, the social and equity aspects, particularly in terms of gender, were added. More recently, the mainstreaming of the ecological dimension in the assessment of food security is gaining acceptance by policy makers.

Ultimately, we need an evergreen revolution, which implies raising farm productivity in perpetuity without associated ecological or social harm (Swaminathan 1996). This calls for technologies based on integrated natural resources management. A farming-systems approach rather than a commodity-centered approach, as was adopted in the development of the green revolution technologies, will be essential for achieving an ecologically sustainable evergreen revolution. The analysis provided in the Sustainability Atlas will be of use in developing such a production strategy, based on integrated natural resources management.

The Objective of the Study

The present study examines the ability of the Indian states to provide present food security as well as future sustainability. The study has been cast in the mould of the present as well as the future.

This Sustainability Atlas, like the ones relating to rural and urban food insecurity, has been designed as a policy instrument. It deals with the ecological foundations essential for sustainable food security, both in a disaggregated and aggregated manner. The most recent data available with reference to population, land, water, flora, fauna and forests have been used for analysis. In the future, climate change resulting in alterations in temperature, precipitation, sea level and ultraviolet-B radiation is likely to have a major impact on food and water systems. Coastal communities, the inhabitants of Andaman and Nicobar Islands and the Lakshadweep group of Islands will be particularly affected adversely if there is a rise in sea level, as is currently being predicted. Therefore, aspects relating to climate change arising from global warming have also been dealt with.

If the Atlas leads to the integration of ecological factors in technology development and dissemination as well as in the design and implementation of agricultural and rural development programmes, it will have served its purpose.

Balance between Present Security and Future Sustenance

The concept of Present Security and Future Sustenance are akin to economic development and ecological health in a much broader sense. Present food security for a billion plus population involves adequate increase in agricultural production, growing employment in rural and urban areas and provision of basic amenities such as safe drinking water and primary health care. All these constitute economic development.[2]

Ecology and economy were in the past considered as contradictory to each other. It was thought one had to sacrifice economic development to achieve ecological health and vice-versa. Reconciling the environment and economic development was first discussed at the United Nations Conference on Human Environment at Stockholm in 1972. At that time, many countries feared that environmental protection might harm rapid economic development.

As the world's economic development progressed and ecological degradation deepened, a realization has come that ecological degradation will limit economic development sooner or later. Protecting the ecological base is extremely important for food production and livelihood access. A balance between Present Security and Future Sustainability is important. Conservation of natural resources for its own sake while people are poor and starving has no meaning. Similarly, high levels of agricultural production and employment generation at present are equally meaningless if they cannot be sustained for long. The goals of food security (food production, employment generation and provision of basic amenities and healthcare) should be pursued and achieved through sustainable use of environmental resources.

The World Business Council on Sustainable Development in its report titled *Changing Course* released at the UN Conference on Environment and Development held at Rio de Janeiro in 1992 has stressed the need to adopt the concept that 'good ecology is good business'. The Council in its report *Walking the Talk*, released at the World Summit on Sustainable Development at Johannesburg in September 2002, has given several examples to illustrate how business and industry can contribute to environmentally sustainable development. Thus the age of sustainable development, whether in agriculture or industry, has begun.

Present Security

First, all states have to become food-secure from the standpoints of food production/availability, food access/livelihood access and food absorption. The natural resources should be sufficient to meet the local demand for food, fodder and other economic needs of the local population. Agriculture that includes crop production,

[2] Economic growth is one of the components of economic development. When economic growth touches all strata of population to bring overall prosperity, it becomes economic development.

livestock, fisheries and forestry depends upon the availability of natural resources such as arable land, water for irrigation and other uses and sufficient common property resources for the people to satisfy their many needs, particularly the need for fodder and fuel wood. Rural people depend upon the Common Property Resources (CPR) for a variety of needs such as timber for housing, grass for animals, water bodies for household use, fuel wood for cooking and wild foods in lean months of food shortages.

Future Sustenance

The natural resources of the country should be sufficient to sustain the livelihoods of local population and satisfy their economic and domestic needs in the future, including that of agriculture: crop production, livestock, fisheries and forestry. If natural resources are destroyed, it will not be possible to sustain livelihoods for long. This requires an assessment of the natural resource depletion that has already occurred. Sustainability in turn depends on the level of unexploited natural resource endowments in relation to population and the provision of free access to natural resources for the rural people.

Sustainability does not mean leaving natural resources untouched. It means people continue to use natural resources for food and livelihood and replenish renewable resources. It means people simultaneously live eco-friendly lifestyles and preserve resources for future use. Sustainability means a symbiotic relationship between the rural population and natural resources. It involves the use of modern technologies, including biotechnology, that help restore depleted resources and conserve natural resources. It covers all eco-friendly and economically viable enterprises. Sustainable food security may not imply a high rate of economic growth; it does, however, imply availability of sufficient food, a nutritious and balanced diet and a better quality of life, particularly for the rural masses.

Indicators of Sustainable Food Security

Having said what Present Security and Future Sustenance mean, it is not easy to find indicators that measure them accurately. However, within the limitations of the data, we have attempted to find several indicators that could describe both Present Security and Future Sustenance. They have been arranged in to three major groups.

I. Indicators of Sustainable Food Availability

II. Indicators of Sustainability of Food Access

III. Indicators of Food Absorption

Seventeen indicators were finally selected for inclusion in the Index on the basis of available and reliable data. Others that were discussed in detail could not be included in the Index, as they were not available for all the 25 states and union territories. The indicators of the First Group are further split into three indicators of Present Production Security and eight indicators of Production Sustenance. The first set of indicators on security are concerned with the size of the resource base for present production and the level of present production itself. The unutilized portions of natural resources represent Production Sustenance. They are an untapped reservoir of resources available for future use.

The Second Group of Indicators of Sustainability of Food Access is split into two sets: Present Livelihood Security indicators and Future Livelihood Sustenance indicators. The first set has two indicators and the second set has five. The second set reflects the population pressure on natural resources that determine the future sustenance of livelihoods.

The Third Group consists of two key indicators that represent food absorption, health care and basic amenities available at present to the population.

Methodology

An assessment of the natural resource base for agriculture has been the prime focus of the study. In order to assess the factors that define the focus of the study, indicators were chosen from the available secondary data sources that best describe each of the key issues relating to Food Availability, Access and Absorption and their sustainability.

The study discusses the chosen indicators one after the other in great detail, sometimes at the aggregate level and sometimes at the disaggregated level of the states. Discussions concentrate on the health of these resources and the problems associated with it. It thus brings out the key concerns about various indicators. Finally, the policy chapter offers possible solutions.

At the end of the discussion, a weighted Index of Sustainability of Food Security has been calculated. The method of indexing and the calculation of the composite index using appropriate weights help the process of aggregating the information. The Index is a composite one that combines the indicators of Present Security and Future Sustenance to get the Indices of Sustainability of Food Production, Sustainability of Food Access and Food Absorption. Each of these indices has been further combined into a final Sustainability of Food Security Index with appropriate weights. The details of indexing and the weighting system are given in Chapter 9. Table 9.4 gives the entire weighting system at a glance. The method of indexing has been described in detail in the same chapter.

The point to be stressed is that the Sustainability Atlas is meant to look at the entire scenario of natural resource base at the state level. It discusses the issues and points out the threats that exist in various states. The final Index and sub indices and the maps related to them are only incidental in the process. The emphasis is on the individual indicators, the issues discussed and the policies recommended, since policy interventions are needed at the level of each indicator.

Maps have been used as a visual tool to identify the relative position of the indicators for all the states. Separate maps have been prepared for each indicator and some for the composite indices. In the maps, the states have been categorized into five groups based on the natural breaks. Natural breaks follow the variations and bunching pattern of the states around the median. More states are in the same category if the variation, between them is less. When one or two states have extreme values, they are classified as a single category.

Data Sources and Limitations

The Sustainability Atlas has been prepared based on the available secondary data collected from a number of Departments of Government of India and reputed institutions. Our selection of the indicators has been limited by the availability of reliable secondary data and their applicability in the current study of sustainability. The detailed list of data sources is given along with the tables.

An important consideration for the study is comparability of data for all the states. Factors where data are not available for all the states have not been considered. One of the major limitations of the study is the lack of adequate data at the state level for several of the parameters that define sustainability. Serious data gaps exist for state- level information on quality of surface water or groundwater, soil quality, or air pollution levels. Similarly, there is a large lacuna on information relating to biodiversity, such as the longitudinal enumeration of like plants, animals and microorganisms, rates of extinction of endemics in flora and fauna, alien invasive species, etc. Similarly, factors that define forest health such as the successional stage of forests, or the ecological functions of forests are lacking at the state level. The huge diversity within India and the overlapping of more than one agro-ecosystem within a state further complicate the analysis. However, it is encouraging that much work regarding exploration and enumeration is in progress. Several institutions like the Botanical and Zoological Surveys of India have taken up the mammoth task of putting different aspects of our biological wealth together. The National Bioresources Board, the National Medicinal Plants Board and the National Bureaus of Plant and Fish Genetic Resources are playing an important role in preparing inventories of our biological wealth.

Finally, a word of caution on the weighting system and the composite Indices adopted. The weighting system is driven mainly by the purpose for which the Sustainability Atlas has been brought out. Hence, the natural resources have been given larger weights in all Indices. All the Indices necessarily suffer from aggregation bias that is common to any Index calculated.

Organization of the Atlas

This Sustainability Atlas follows the basic pattern of organization followed in the previous two Atlases, The Food Insecurity of Rural India and the Food Insecurity of Urban India. The three pillars of food security—**Availability, Access** and **Absorption** are dealt in the three parts: one, two and three. Part four gives the composite index and the policy implications. The recommendations based on the study as the "**Sustainable Food Security Compact**" gives the guidelines.

Part One: Sustainability of Food Production: This part has four chapters. The first three chapters deal with Land and Water, Forest and Biodiversity and Atmosphere and Climate Change. At the outset, a detailed analysis of population pressure on natural resources has been presented. These chapters deal with the current state of the resource base and sustainability in the physical availability of natural resources to support food production systems that will ensure long-term food security. A sector-wise analysis of the key parameters of Population, Land, Water, Forest, Biodiversity and Atmosphere and Climate change are elaborated here. This analysis outlines the current levels of utilization of the natural resources and the major issues that arise out of unsustainable resource use. Chapter four, in part one, deals with the sub index of Sustainable Food Availability that combines all the indicators into a composite Index, giving 75 per cent weight to sustainability indicators and 25 per cent weight to present security indicators. This chapter also discusses the situation of higher levels of current production but poor sustainability of food production in some states and vice versa in other states.

Part Two: Sustainability of Food Access: This part of the Atlas includes chapters 5 and 6. Chapter 5 deals with the sustainability of livelihood access from natural resources. It depicts accessibility of natural resources such as land, forests and water to the people. The livelihoods of the rural population depend heavily upon the health of natural resources. The present security of livelihoods, reflected by the extent of poverty and the present path of rural development that has scope for non-farm employment, has been contrasted with the sustainability aspect, the human pressure on natural resources, through an illustrative matrix. Chapter 6 calculates the composite Index of Sustainability of Food Access by combining the Index of Present Food Access and Livelihood Access Security and the Index of Sustenance of Food Access and Livelihood Access of rural people. The concern was with rural poor, as urban poverty is essentially a spill over of the rural poverty. If rural poverty is arrested and environmental refugees are stopped, distress migration does not occur from rural to urban areas.

Part Three: Food Absorption: Chapters 7 illustrates absorption aspect. This chapter gives an account of water and air pollution and their impact on the health. Two key indicators are used in the absorption Index. The parameters that lead ultimately to food absorption at the individual level are safe drinking water and low infant mortality rates. They are the key indicators, as they sharply bring out the health status of the population. Safe drinking water minimizes infections. Outbreaks of water-borne diseases are rampant in India and claim several lives. The high levels of mortality affect the overall productivity of households in terms of total work force, which in-turn affects the earning capacity of that household. The Infant Mortality Rate (IMR) as it relates to a host of factors including female literacy, immunization, income, prosperity, etc. is a proxy for several indicators and represents the health status of the population in a nutshell. It then combines these two indicators into an Index of Food Absorption that illustrates the position of the states.

Part Four: Towards Sustainability of Food Security: This section has two chapters chapter 8 and 9. Chapter 8 deals with the trend in food grain production, future prospects in and the influence of markets on agricultural production and natural resource degradation. Chapter 9 deals with the integration of all the indicators that have been brought out in the previous sections. It outlines the methodology adopted for computing the final Sustainability of Food Security Index. It is worthwhile to mention that the natural resource endowment of a state and the unexploited portion of the natural stock are the major factors that control the sustainability of food security. It has been given a weight of 75 per cent. In contrast, the present security of food availability and food access get a weight of only 25 per cent. Among the three major heads of Food Availability, Food Access and Food Absorption, the first gets a weight of 65 per cent, the second gets a weight of 25 per cent and the third, a weight of 10 per cent. This is because natural resource wealth is the key to Sustainability and we cannot afford to damage our basic life-support systems. While there is no justification for using only these weights and not any other, the decision is guided by the objective of the study, namely, to assist policy makers to launch the country on the path of an evergreen revolution in agriculture.

Interpretation of the results is an important part of the ninth chapter. In every state, the forces at work vary and each state has its own strengths and weaknesses. The combinations and permutations have been discussed to some extent to show how some states are high on sustainability but low on basic food security. There are others that are neither food secure at present nor sustainable in future. These states are in greater danger and need urgent attention. The results however are only indicative and limited by the methodology of indexing. Chapter 10 discusses Policies and Programmes. This chapter points out the lacunae in the existing policies and indicates ways of improving them. It contains a fairly detailed account of various policies and programmes that touch upon sustainable food security.

The final recommendations titled "**Sustainable Food Security Compact**" highlights how agriculture and livelihoods based on natural resources can be made sustainable. A conceptual framework for sustainable food security based on the conservation and enhancement of the environmental capital stocks and the promotion of sustainable lifestyles and resource use is presented in the Compact.

PART I

SUSTAINABILITY OF FOOD PRODUCTION

CHAPTER 1

Land and Water

I. Land

Land is an important natural resource for agriculture. Centuries ago, the Malthusian theory of population as well as David Ricardo's theory of rent stressed the harsh reality that even as population and food needs increase, land resources do not. The industrial revolution and the emergence of scientific agriculture have enabled food supply to keep pace with the growing population. However, we have yet to resolve the question of long-term resource constraints. Enormous demands have been placed on land resources in India. The use and abuse of these resources determine the sustainability of agriculture. Land resources include not only cropland but all land — forests, shrubs, groves, valleys, hills and deserts, cold and hot. Even snow-covered cold deserts yield water for agriculture and the human population when snow melts.

This section on land examines the sustainability of land resources required for long-run agricultural production. But it is difficult to assess the sustainability of land in precise terms. Five important aspects of land have been examined.

- *The first* is **population pressure on land resources**. Excess population leads to over-exploitation of natural resources; hence it should be contained to suit the carrying capacity of the region.
- *The second* is **land utilization**. Markets drive changes in land use. Land is being put to the use that generate the highest revenue, not to the purpose for which it is best suited.
- *The third* concerns **net sown area**, changes in the area sown over a period of time. As net area sown increases, more and more of marginal lands are put to cultivation and yields fall.
- *The fourth* relates to **crop patterns**. This is decided mostly by the subsistence needs of the population and the prices of outputs. The response of supply to price determines the area under each crop.
- *The fifth* deals with **land degradation –** which has been spurred by several factors including intensive use of land for agricultural production.

1.1 Population Pressure on Land

The survival of the human race depends upon its ability to be in long-lasting equilibrium with Nature. However, while the rate of human population growth is declining, the absolute number of people on Earth continues to increase. This places an ever-mounting pressure on the Earth's limited environmental and natural resources. The impact of population pressure on the environment is often claimed as a product of three factors; namely, population, consumption per person and technology. Population is the total number of people; consumption relates to the amount each person consumes; and technology determines input use and how much waste or pollution is produced per unit of output consumption. In every human interaction with the environment, these three major elements are in play. They can be linked in the famous formula introduced by Ehrilich and Holdren (Ehrilich *et.al* 1971)

I = P x A x T, or

Impact on the environment = Population x Affluence x Technology

The dominance of population, affluence and technology and their impact on the environment is country-specific. In many developing countries, population growth has led to a reduction of per capita cultivable land and to deforestation, as a result of the excessive dependence of the population on agriculture for their livelihoods. As a country grows, the consumption per person increases. This exerts a demand on natural resources leading to a negative impact on the environment. Technology has its positive and negative impacts in an economy. On the one hand, technology has brought a dramatic rise in human output since the beginning of the industrial revolution, especially in the developed world; on the other hand, it has led to global warming, ozone depletion and other global environmental problems. Ehrilich used the formula to show that population growth was one of the dominant factors in environmental damage (Ehrilich 1971).

In 1798, Malthus, in his famous *Essay on Population*, predicted terrible disasters resulting from population growth and a consequent imbalance in 'the proportion between the natural increase of population and food.' At a time when there were fewer than a billion people, he was quite convinced that 'the period when the number of men surpass their means of subsistence has long since arrived.' He claimed that the pressures of resource demands and pollution loads could build up and predicted that these would reach crisis levels if economic activity continued as usual, unless positive checks occurred or preventive checks undertaken. The pressure of population both human and animal on Common Property Resources (CPR) means that CPRs are under constant threat in developing economies. Resources such as groundwater, fishing stocks and the oceans and atmosphere, which we use as sinks for our liquid and gaseous wastes, are under threat. Lack of ownership or management arrangements encourages individuals to overuse common resources for their private advantage, even if this means degrading the resource (Hardin 1968). Each user gains the full advantage of its overuse, but suffers only a very small share of the losses it causes. This is the well-known 'tragedy of the commons'.

However, there are other views on population, which are not visions of doom or a 'bomb' that has been planted and is about to 'go off'. They claim that the population problem is serious, certainly, but neither because of 'the proportion between the natural increase of population and food' nor because of some impending apocalypse, but because of the long-term effects of population growth on the environment (Sen 1994). Hence, the two divergent standpoints on population converge on a common ground: that the excessive population pressure is a grave threat to the sustainability of natural resources in the long run.

1.1.1 The Indian Scenario

India supports 17 per cent of the world's population on just 2.4 per cent of world's land area (Srinivasan *et. al.* 2001). India's population has gone up from 361 million in 1951 to over one billion in 2001. The rate of population growth between 1991 and 2001 has been 1.9 per cent, which continues to pose a persistent population challenge. Along with the population increase, the country has witnessed structural changes in terms of rural–urban distribution, migration and reclassification. But India still remains predominantly rural. For the country as a whole, the urban population was 27.78 per cent in 2001 compared to 25.71 per cent in 1991. The share of urban population has increased by just 2.06 per cent in the last decade whereas the previous decades have shown a larger increase in urban population. This shows that a large population is still dependant on land as a means for their livelihood. The level of urbanization and industrialization seems to be insufficient to draw the large population away from agricultural activities. The carrying capacity of the urban areas is still too small to accommodate the rural masses that often find their rural occupations more viable than getting stuck in the rut of the urban informal sector.

In India, a couple's fertility decisions often depend on the opportunity costs, which here refers to the amount of income foregone in the process of bringing up the child. In states like Bihar and Uttar Pradesh where the opportunity cost is low, fertility rates are high. In these rural societies, there are strict norms on women spending a majority of their time in child-rearing. Women's wages in these regions are also low, bringing down the opportunity costs of having children and keeping the birth rates high. Children, especially in rural areas, are also viewed as an 'investment good', i.e., a source of support to the parents in their old age and an embodiment of income-generating capacity. As the country develops and investments are made in education, and as income and employment opportunities increase for both men and women, opportunity costs will increase and fertility rates will eventually fall. In such a society, people will enjoy a better lifestyle, as more economic resources will be available per head (Ray 1999).

1.1.2 Density of Population

One of the important indices of population concentration is the density of population. Population density is defined as the number of persons per square kilometer. The population density of India in 2001 was 324 persons as against 267 persons in 1991; this means that the population density has increased by 21.3 per cent in that decade. High increase in the density of population is a matter of great concern as it puts immense pressure on our natural resources, especially land, and, also, it may adversely affect the quality of life. Differences in climatic conditions, availability of and access to resources, levels of urbanization, industrialization etc., have meant that the states and union territories of our country are largely varied in terms of density: from 13 persons in Arunachal Pradesh to 9294 in Delhi. The union territories of the country especially have a high density. The density of population has increased in all states and union territories of our country between 1991 and 2001.

Among the bigger states, West Bengal is still the most thickly populated, where population density has gone up from 767 in 1991 to 904 in 2001. Bihar is the second highest densely populated at 880 persons followed by Kerala in the third spot at 819 in 2001. Punjab and Tamil Nadu fall in the middle rung among all the states and union territories at 482 and 478 persons respectively (Table 1.1).

The growing population in the country has increased the demand for forestland, trees and water, which, coupled with tenure insecurity or the absence of clear property rights, has resulted in the over-exploitation of these natural resources. In an agriculture-based economy such as India, population poses a threat to the natural resources and will result in regional environmental problems, such as land degradation, deforestation, soil erosion and siltation of water bodies, which have a strong bearing on the growing needs of the people. This in turn threatens the sustainable development of agriculture, forestry and livestock sectors.

The average size of the land holding shows us the pressure of population on land (Chapter 5, Table 5.1

Table 1.1

Popualtion Density and Total Fertility Rate - 2001

S.No	States	Population Density (persons/ square km)	Total Fertility Rate No. of Children/ Women (15-49 year)
1	Andhra Pradesh	275.00	2.30
2	Arunachal Pradesh	13.00	3.90
3	Assam	340.00	3.20
4	Bihar	880.00	4.50
5	Goa	363.00	1.80
6	Gujarat	258.00	2.60
7	Haryana	477.00	3.20
8	Himachal Pradesh	109.00	2.40
9	Jammu and Kashmir	99.00	3.00
10	Karnataka	275.00	2.40
11	Kerala	819.00	1.70
12	Madhya Pradesh	196.00	3.90
13	Maharashtra	315.00	2.60
14	Manipur	107.00	2.60
15	Meghalaya	103.00	4.50
16	Mizoram	42.00	3.40
17	Nagaland	120.00	3.20
18	Orissa	236.00	2.80
19	Punjab	482.00	2.40
20	Rajasthan	165.00	4.20
21	Sikkim	76.00	3.00
22	Tamil Nadu	478.00	1.80
23	Tripura	304.00	2.50
24	Uttar Pradesh	689.00	4.40
25	West Bengal	904.00	2.60
26	Andaman & Nicobar Island	43.00	2.30
	All India	324.00	3.20

Source: Guilmoto C.Z., and Irudaya Rajan S., "District Level Estimates of Fertility from India's 2001 Census", Economic and Political Weekly - Feb 2002

shows the state-wise performance on the average size of land holdings). Excess pressure of population on land results in uneconomical land holdings, as the land is fragmented into marginal hectares. These pieces of land are no longer sustainable for food access or livelihoods as the thrust of population reduces land fertility. The pressure of population and the essential development requirements for forest products, such as fuel wood, fodder, timber and paper, leads to clearing of forests or over-exploitation beyond the capacity of the forest to regenerate. Forests are a source of livelihood and a source of subsistence in our economy. Deforestation poses a stress for the poorer sections of our society, especially women, who invest large portions of time in collection of fodder and fuel wood. The predominant causes for dwindling forest wealth has been identified as overgrazing, illegal encroachments, unsustainable practices, forest fires and indiscriminate setting of development projects in forest areas (GOI, Economic Survey 1998). Forests have declined from 72 million hectares in 1951 to 63 million hectares in 1997 (Forest Survey of India 1997). The withdrawal of fuel wood from forests and demand for industrial wood is above the sustainable capacity in the country. The current annual withdrawal of fuel wood from forests is estimated at 235 million cubic metres against a sustainable capacity of 48 million cubic metres and the annual demand for industrial wood is about 28 million cubic metres against the production of 12 million cubic metres (UNFPA 2000). Hence, population pressure has undoubtedly exerted a demand on natural resources and has contributed to forest depletion and degradation.

Population change is determined by fertility, mortality and migration. Each of these, in turn, is affected by a host of other factors, from patterns of breastfeeding and the status and education of women to child health, availability of contraception, the distribution of land and income and the opportunities for migration.

1.1.3 Total Fertility Rates

The story of population growth in India is fairly in tune with the classical theory of demographic transition. During most of the nineteenth century, India witnessed a fluctuating but ultimately more or less stagnant growth of population, which continued into the twentieth century, until 1921. Thereafter, the country successively passed through all the phases of demographic transition and is now widely believed to have entered the fifth phase, usually characterized by rapidly declining fertility.

In the last few decades, India has witnessed a fall in mortality rates and total fertility rates, but the fall in the death rates has not been large enough to offset the total fertility rates (Guilmota and Irudaya 2002). Total fertility rate is a summary measure that gives the number of children a woman would bear during her reproductive years. Fertility decline is however not uniform across the states of the country. According to the Sample Registration Survey data, the total fertility rate of Kerala is 1.70 followed by Tamil Nadu and Goa at 1.80. Bihar and Meghalaya have the highest total fertility rate at 4.50 followed by Uttar Pradesh at 4.40 (Table 1.1 and Map 1.1)

States like Tamil Nadu, Kerala and Andhra Pradesh have witnessed initiatives by the Government through various awareness programs on family planning techniques. In Tamil Nadu, declining fertility rates can be attributed to the social reform movement, early start of family welfare programs and the school midday-meal scheme. In Kerala among the various factors such as historical background, form of Government, matrilineal society and migration, the single most important factor in explaining the demographic transition is female literacy. Most often women suffer from lack of awareness and/or availability of culture specific family planning services, which is a major constraint in several parts of the country.

Education of women is a key element for improving the status of women and achieving a reduction in fertility (Mitra 1979). The National Family Health Survey in India has shown that the education of women can play a major role in shaping their attitudes and behaviour. Educational attainments showed a strong association with every important variable considered, including age at marriage, fertility behaviour, the use and demand for family planning, number of children desired, use of antenatal care, delivery in a health facility, vaccination and nutritional status of children and infant and child mortality. Furthermore, the more the years spent in schooling the better the outcome on these variables. Contraceptive use at the all-India level among currently married women generally increases with education, from 43 per cent among illiterate women to 57 per cent among women with at least a high school education. In Meghalaya, 79.8 per cent of the married women do not use any method of contraception; this figures stands at 75 per cent in Bihar and at 72 per cent in Uttar Pradesh. Kerala, where 36.3 per cent of the women do not use contraceptives and yet have low fertility rates, shows the impact of female education.

The best way of dealing with the population problem is to provide greater opportunities for female education, to improve old age security and promote greater participation of women in employment and in political action (Sen 1994).

The National Population Policy (NPP), 2000, recently adopted by the Government of India, states that 'the long-term objective is to achieve a stable population by 2045, at a level consistent with the requirements of sustainable economic growth, social development, and environment protection.' It has been assumed in the policy document that the medium-term objective of bringing down the Total Fertility Rate (TFR) to the level of 2.1 by 2010 will be achieved. It is envisaged that if the NPP is fully implemented, the population of India should be 1013 million by 2002 and 1107 million by 2010. Even with

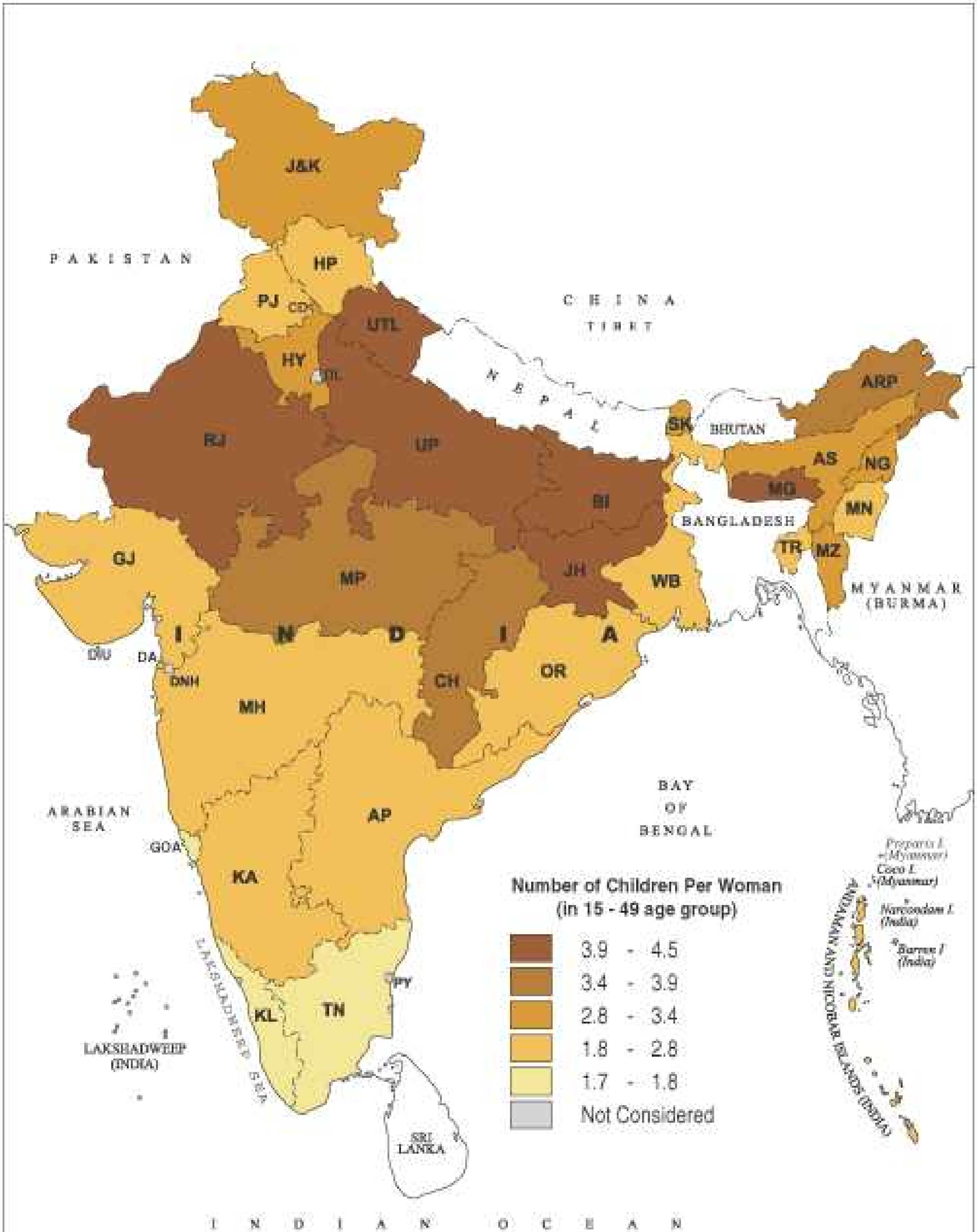
Table 1.2

Growth of population and average annual exponential growth rates 1981-91and 1991-2001

S.No	State / UT	Total Population		% decadal growth		Change in % decadal gorwth	Average annual exponential growth rate	
		1991 (in'000)	2001 (in'000)	1981 to 1991	1991 to 2001		1981 to 1991	1991 to 2001
1	A. & N. Islands	280.7	356.3	48.70	26.94	-21.76	3.97	2.39
2	Andhra Pradesh	66508.0	75727.5	24.20	13.86	-10.33	2.17	1.30
3	Arunachal Pradesh	864.6	1091.1	36.83	26.21	-10.63	3.14	2.33
4	Assam	22414.3	26638.4	24.24	18.85	-5.39	2.17	1.73
5	Bihar	64530.6	82878.8	23.38	28.43	5.05	2.1	2.50
6	Chandigarh	642.0	900.9	42.16	40.33	-1.84	3.52	3.39
7	Chhatisgarh	17614.9	20796.0	25.73	18.06	-7.67	2.29	1.66
8	Dadra & Nagar Haveli	138.5	220.5	33.57	59.20	25.63	2.89	4.65
9	Daman & Diu	101.6	158.1	28.62	55.59	26.97	2.52	4.42
10	Delhi	9420.6	13783.0	51.45	46.31	-5.14	4.15	3.81
11	Goa	1169.8	1344.0	16.08	14.89	-1.19	1.49	1.39
12	Gujarat	41309.6	50597.0	21.19	22.48	1.29	1.92	2.03
13	Haryana	16463.6	21083.0	27.41	28.06	0.65	2.42	2.47
14	Himachal Pradesh	5170.9	6077.2	20.79	17.53	-3.26	1.89	1.62
15	Jammu & Kashmir	7803.9	10069.9	30.34	29.04	-1.30	2.65	2.55
16	Jharkhand	21843.9	26909.4	24.03	23.19	-0.84	2.15	2.09
17	Karnataka	44977.2	52734.0	21.12	17.25	-3.87	1.92	1.59
18	Kerala	29098.5	31838.6	14.32	9.42	-4.90	1.34	0.90
19	Lakshadweep	51.7	60.6	28.47	17.19	-11.28	2.51	1.59
20	Madhya Pradesh	48566.2	60385.1	27.24	24.34	-2.91	2.41	2.18
21	Maharashtra	78937.2	96752.2	25.73	22.57	-3.16	2.29	2.04
22	Manipur	1837.1	2388.6	29.29	30.02	0.73	2.57	2.63
23	Meghalaya	1774.8	2306.1	32.86	29.94	-2.93	2.84	2.62
24	Mizoram	689.8	891.1	39.70	29.18	-10.51	3.34	2.56
25	Nagaland	1209.5	1988.6	56.08	64.41	8.33	4.45	4.97
26	Orissa	31659.7	36706.9	20.06	15.94	-4.12	1.83	1.48
27	Pondicherry	807.8	973.8	33.64	20.56	-13.08	2.9	1.87
28	Punjab	20282.0	24289.3	20.81	19.76	-1.05	1.89	1.80
29	Rajasthan	44006.0	56473.1	28.44	28.33	-0.11	2.5	2.49
30	Sikkim	406.5	540.5	28.47	32.98	4.51	2.51	2.85
31	Tamil Nadu	55858.9	62110.8	15.39	11.19	-4.20	1.43	1.06
32	Tripura	2757.2	3191.2	34.30	15.74	-18.56	2.95	1.46
33	Uttar Pradesh	131998.8	166052.9	25.55	25.80	0.25	2.28	2.30
34	Uttaranchal	7113.5	8479.6	24.23	19.20	-5.03	2.17	1.76
35	West Bengal	68078.0	80221.2	24.73	17.84	-6.89	2.21	1.64
	India	846387.9	1027015.2	23.86	21.34	-2.52	2.14	1.93

Source: Census of India - 2001

TOTAL FERTILITY RATE



Map No. 1.1

the best intention and implementation of this policy, population size could probably overshoot the desired limits before settling down at an acceptable level. This is because a high population growth in the past results in a large population currently in their reproductive years. So, even if the total fertility were reduced, the sheer quantum of young people would lead to a large number of births. In 2001, 15.42 per cent of the total population was between 0–6 years. For the country as a whole (excluding Jammu and Kashmir), there has been an increase by about 6.4 million children during the decade 1991–2001. However, in as many as thirteen states and union territories, a decline in the absolute number of children during this period has been observed.

1.1.4 Decadal Growth of Population

The percentage decadal growth of population in India during 1991–2001 has registered the sharpest decline since independence. It has declined from 23.86 per cent for 1981–1991 to 21.34 per cent for the period 1991–2001, a decrease of 2.52 percentage points (Table 1.2).

The percentage decadal growth of population in the inter-census period 1991–2001 varied from a low of 9.42 per cent in Kerala to a very high 64.41 per cent in Nagaland. Delhi with 46.31 per cent, Chandigarh with 40.33 and Sikkim with 32.98 registered very high growth rates, whereas the small union territories of Dadra and Nagar Haveli and Daman and Diu also registered very high growth rates. In addition to Kerala, Tamil Nadu and Andhra Pradesh registered low growth rates during 1991–2001. The decadal growth in population (percentage increase over the last census) has declined during the census decade 1991–2001 in all the states and union territories except Haryana, Uttar Pradesh, Bihar, Sikkim, Nagaland, Manipur, Gujarat, Daman and Diu and Dadra and Nagar Haveli. These mentioned states and union territories that have shown increases in per cent decadal growth together constitute about 32 per cent of India's population. Daman and Diu, Dadra and Nagar Haveli and Nagaland especially recorded a high percentage growth in population during the last decade: 26.97, 25.63 and 8.33 respectively. Bihar and Uttar Pradesh are still in the stage of transition where the number of births outweighs other factors; so, constant efforts and programmes need to be targeted at these states to abate the pressure of population, similar to the programmes Tamil Nadu, Andhra Pradesh and Kerala have embarked on. States such as Jammu and Kashmir, Himachal Pradesh, Punjab, Meghalaya, Orissa, Madhya Pradesh, Maharashtra, Karnataka, Goa, Kerala and Tamil Nadu and the union territory of Chandigarh have shown a decline of one to five percentage points in their growth during 1991–2001 as compared to 1981–1991, and these twelve states and union territories together account for 37.54 per cent of the total population. Andhra Pradesh, Arunachal Pradesh and Mizoram have shown an impressive fall in decadal growth rate by over ten percentage points within a short span of a decade. On the whole, India witnessed a decline in the growth of population between 1991 and 2001.

Population is an important resource of human development and wealth, yet it can prove to be a major cause of environmental degradation. Population impacts on the environment are primarily through the use of natural resources and production of wastes, which result in environmental stresses such as loss of biodiversity, air and water pollution and increased pressure on arable land. The impact of population depends on the sensitivity of the environment and this is not always predictable, as there are certain thresholds, which, if crossed, lead to rapid depletion and degradation. Resources such as fisheries, forests and groundwater have a maximum sustainable yield, beyond which they will be unable to replenish themselves. Sinks for our wastes, such as soils, rivers, lakes, oceans and atmosphere, have critical loads for various pollutants, beyond which important aspects of their productivity will degrade.

1.1.5 Human Footprint on Environment

The demand of people on natural resources is typically measured in terms of human footprint. A human footprint is a measure of the per capita demand of the population of a country on natural resource use. It measures the amount of forestland needed, the amount of grazing land needed and the amount cropland needed to meet the average requirement of a person. Accordingly, it is called the forest footprint, grazing land footprint, cropland footprint and finally the ecological footprint, which is a combination of the demands on all types of land.

The World Wide Fund for Nature's "Living Planet Report 2002", measures the standards of living and human development impact on natural resources through Living Planet Index and Ecological Foot print. Living Planet Index (LPI) is based on trends in populations of hundreds of species of birds, mammals, reptiles, amphibians and fish.

Ecological Footprint (EF) is a measure of the consumption of renewable natural resources by a human population, be it that of a country, a region or the whole world. The report reveals that humans are using over 20 per cent more natural resources each year than can be regenerated. And the figure is growing every year. This means that by 2050, two earths will be needed to cope with our resource demands.

The LPI clearly shows that the current human consumptive pressure is unsustainable. Over the past 30 years, the LPI has declined by about 37 per cent. The consumption of natural resources in terms of ecological footprint is 2.3 hectares per person. While the footprint of the average African or Asian consumer was less than 1.4 hectares per person in 1999, the average Western European's footprint was about 5.0 hectares. The average North American's was 9.6 hectares.

The foot print measure is ideal to show the overall demand of people on natural resources in the world. It tells us about the demand of the people that would lead to the exploitation of natural resources worth so many hectares. It does not reveal the impact of this on the environment of their country. It is because, the apparent consumption concept measures the consumption of a region's population and it measures its impact in terms of land area needed to satisfy these demands. For example the ecological footprint of northern American is 9.6 hectares, whereas that of an Asian is only 1.4 hectares. It does not mean that Asia is environmentally more sustainable. It only shows that Americans need that much of land to meet their demands. It may be coming from Australia or Europe or Asia. If USA imports Australian livestock product and Dutch dairy products and Malaysian wood products, its foot print is distributed on these nations and it is not completely reflected in USA itself. Thus consumption of USA may lead to over exploitation in some other parts of the world such as Latin America and China and not necessarily all of it in USA.

Thus the ecological footprint only measures the size and not the location of the footprint and hence is not the right measure for assessing the natural resource sustainability and livelihood sustainability of a location with in the country. The consequent livelihood problems of the poor the respective countries due to over exploitation of their resources, is not apparent in the ecological footprint concept. Removal of vegetative cover due to over grazing, depletion of soil fertility due to high yields, or disruption of water sheds and water availability, non availability of forest foods and free fuel wood due to commercial felling of the forests and so on come under this category. Hence we did not use the footprint method to assess the sustainability. Instead we have considered the indicators that reflect the pressure of population and livestock on land resources in chapter 5.

Although the rate of growth of population in India is on the decline from the previous decade, India has to watch the environmental resource base that underpins agriculture. India needs to pay attention to the sustainable carrying capacity of the environment in her ongoing path to economic development. The focus should be on improving the quality of life within the Earth's capacity. Ensuring access to basic resources and improving the health and livelihoods of the India's poorest people cannot be tackled separately from maintaining the integrity of natural ecosystems.

1.2 Land Utilization

The land utilization statistics of India are not comparable over a period of time, as the reporting area has been extending. Besides, uniform definitions have not been followed. The definitions adopted here are given in the appendix (Appendix 1.1). The more difficult terrain in forested areas was surveyed only in recent decades. The area under illegal occupation by China and Pakistan is not included in the reporting area of Jammu and Kashmir. For the states of Arunachal Pradesh and Himachal Pradesh, the difference between reporting area for land utilization statistics and geographical area is way over 10 per cent. The analysis for these states may, therefore, not be completely reliable. For the rest of the states the geographical area is close to reporting area and the changes are quite reliable. Yet, a trend increase as well as actual area increase under some categories can be misleading.

Natural ecosystems differ widely. Some may have forests and others have plains and deserts. All natural ecosystems have their functionality. The flora, fauna and the native human population of the ecosystems left untouched are well balanced. Forests are complex and productive ecosystems. They are also huge repositories of biodiversity. In mountains and hills, they contribute to the health of watersheds and regulate the quantity and quality of downstream rivers. They enhance the productivity of agro-ecosystems by recharging soil nutrients, assimilating and recycling chemicals released by fertilizers and pesticides and creating and preserving soil. They play a vital role in controlling global climate change through the process of carbon sequestration. Rural and tribal people look to the forests to provide them with food, medicines, fuels, oils, resins, construction material, etc. Apart from forests, permanent pastures and grazing lands also play an essential role in sustainable food security. These pastures and grazing lands are vital to livestock security.[1]

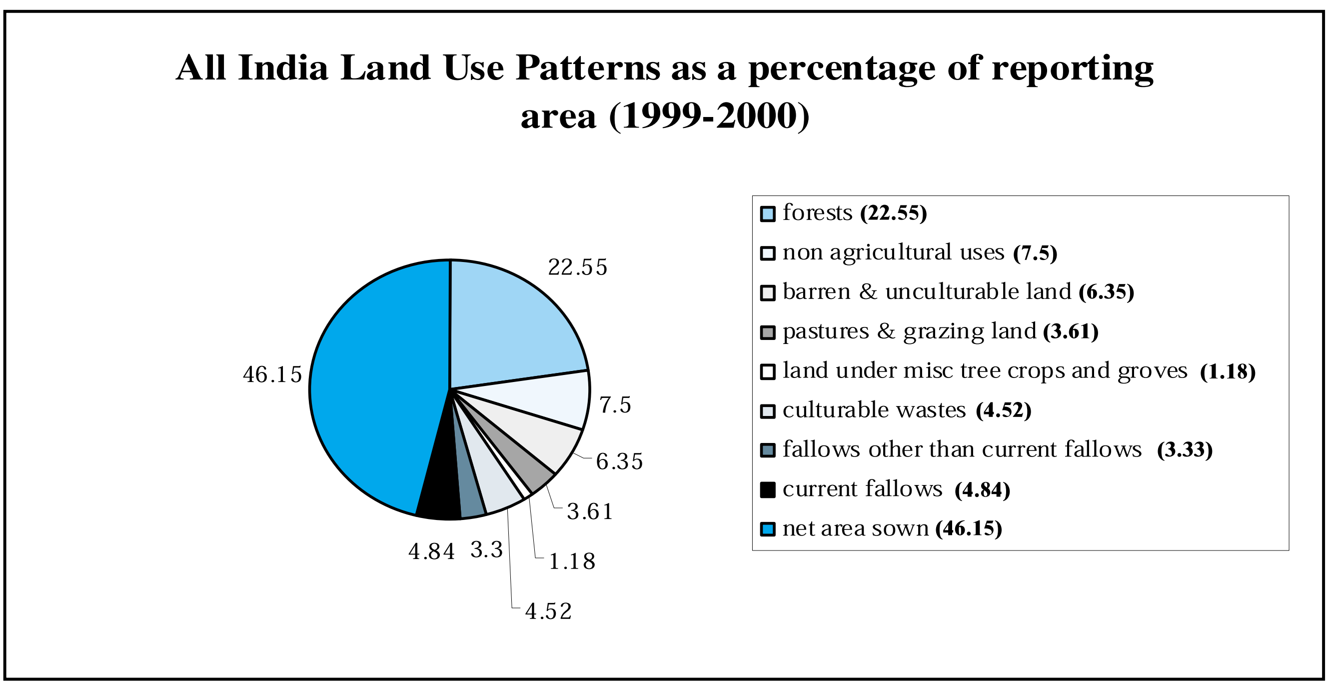
[1] "The last sheep farmer in the Lubéron Mountains of France, grazes his flock on 36 acres of pasture and sends them off in the summer to wild mountain meadows, a land-intensive and expensive method underwritten by cheques from the European Union and the French government. His lamb is never sold outside the region, much less overseas." (New York Times, June 2003) The European countries are increasingly realizing the importance of natural methods of feeding animals and balancing the pressure on the ecosystems, while developing countries are over exploiting their natural resources. The imbalances in land use caused by national and international market pressures will be considered in a separate section.

Current fallows also serve a purpose. Traditionally, land is left fallow as a method of replenishing its nutrients and restoring productivity. However, if land is left fallow for reasons such as the unremunerative nature of farming, poverty of the cultivator, inadequate water supply, silting of canals etc., then to bring these areas under cultivation these issues must be addressed. Fallow land is now considered wasteful and crop rotation, growing leguminous crops and mixed cropping are preferred to letting land lie fallow. The untapped potential of fallows if harnessed could boost food production and provide benefits to poor and marginal farmers. Culturable wastes sometimes play an important role as watersheds. Bringing these areas under cultivation may prove to be detrimental to food security in the long run. Only those culturable wastes that do not play a role as watersheds may be considered as potential arable lands. States that have a good proportion of their area under forests, substantial tree cover and adequate pastures and grazing lands are environmentally more sustainable. Only when human activity upsets the balance, then food production and livelihood support systems become unsustainable. Ideally, one should study sustainability of the land utilization against the benchmark of a period of lowest exploitation. However, the data does not permit such bench marking because of changes in the reporting area.

Arable land consists of net sown area and the current fallow land. Converting as much land as possible into arable land is neither ecologically stable nor desirable. Instead, one should give priority to land-saving technologies. Thus, sustainability is closely related to the preservation of the natural ecosystem. In turn, it means resisting the temptation to convert all land into cropland.

Arable land as a percentage of geographical area in India is about 51 per cent, one of the highest in the world (Figure 1.1). Compare this to France (31.8 per cent), Pakistan (23.9 per cent), United Kingdom (29.6 per cent), Burma (27.4 per cent), United States

Figure 1.1



(20.4 per cent), Japan (13 per cent) and Australia (5.8 per cent).[2] While India has 2.4 per cent of the world's geographical area, Indians constitute 16 per cent of the world's population. With 0.5 per cent of the world's grazing area, the country supports over18 per cent of the world's cattle population (Planning Commission 2002a).

The all-India land utilization pattern for 1999–2000 shows that the area put to non-agricultural uses is 1.18 per cent. There has been an increase in area put to non-agricultural uses over a period. It increased from 9357 thousand hectares in 1950–1951 to 22967.21 thousand hectares in 1999–2000. Total fallow lands show a decline while the net sown area has been steadily increasing. A substantial part of this increase in net sown area took place before the mid-sixties. Pastures and grazing lands have declined since then. The area of land under miscellaneous tree crops and groves has been declining for the last fifty years. While forests have shown an increase, this could be because there was an increase in the reporting area under forests, misreporting of plantation crops as forest area and under-reporting in the earlier years. The practice of including all legal forest area as forest irrespective of actual use may have lead to an over estimation (Appendix 1.2). The major observations on land utilization patterns across the states over a period of 25 years, from 1974–1975 until 1999–2000, has been summed up (Appendix 1.3).[3]

The land put to non-agricultural uses increased in all most all the states, witnessing a shift of area to human activities. Probably a part of it comes from prime agricultural land and forests being used for the expansion of cities, towns and industries. Jammu and Kashmir and Punjab seems to have de-industrialized their rural areas, showing a decline in non-agricultural activities.

Barren and unculturable land has declined, probably due to wasteland development and shift to net sown area. However, it is important to note that many states have very little area left as unculturable waste, except Orissa and Punjab. This is an indication of the limitations to waste land development and the desirability of extending net sown area against the possibility of improving yields on the existing land.

India has very little land under permanent pastures despite it having the largest cattle population in the world. In the past twenty-five years, pastures have reduced further to a mere 3.6 per cent of the geographical area.

Over twenty-five years, the other fallow land has increased slightly for the country as a whole. It is interesting to note that in the states such as Tamil Nadu, other fallows constitute as much as 8.8 per cent of the reporting area. Current fallows are declining in the country across the states. However, the current fallows are of a higher percentage of the reporting area in Andhra Pradesh, Tamil Nadu, Rajasthan and Karnataka, probably as a result of the frequent droughts in some areas of these states.

Net sown area constitutes a very high per cent in India. It is the highest in Punjab, constituting more than 84 per cent of the reported area. Haryana is also close behind with 80 per cent. In some states it has declined, probably at the expense of a shift to non-agricultural uses. In many states it has increased at the expense of forestland, permanent pastures and culturable waste.

To conclude, land use patterns show an increase in the net area sown at the expense of forests, land under tree crops and groves and permanent pastures and grazing lands. Punjab and Haryana show extremely low forest cover and very high percentage

[2] www.krishiworld.com

of net sown area. Madhya Pradesh, Orissa and the northeastern states have substantial forest cover. There is scope to bring more area under cultivation in Meghalaya, Rajasthan, Andhra Pradesh, Bihar, Tamil Nadu, Karnataka, Nagaland and Mizoram because of the presence of large areas of fallows. However, one should not target these areas without first assessing their ecological functionality.

1.3 Net Sown Area

Much of the arable land in India is under cultivation because a large percentage of people are dependant upon agriculture. The scope for realizing very high yields of net sown area is limited under rain-fed subsistence farming and small size of the holdings. Though it is ideal to increase the productivity substantially on some lands and reduce the total land under cultivation, it is not possible to do so in India as the livelihoods of many depend upon a piece of land, however small it may be. Until the country is able to shift a large per cent of population out of agriculture, a higher net sown area remains a sign of food security and livelihood security. Larger areas under crops and lesser area under natural habitat may upset the ecological balance.

The area under cultivation in proportion to the total area in India is one of the largest in the world. Net sown area constitutes 46.15 per cent of the total reporting area. In 1974–1975, this was 45.41 per cent. In Punjab, it is the highest, increasing from 81.30 per cent to 84.21 per cent over the 25-year period taken into consideration. Fallow land and culturable wastes have seen a corresponding decline. Haryana is not very far behind with 80.72 per cent of its reporting area classed as net sown area. Other states that have a larger proportion of their reporting area as net area sown, compared the all-India average, are Gujarat, Karnataka, Kerala, Maharashtra, Uttar Pradesh and West Bengal. Gujarat has seen a rather dramatic increase in this per centage from 42.22 to 51.39. A corresponding decline in fallows has been observed. West Bengal has recorded a decline in net sown area as a per cent of reporting area from 69.84 per cent in 1974–1975 to 62.97 per cent in 1999–2000, and area devoted to non-agricultural uses has increased at the expense of the net sown area. Maharashtra has also seen a slight decline in the proportion of net sown area with a corresponding increase in fallows. The northeastern states of Arunachal Pradesh, Tripura, Manipur, Meghalaya and Nagaland have seen an overall increase in the net sown areas but the proportions remain extremely small. Other states with a much smaller proportion than the rest of the country are Himachal Pradesh, Jammu and Kashmir, Sikkim and Assam. Orissa has increased this percentage from 36.80 in 1974–1975 to 39.01 in 1999–2000 by reducing its fallow lands. Goa has reduced its culturable wasteland and thus has been able to increase its net sown area as a per cent of reporting area from 35.95 per cent to 39.19 per cent. Rajasthan has increased the percentage of net sown area from 40.73 per cent to 45.27 per cent. Andhra Pradesh and Bihar have recorded a decline in the net sown area. This has been accompanied by an increase in fallows in Andhra Pradesh and an increase in area put to non-agricultural uses in Bihar.

For the country as a whole, out of the total net sown area about 40 per cent is irrigated and the remaining 60 per cent is rain-fed. The net sown area has increased from 118.7 million hectares in 1949–1950 to 136.2 million hectares in 1960–1965 and then increased slowly to reach 140.26 million hectares by 1970–1971. Thereafter, the net sown area has been fluctuating and has shown a slow increase. The peak level of 142.9 million hectares was reached by 1990–1991. Thereafter, the area declined to about 141 million hectares—a decline of about 1.78 million hectares. The decline in the past decade could be because some of the agricultural land was converted into land put to non-agricultural uses, whereas more of wasteland was converted into net sown area. On the balance, the net impact may have been a reduction in the net sown area. Increased fallows also could be an important contributor to the decline of net sown area in absolute terms.

The undivided states of Madhya Pradesh and Uttar Pradesh as well as Maharashtra, being large have more net sown area than other states as of 1998–1999. The gross cropped area in actual area is the highest in Uttar Pradesh. Population pressure on land is more obvious when we consider the per capita availability of agricultural land. The net sown area per capita shows

Table 1.3

Statistics Related to Agricultural Land - 1998-99

S.No	State	Net Sown Area (NSA) ('000 hec.)	Per Capita Net Sown Area hec./person	% of Net Irrigated Area to NSA	Weighted NSA ('000 hec.)	Change in NSA from 1991-92 to 1998-99 (percent.)	GCA ('000 hec.)	Per Capita GCA	Cropping Intensity	Irrigation Intensity
1	Andhra Pradesh	10978	0.15	41.34	5108.60	-0.57	13625	0.18	124	134
2	Arunachal Pradesh	185	0.17	19.46	69.90	24.16	250	0.22	135	100
3	Assam	2701	0.11	21.18	1039.10	-0.18	3941	0.15	146	100
4	Bihar	7431	0.08	49.55	3702.10	-3.68	10053	0.10	135	129
5	Goa	142	0.09	15.49	51.40	7.58	171	0.11	120	155
6	Gujarat	9674	0.21	31.61	4125.40	4.12	10702	0.23	111	124
7	Haryana	3628	0.19	78.34	2225.20	3.42	6320	0.33	174	177
8	Himachal Pradesh	549	0.09	18.76	205.90	-4.36	970	0.15	177	178
9	Jammu and Kashmir	733	0.08	42.16	343.50	-0.14	1081	0.11	147	145
10	Karnataka	10489	0.21	23.76	4143.50	-2.05	12312	0.24	117	125
11	Kerala	2259	0.07	16.60	827.70	0.49	2917	0.09	129	112
12	Madhya Pradesh	19839	0.26	33.07	8575.70	2.46	26011	0.34	131	104
13	Maharashtra	17732	0.20	16.61	6498.00	-0.91	22155	0.25	125	116
14	Manipur	140	0.06	46.43	68.00	0.00	216	0.09	154	115
15	Meghalaya	221	0.10	21.72	85.50	9.41	266	0.12	120	115
16	Mizoram	109	0.12	8.26	36.30	67.69	116	0.13	106	111
17	Nagaland	261	0.17	24.14	103.50	34.54	286	0.18	110	116
18	Orissa	6048	0.17	34.56	2650.40	-4.56	8425	0.24	139	113
19	Punjab	4238	0.18	94.48	2873.00	0.55	8117	0.35	192	187
20	Rajasthan	16073	0.31	34.21	7021.50	3.76	21401	0.41	133	124
21	Sikkim	95	0.18	16.84	34.90	0.00	127	0.24	134	100
22	Tamil Nadu	5635	0.09	53.58	2898.10	-1.59	6627	0.11	118	120
23	Tripura	277	0.08	12.64	97.10	5.32	444	0.13	160	171
24	Uttar Pradesh	17585	0.11	72.17	10351.90	2.14	26609	0.16	151	139
25	West Bengal	5440	0.07	35.13	2396.40	-0.68	9290	0.12	171	130
	All India	142600	0.15	40.01	65605.10	0.79	192619	0.20	135	132

Source: GOI, Agricultural Statistics at a glance, Department of Agriculture & Cooperation, 2000

GOI, Census of India, Registrar General and Census Commissioner, 2001

GOI, 2002, "Statewise land use classification and irrigated area" in Land Use Ststistics At A Glance (1997-98 & 1998-99)

Department of Agriculture and Cooperation, Ministry of Agriculture, CMIE, "Agriculture", - 2001, data pertains for the year 1991-92

GCA - Gross Cropped Area

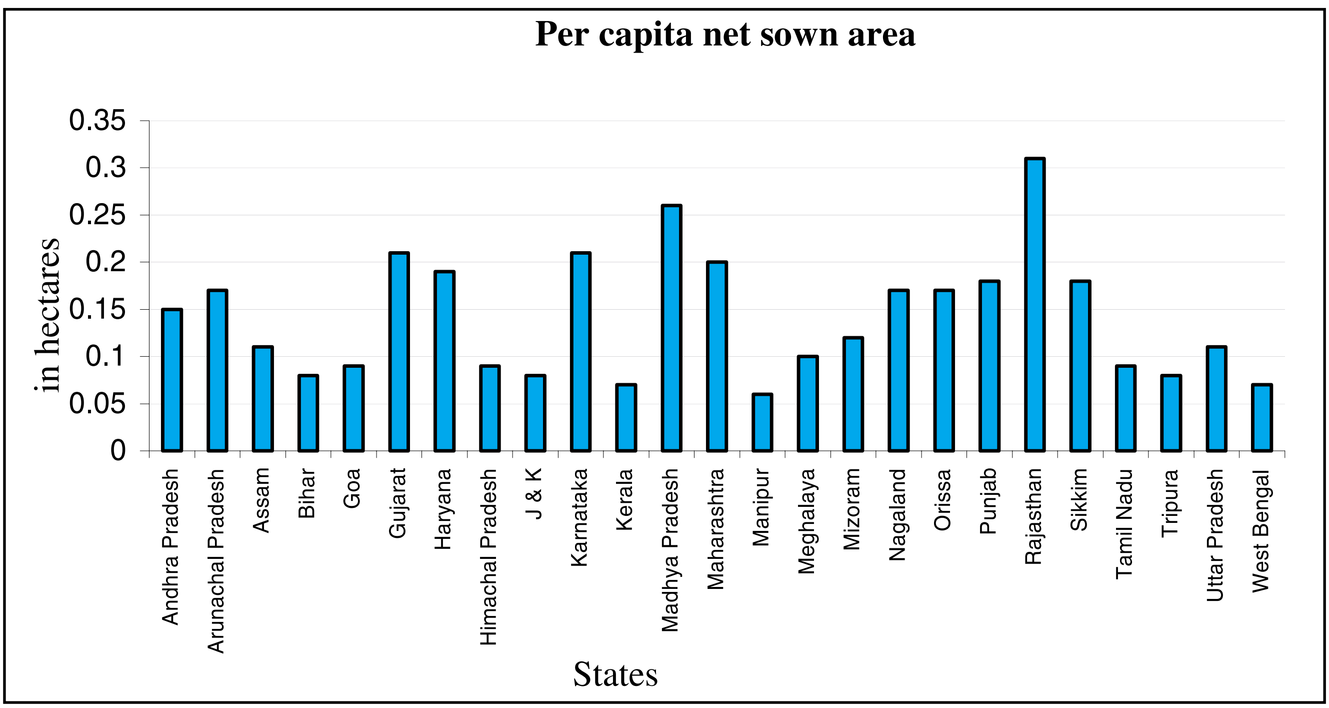
that it is the highest in Rajasthan and Madhya Pradesh at 0.31 and 0.26 hectares. It is the lowest in Manipur at 0.06 followed by 0.07 in Kerala and West Bengal and 0.8 in Bihar, Jammu and Kashmir and Tripura. The net sown area per person at the national level is 0.15 hectares (Table No. 1.3 and Figure 1.2).

In contrast, the gross cropped area per capita in the same year was highest in the state of Rajasthan at 0.41, followed by Punjab at 0.35 hectares. Remarkable land-augmenting technologies have made Punjab food secure. Gross cropped area per person is the lowest in Manipur, Kerala and Bihar: between 0.09 and 0.10. Gross sown area per person is 0.20 hectares at the national level.

The larger the net sown area, the better the position of the state in terms food production. However, the fertility of the land differs. Irrigation is one of the important factors that determines the yields. Irrigated yields are 70 per cent higher than the un-irrigated yields. A weight of 0.70 was assigned to irrigated land and a weight of 0.30 was assigned to un-irrigated land to arrive at the weighted average net area sown.

Weighted net sown area makes interstate comparison more meaningful. In other words, weighted net sown area reflects the quality of land based on irrigation status. The weighted net sown area represents the available land resource of the state. The larger the net sown area expressed in weighted form, the better the prospect of the state to produce more food. With land resources available, it is possible to both intensify production through double cropping and to diversify production to livestock or to horticultural crops. The net sown area symbolizes present food security, and it has been included as one of the indicators of present food security in the final Sustainability Index.

Figure 1.2: Per capita Net Sown Area, 1998–1999



Source: Agricultural Statistics at a glance, 2000, Department of Agriculture & Cooperation

The weighted net sown area ranges from a low of 35 thousand hectares in Sikkim to a high of 10 million hectares in Uttar Pradesh. Weighted net sown area puts Uttar Pradesh on the top of the list. Madhya Pradesh comes next with over 8 million hectares weighted area sown; Rajasthan, Maharashtra and Andhra Pradesh follow. Smaller states, apart from Sikkim, with smaller land resources are Mizoram, Goa, Manipur and Arunachal Pradesh (Table 1.3 and Map 1.2)

1.3.1 Changes in the Net Sown Area

The change in net sown area in recent years is an important indicator of the potential of the land resources to be either augmented or destroyed. Since most of the arable land was brought under the plough by the end of eighties, the decline in net sown area could be either because of degradation of the soils or the shift of prime agricultural land to other uses such as the extension of townships or use for industrial purposes. States that show a negative trend in net sown area in the recent years face a greater threat to their food security than the states that show an expansion trend. Hence, change in net sown area has been taken as the indicator of present food security.

However, the expansion or the shrinkage of net sown area may not be a contributing factor to the sustainability of agriculture. Hence, whereas it is considered as an indicator of food security it is not a sustainability indicator. Ideally, the changes in the net sown area should be studied along with the changes in the soil fertility in the state. Soils vary across the states and the depletion of fertility is very difficult to estimate; hence, the net sown area is used as a poor proxy indicator. Those states where the net sown area is expanding are considered as better off in respect of present food security.

The states that recorded an expansion in net sown area in the recent years are the Mizoram, Arunachal Pradesh and Nagaland. The expansion, between 1991 and 1999, ranged from about 68 per cent in Mizoram to about 35 per cent in Nagaland, and 24 per cent in Arunachal Pradesh. Orissa, (4.5 per cent) Himachal Pradesh (4.36 per cent) and Bihar (3.7 per cent) experienced a negative trend in net sown area over the same period. Karnataka and Tamil Nadu followed suit with a decline of 2.05 per cent and 1.59 per cent respectively. Smaller negative changes are seen in the states of Andhra Pradesh, Assam, Maharashtra and West Bengal (Map 1.3).

1.3.2 Cropping Intensity

Cropping intensity is measured as a ratio of the gross sown area to net sown area and is expressed as a percentage. The gross sown area was about 35 per cent more than the net sown area for the country as a whole during the year 1998–1999. This could be attributed to the spread of irrigation, especially the area under well irrigation in the 1990s. Apart from the increased irrigation, the increasing cropping intensity can also be attributed to the health and moisture retention capacity of the soil. Better soils have higher cropping intensity. For example, West Bengal has higher cropping intensity despite having only 35 per cent of area under irrigation and an irrigation intensity of only 130.

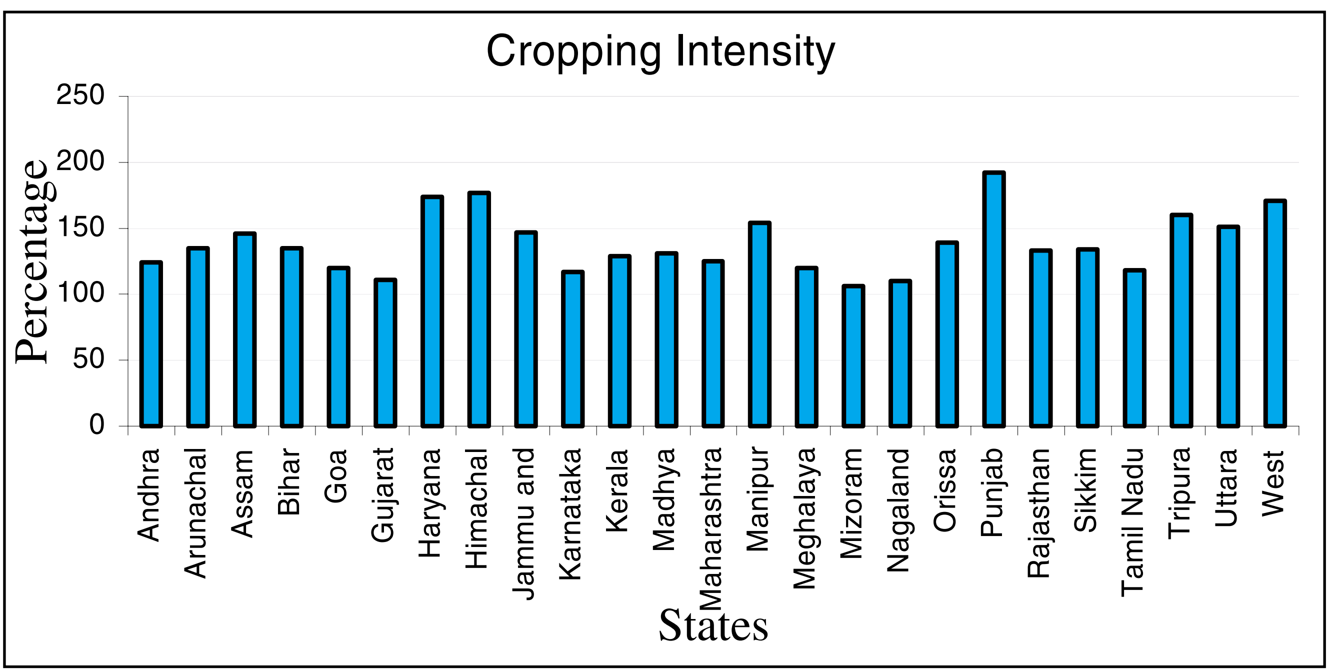
Though many states recorded a higher cropping intensity than the national average during the year 1998–1999, there are very wide inter-state variations. Punjab (92 per cent) followed by Himachal Pradesh (77 per cent), Haryana (74 per cent) and West Bengal (71 per cent) show high cropping intensities. Other than West Bengal, these states also show a high level of irrigation intensity, between 170 and 187. Just like cropping intensity, irrigation intensity is the ratio of gross irrigated area to net irrigated area. (Table 1.3, Fig 1.3 and Map 1.4)

1.4 Changes in Cropping Pattern

As the gross cropped area increased in the country, some regions in particular have experienced a shift in the cropping pattern. This section considers the changes in the cropping pattern over time at the all-India level and at the state level, and draws conclusions on what these changes could mean for the sustainable food production in the states. One has to be clear about the crops that occupy prime agricultural land and others that have been relegated to marginal lands. The shift in the cropping pattern becomes more meaningful when we study the change over an average period of three years rather than the change between individual years. Triennium averages ending in 1960 and 2000 have been worked out to study decadal changes at an all-India level. At the state level, the analysis is restricted to changes from the triennium ending in 1990 to the triennium ending in 2000.

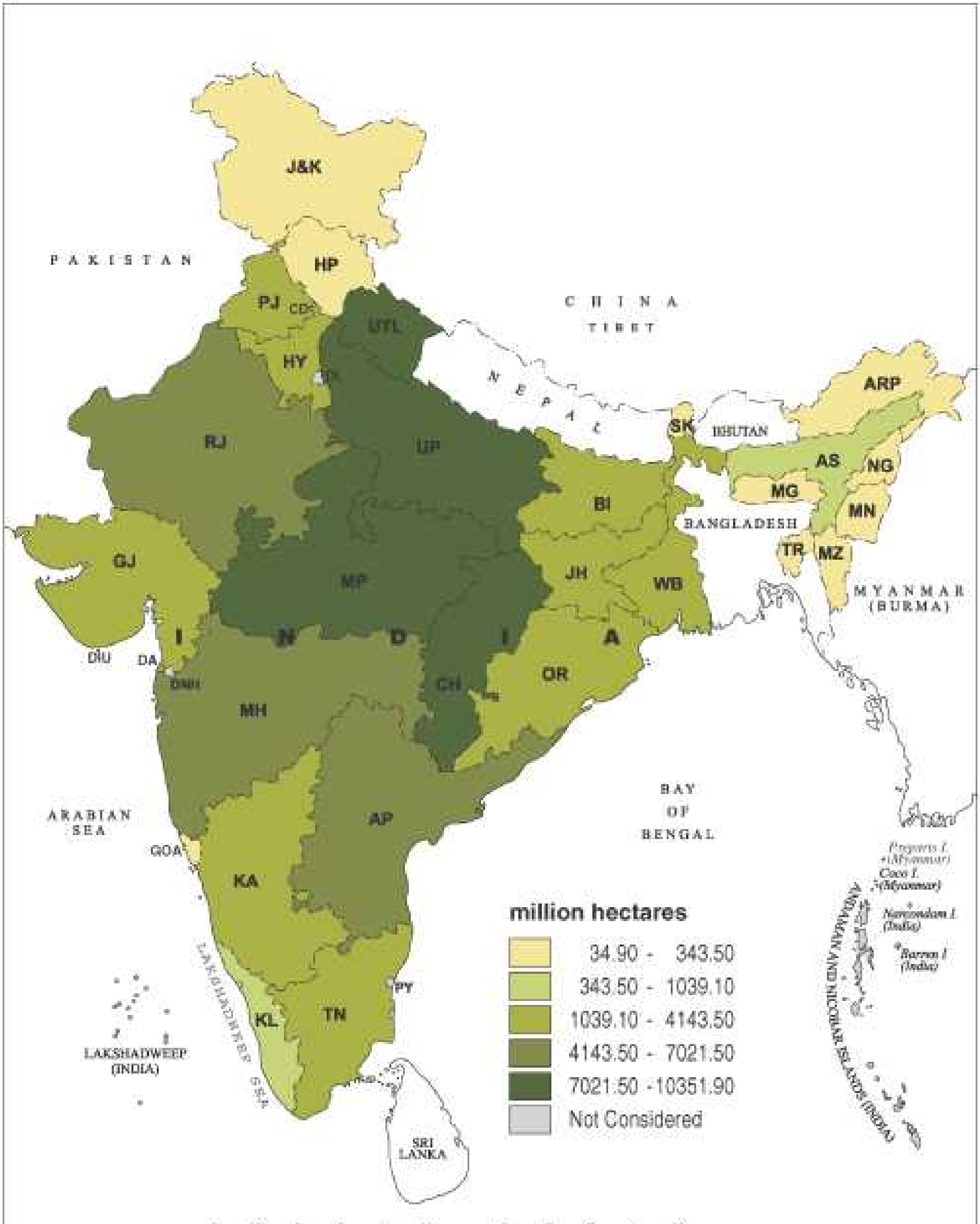
All India: The area under food grain production as a per centage of the gross cropped area has declined in India from the triennium ending in 1960 to the triennium ending in 2000 (Table 1.4). A closer look at the data reveals that most of the decline has taken place in the last two decades. The percentage of gross cropped area under food grains fell from 74.38 per cent in the triennium ending 1980 to 65.4 per cent in the triennium ending in 2000, and that the area under non-food grains rose from 25.6 per cent to 34.6 per cent. Within the category of food grains, the proportion of area under cereals fell from over 60 per cent to around 53 per cent; most of this decline occurred after 1980. The proportion of the gross cropped area under rice has more or less remained unchanged, whereas that under wheat has increased from 8.45 per cent to over 14 per cent in the same period. The area under coarse cereals as a per cent of the gross cropped area has declined from over 29 per cent to less than 16 per cent. Most of the decline has taken place after the seventies. The area under pulses as a per cent of the gross cropped area has also declined from over 16 per cent in 1960 to around 12 per cent in 2000.

Figure 1.3: Cropping Intensity (1998-1999)



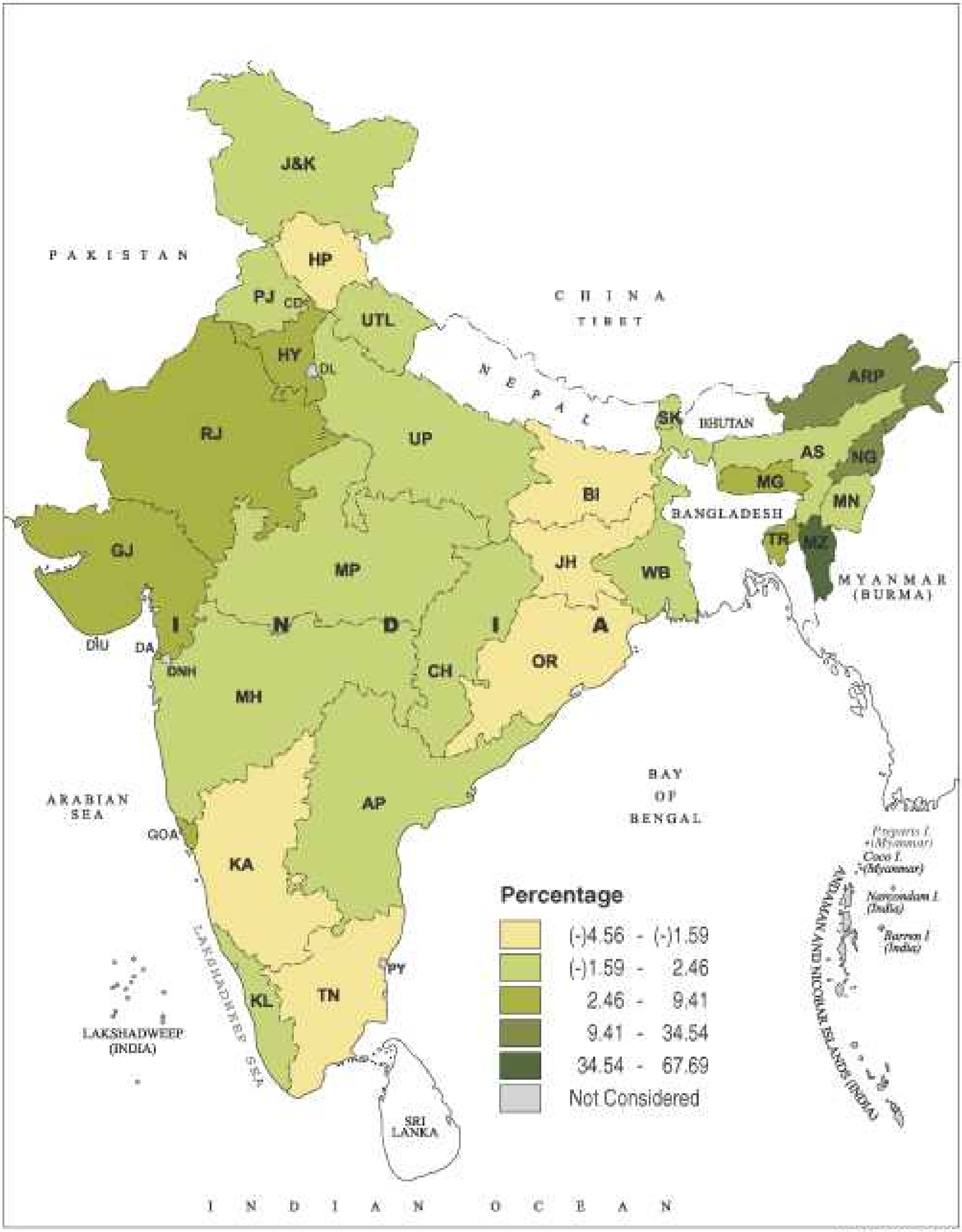
Source: Ministry of Agriculture and Cooperation, Government of India.

NET SOWN AREA (WEIGHTED)



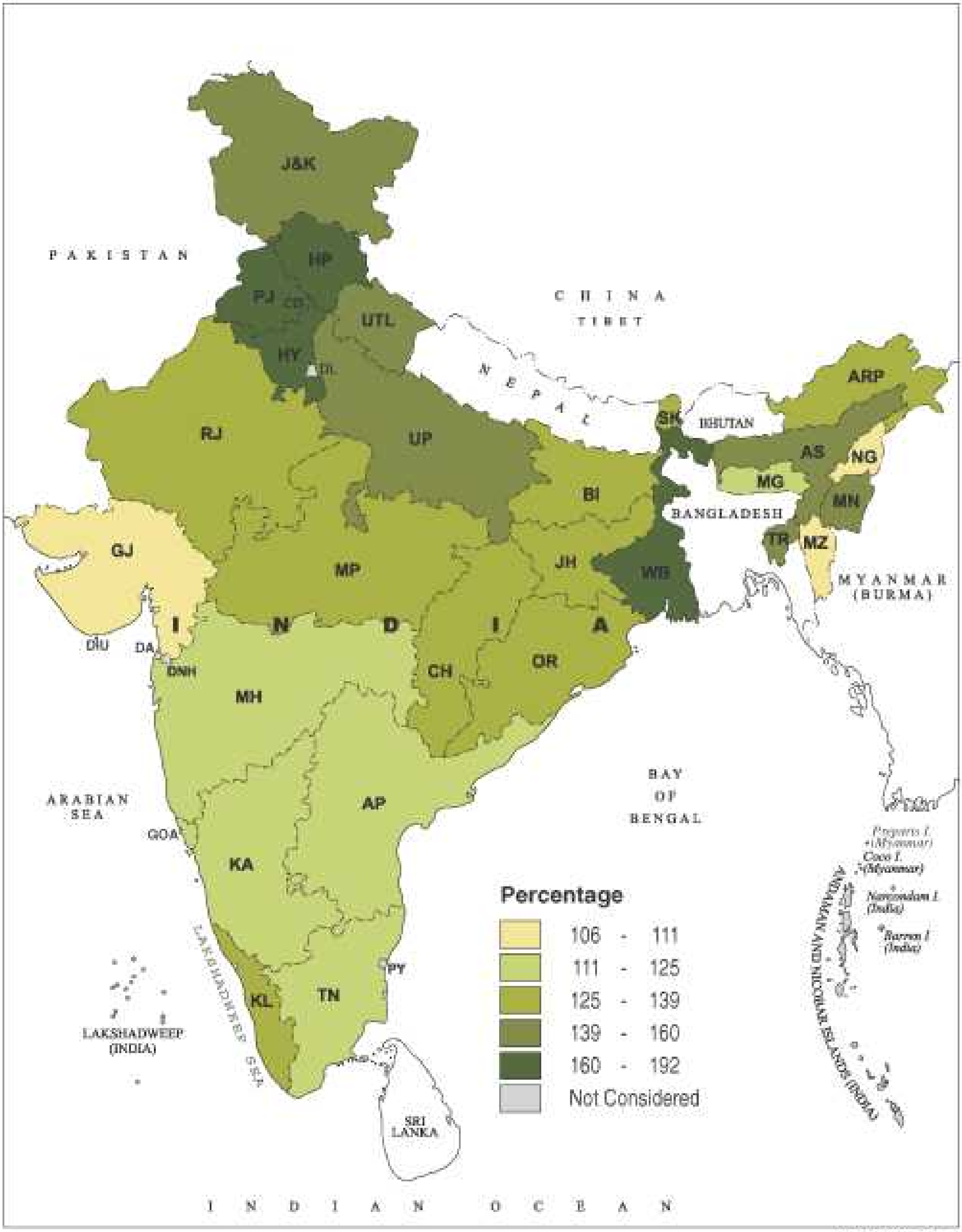
Map No. 1.2

CHANGE IN NET SOWN AREA (1991-92 TO 1998-99)



Map No. 1.3

CROPPING INTENSITY



Map No. 1.4

The area under oilseeds has increased, though the increase has been greater for non-edible oilseeds. In 1970, the area under edible oilseeds as a per cent of the gross cropped area was 8.63 per cent while the area under total oilseeds as a per cent of the gross cropped area was 8.88 per cent. In 2000, the percentages for the two were 12.61 per cent and 14.51 respectively. The gap between edible and total oilseeds has widened in the last two decades. The proportion of area under sugarcane, spices and condiments and fruits and vegetables has increased in the period considered.

The area irrigated as a percentage of area cropped has more than doubled for both food grains and non-food grains, the percentages being 42.12 per cent and 33.88 per cent respectively in the triennium ending 2000. A closer examination of the data reveals that area irrigated as a per cent of the area cropped has increased substantially for rice from 36 per cent in the sixties to over 51 per cent around 2000 and that of wheat has increased dramatically from around 32 per cent to over 86 per cent over the same period. However, for coarse cereals the area irrigated as a per cent of area cropped has increased only marginally from 7.65 per cent to 11.82 per cent in this period. Area irrigated as a per cent of the area cropped has increased very slightly for pulses: from 8.67 per cent in 1960 to about 12.28 per cent in 2000 (Table 1.5).

Among the non-food grains, though the proportion of area irrigated has increased substantially for oilseeds, sugarcane and spices and condiments, the area irrigated as a per cent of area cropped in 2000 was only 24 per cent for oilseeds as opposed to 52 per cent for spices and condiments and 92.4 per cent for sugarcane. These figures reaffirm the secondary status occupied by coarse cereals and pulses among food grains and oilseeds among non-food grains.

Table 1.4

Area under Crops as a Percent of Gross Cropped Area - All India

Items	Triennium ending				
	1960	1970	1980	1990	2000
Rice	22.23	22.70	23.39	22.95	23.32
Wheat	8.45	9.85	12.81	13.22	14.28
Coarse Cereals	29.45	28.91	24.52	21.12	15.76
Cereals	60.14	61.46	60.73	57.29	53.36
Pulses	16.15	14.13	13.65	12.69	12.08
Food-Grains	76.29	75.59	74.38	69.98	65.44
Edible Oil Seeds	N.A	8.63	8.72	11.14	12.62
Total Oil Seeds	8.66	8.88	8.95	12.48	14.51
Sugarcane	1.41	1.54	1.88	1.88	2.19
Total Condiments & Spices	0.92	1.04	1.26	1.12	1.22
Total Fruits & Vegetables	1.70	2.22	2.68	3.56	4.22
Non-Food Grains	23.71	24.41	25.62	30.02	34.56

Source: GOI, Ministry of Agriculture "Indian Agricultural Statistics" - 1997 and www.agricoop.nic.in

Note: Calculations are based on the data given in the Source, N. A -Not Available

States: Whereas the nineties have witnessed an over seven per cent increase in the gross cropped area for the country as a whole, the experience in states has been varied. States that have recorded a substantial increase in gross cropped area in the past decade were Mizoram, Nagaland and Rajasthan. Some states have, however, experienced an absolute decline in the gross cropped area. These include Sikkim, Kerala, Orissa, Bihar, Tamil Nadu and Himachal Pradesh.

A study of the state-level data on cropping patterns reveals that rice is the major crop in the east and the northeast states and in the southern states of Tamil Nadu and Andhra Pradesh. Wheat is predominantly grown in Punjab, Haryana, Himachal Pradesh and Uttar Pradesh. A considerable portion of the gross cropped area in Rajasthan, Karnataka, Maharashtra, Himachal Pradesh, Jammu and Kashmir and Sikkim is devoted to growing coarse cereals. Pulses are important crops in Madhya Pradesh, Rajasthan, Maharashtra, Orissa and Karnataka. Edible oilseeds are grown on around 13 per cent of the gross cropped area for the country as a whole, but this figure is much higher for Gujarat, Madhya Pradesh and the southern states. States that have a sizeable portion of their gross cropped area devoted to the production of non-food grains are Kerala, Gujarat, Goa, Andhra Pradesh, Meghalaya and Tamil Nadu.

The data on the cropping patterns of the past decade show that at the all-India level, there has been a shift away from food grains towards non-food grains, and within the category of food grains, a shift away from cereals. The decline has been the highest for coarse cereals. The superior cereals of rice and wheat appear to have benefited from the fall in the area under coarse cereals. The major factor responsible for the predominance of the superior cereals (rice and wheat) was the price incentive provided by the procurement prices. Certain states continue to take advantage of the procurement and minimum support prices offered by the government. Cropping patterns are highly sensitive to price. Price movements can explain, to some extent, the shift to the superior cereals and some of the non-food crops (Kumar 1993; Kelly 19 97). A study of the state-level data reveals that the shifts in the cropping pattern have been more in certain states than in others.

Table 1.5

Crop Area Irrigated as a pecentage of total area under the crop - All India

Items	Triennium ending				
	1960	1970	1980	1990	2000
Rice	36.16	38.40	41.55	45.20	51.45
Wheat	32.30	48.26	66.31	78.80	86.09
Total Coarse Cereals	7.65	8.86	9.09	9.60	11.82
Total Cereals & Millets	21.66	26.08	33.67	39.80	48.95
Total Pulses	8.67	9.28	7.92	9.59	12.28
Total Food grains	18.91	22.94	28.94	34.31	42.12
Sugarcane	66.82	75.60	77.73	86.25	92.43
Total Oil Seeds	3.28	5.28	11.33	21.69	24.09
Spices & Condiments	22.76	28.96	39.40	46.05	52.21
Total Non-Food grains	15.15	18.26	24.52	31.41	33.88

Source: GOI, Ministry of Agriculture "Indian Agricultural Statistics" - 1997 and www.agricoop.nic.in

Note: Calculations are based on the data given in the Source

The situation in Punjab shows less diversification: a predominance of superior cereals being grown to the virtual exclusion of coarse cereals, pulses and edible oilseeds. Uttar Pradesh and Haryana have decreased the proportion of the gross cropped area under coarse cereals, pulses and edible oilseeds. Rajasthan has increased the proportion of its area under pulses and edible oilseeds, but has also seen a massive decline in the proportion of area devoted to growing coarse cereals. The southern states of Karnataka, Andhra Pradesh and Tamil Nadu have decreased the proportion of their gross cropped area under coarse cereals and edible oilseeds and increased the area under sugar cane. A continuation of this trend will prove to be less sustainable in the long run (Appendix 1.4, Appendix 1.5).

Madhya Pradesh has a reasonable proportion of its area under pulses and oilseeds, but the proportion of its area under coarse cereals is much smaller than the already inadequate all-India average. Maharashtra has a substantial percentage of its gross cropped area under coarse cereals. However, it shows a declining trend, which is worrying. Jammu and Kashmir and Himachal Pradesh have adequate area under coarse cereals but their performance as far as pulses are concerned leaves much to be desired. Orissa and West Bengal have very small areas under coarse cereals and edible oilseeds. Except Sikkim and Arunachal Pradesh, the other northeastern states confine themselves to growing rice among the cereals.

The proportion of area under oilseeds has declined for all the states in the north east region. Gujarat has decreased the proportion of its gross cropped area under coarse cereals and further increased the area under cultivation of non-food grains. Kerala has again increased its already large proportion of area under nonfood grains. This shift towards non-food grains is a trend clearly visible in nearly all the states in the country. The level of diversification of area under crops and under legumes is also an important indicator of the sustainability of food security and is discussed in the next section.

1.4.1 Diversification of Cropped Area and Impact on Sustainability

An important indicator of the sustainability of food production of any region is the diversification of area under crops. The higher the level of diversification, the more sustainable the food production. Diversification is important for food security as it is likely to increase sustainability of production and of livelihoods and encourages a more balanced diet among the people. Thus, all the three aspects of food security are taken care of by diversification.

1. The greater the diversification, the greater is the likelihood of different crops that require different soil nutrients being grown. A more diversified crop base is likely to include leguminous crops. Leguminous crops fix atmospheric nitrogen in the soil and replenish soil fertility.

2. Different crops have different water needs. Certain crops like rice and sugarcane have very high water requirements. Mono-cropping of these crops would result in very high water utilization and perhaps even ground water exploitation, as has been experienced in many a state. A state with a more diversified cropped area is likely to be more rational in its water use. Hence, it follows that greater diversification in the cropped area is likely to result in a more sustainable use of natural resources.

3. Diversification in the cropped area is also important for sustainable livelihoods. A diversified crop base greatly reduces the production risk in rain-fed agriculture, both from deficient as well as excess rainfall. Under conditions of deficient rainfall, crops requiring more water yield less, others requiring less water yield more. Even if some crops fail as a result of, say, a pest attack or high humidity, other crops may survive.

4. Diversification is an insurance against crop failure. Even in irrigated agriculture, farmers can grow more crops with less water, as the water needs of crops differ. More efficient use of water is possible.

5. Diversification also reduces the price risk for the farmer. A crash in the price of one crop will not affect the farmer who has a more diversified crop base as much as it will affect the farmer who cultivates only a single crop. Production and prices together determine the income. It thus follows that the income risk is greatly reduced with diversification.

6. From the point of view of consumption—for oneself and for the local communities—a more diversified crop base is more likely to fulfil the nutritional requirements of the people. Livelihood opportunities increase with diversification because of greater scope for agro processing and other value-added industries.

The Diversification Index

There is a better chance of diversification in subsistence farming compared to commercial farming. In commercial farming, to achieve economies of scale and to provide larger supplies of a crop, farmers are encouraged to take up monocropping. The area around sugar mills is a case in point. It was mandatory for the farmers to grow only sugar cane and supply it to the sugar mills. However, it is better to set up a number of agro-processing units of different scales for local production and consumption and give incentives to the small farmers to produce a variety of crops in rotation. This requires careful crop planning.

In this section, we attempt to study two levels of diversification and the changes witnessed in the extent of diversification over the last decade in the various states of the country. To capture the extent of diversification, the Area Diversity Index (ADI) has been calculated using the following formula (Indian Space Research Organization 2002)

$$ADI = 1 \div [\Sigma^{n}_{i=1} (a_i / \Sigma^{n}_{i=1} a_i)]^2$$

Where the summation 'Σ' is done over 'n' number of crops varying from 'i' to 'n'.

'a_i' stands for the area under the 'i'th crop.

ADI = Area Diversification Index.

The larger the value of 'n' and the greater the value of 'a' the greater will be the value of the Area Diversification Index. Both the percentage of area under each crop as well as the number of crops affect the diversification index. The higher the dominance of one crop, the lower the diversification index. Even if there are two crops, if one crop is cultivated in a large area and the second in a lesser area, the diversification index falls. The ADI of both food grains and all crops have been calculated for all the states. The ADI calculated for all India cannot be considered as an average. The country taken as a whole will have all the crops grown in all the states and, hence, it is obvious that the ADI for India will be higher than that of the states taken separately.

However, there are several limitations to the present study of diversification and the Diversification Index measured. Only the major categories have been calculated for food crops. Within each group, there are several individual crops that have not been considered. The entire non-food crop category is considered as one and, hence, the diversification index value will be lower. The main reason is the paucity of data. Data showing the break-up of each category into individual crops are not available. The study is, therefore, restricted to major categories and major crops.

The ADI of food grains with four categories: The Area Diversification Index (ADI) for food grains was calculated using a four-fold break up of food grains—rice, wheat, coarse cereals and pulses. The diversification of area under food grains indicated by the value of ADI was found to be the highest in Madhya Pradesh followed by Gujarat, Uttar Pradesh and Jammu and Kashmir. Of these four states, only Gujarat has seen an increase in the value of the ADI over the last decade. Even though Gujarat has only around 38 per cent of its gross cropped area under food grains, the distribution across these crops is not concentrated. Uttar Pradesh and Madhya Pradesh have shown a decline in the ADI of food grains because of the shift to superior cereals (Table 1.6).

States with a moderately high level of diversification are Haryana, Rajasthan, Karnataka, Himachal Pradesh, Maharashtra, Bihar and Andhra Pradesh. Haryana has seen a decline in the ADI because of an increase in the area under rice and wheat at the expense of pulses and coarse cereals. Andhra Pradesh has also seen a decline in the area under coarse cereals, which has caused the value of the ADI to fall. Karnataka, Rajasthan and Maharashtra have traditionally had a large percentage of their cropped area under coarse cereals. The increase in the value of the ADI in these states indicates a shift away from coarse cereals and a diversification into rice and wheat. Bihar has seen a decline in the area under pulses, which has caused the ADI to fall. Sikkim, Tamil Nadu, Punjab, Arunachal Pradesh and Nagaland have moderate levels of diversification. The extent of diversification has fallen in Sikkim and Tamil Nadu but has remained unchanged in Punjab. The diversification is only moderate in Tamil Nadu because it has no area under wheat. It has fallen in the last decade because the area under rice has increased at the expense of pulses and coarse cereals.

The eastern states of West Bengal and Orissa, the northeastern states of Manipur, Meghalaya, Mizoram and Tripura, and Goa and Kerala show low levels of diversification. This is so in Kerala because it has only around 14 per cent of its gross cropped area under food grains. Thirteen per cent of its gross cropped area is under rice. The area under pulses and coarse cereals together constitute less than one per cent of the gross cropped area and the state grows no wheat. The east and the northeastern states and Goa are rice-growing states with hardly any area under the other cereals and pulses.

ADI with eight categories: The ADI for all crops has been calculated using an eight-fold break up of all crops—rice, wheat, coarse cereals, pulses, edible oilseeds, sugarcane, spices and condiments and other crops. The category of other crops includes fruits and vegetables and all the non-food crops. Here again, Madhya Pradesh followed by Karnataka, Andhra Pradesh, Rajasthan, Uttar Pradesh, Tamil Nadu and Haryana have high levels of diversification among all crops. All these states except Haryana have large areas under edible oilseeds.

The fall in the extent of diversification in Madhya Pradesh and Haryana can be explained by the fall in the ADI of food grains. The ADI for all crops has increased over the last decade in Karnataka and Rajasthan. In Rajasthan, this can be attributed to the

Table 1.6

State wise area diversification index for food grains and all crops for 1990 and 2000

S.No	State	ADI for food grains		ADI for all crops	
		1990	2000	1990	2000
1	Andhra Pradesh	2.65	2.43	4.90	4.89
2	Arunachal Pradesh	1.85	1.98	2.85	3.20
3	Assam	1.22	1.19	2.25	2.15
4	Bihar	2.62	2.52	3.15	3.10
5	Goa	1.10	1.44	2.01	2.17
6	Gujarat	2.51	3.25	3.80	4.29
7	Haryana	3.07	2.84	4.85	4.60
8	Himachal Pradesh	2.68	2.61	3.31	3.32
9	Jammu and Kashmir	3.21	3.14	4.29	4.30
10	Karnataka	2.38	2.65	4.52	5.05
11	Kerala	1.11	1.14	1.96	1.76
12	Madhya Pradesh	3.94	3.79	5.70	5.58
13	Maharashtra	2.26	2.53	3.96	4.19
14	Manipur	1.06	1.10	1.28	1.58
15	Meghalaya	1.55	1.55	3.04	2.80
16	Mizoram	1.24	1.39	1.77	2.29
17	Nagaland	1.48	1.87	2.28	2.76
18	Orissa	2.09	1.73	3.44	2.83
19	Punjab	2.18	2.19	3.34	3.23
20	Rajasthan	2.22	2.78	3.95	4.88
21	Sikkim	2.81	2.37	5.24	4.20
22	Tamil Nadu	2.71	2.22	5.02	4.68
23	Tripura	1.09	1.09	2.05	2.08
24	Uttar Pradesh	3.36	3.15	4.83	4.78
25	West Bengal	1.28	1.22	2.08	2.14
	All India	3.74	3.75	5.92	6.06

Source: GOI, Ministry of Agriculture-"Area and Production of Principal Crops in India"-1990-93

GOI, Reports of the Commission For Agricultural Costs and Prices for the Crops Sown

During 2000-2001 Season, Department of Agriculture and Co-operation, Ministry of Agriculture, New Delhi- 2001

GOI, Ministry of Agriculture "Indian Agriculture in Brief"- Jan 2000, Webside: http://agricoop.nic.in/statistics/st3.htm.

increase in area under edible oilseeds and non-food crops. In Karnataka, this has been because of an increase in diversification among food grains. States that have moderately high levels of diversification are Gujarat, Jammu and Kashmir, Maharashtra and Sikkim. The ADI for Gujarat has increased because of an increase in diversification among food grains and an increase in area under edible oilseeds and sugarcane. The increase in diversification in Maharashtra can again be attributed to the diversification among food grains. The levels of diversification have substantially fallen in Sikkim over the last decade because of a decrease in diversification among food grains and also because the state no longer grows edible oilseeds. In 1990 it had around ten per cent of its area under edible oilseeds. The extent of diversification in Punjab and Himachal Pradesh is not very high because both these states grow mostly food grains. Himachal Pradesh has only around thirteen per cent of its gross cropped area under non-food grains. The ADI has fallen as the state has decreased the area under all the non-food grains. The east and the northeastern states again have moderate to low levels of diversification because these states mostly grow food grains and the extent of diversification among food grains is low. Kerala shows a very low value of ADI and though it has diversified, the diversification has taken place among non-food crops. For the purpose of our analysis, all the non-food crops have been clubbed together.

1.4.2 Area under Legumes

It is vital to have an adequate area under leguminous crops to ensure sustainable crop patterns. This is so for several reasons. Most legumes can convert nitrogen gas from the air into ammonia, a soluble form of nitrogen that can be readily utilized by plants. These nitrogen contributions of legumes are extremely important to maintain the fertility of the soil (National Academy of Sciences 1979). They are rich in proteins and the amino acid profile of their proteins is complementary to that of cereals. Leguminous crops are adapted to harsh and marginal agro-ecological conditions and they fit into varying cropping patterns. They are an important source of nutrition and income for poor farmers (Singh 1992).

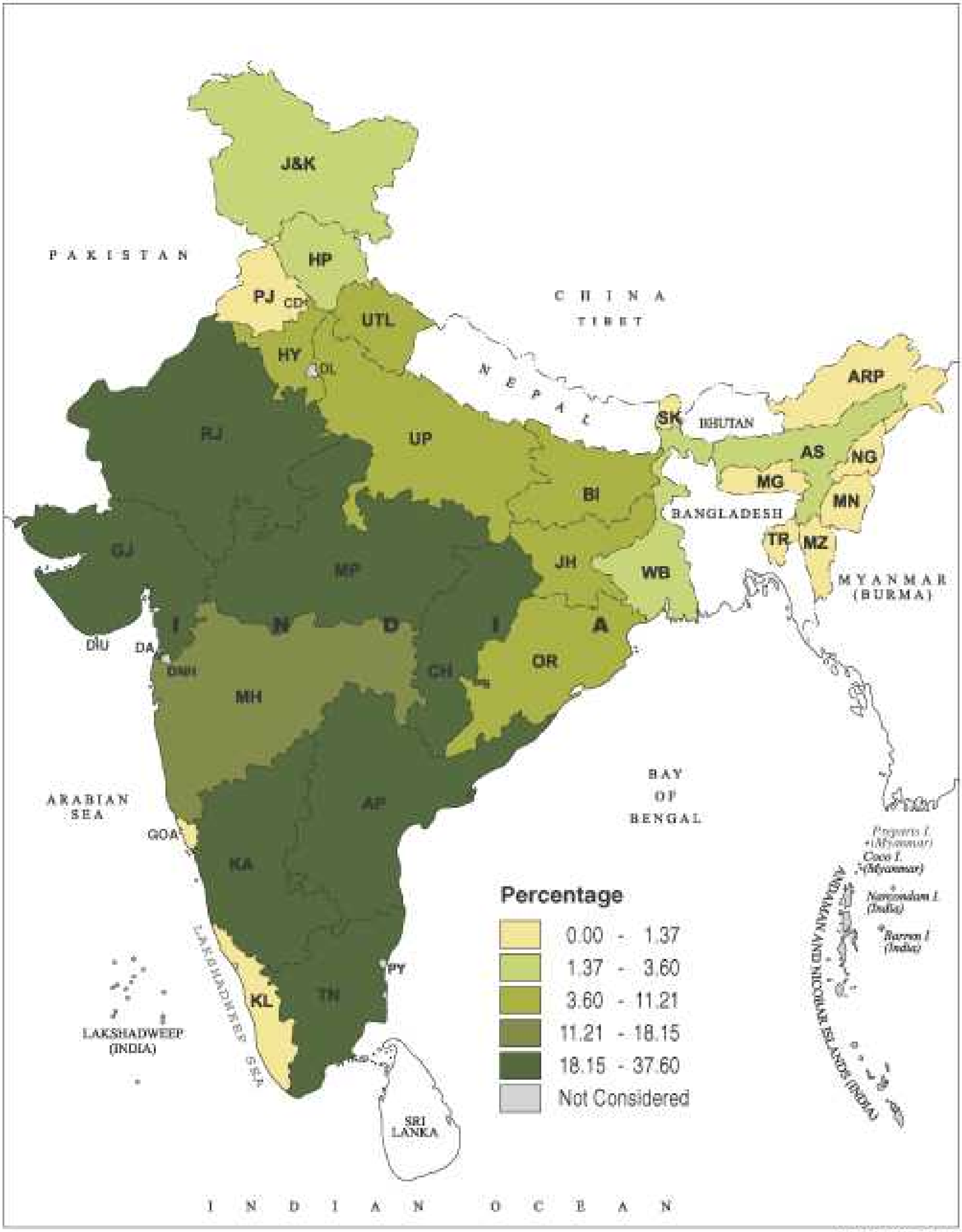
Leguminous crops include gram, tur, other pulses, groundnut and soybean. There are several other crops including fodder crops, which are legumes. They have been excluded because of lack of data.

Tripura, Sikkim, Nagaland, Mizoram, Manipur, Arunachal Pradesh, Meghalaya, Goa, Punjab and Kerala have less than 1.37 per cent of their gross cropped area under legumes. Not very far behind are West Bengal, Jammu and Kashmir, Assam and Himachal Pradesh. They have only between 1.37 and 3.60 per cent of their gross cropped area under leguminous crops. Haryana, Bihar, Orissa and Uttar Pradesh have between 3.6 and 11.21 per cent of their gross cropped area under legumes. Maharashtra has 18.15 per cent of its gross cropped area under leguminous crops. The states that show a fairly large area under leguminous crops are Karnataka, Andhra Pradesh, Tamil Nadu, Gujarat, Rajasthan and Madhya Pradesh. These states have between 12.15 and 37.60 per cent of their gross cropped area under leguminous crops. It is essential that states that have a very small area under leguminous crops introduce these crops in their cropping cycles and ensure sustainability of cropping systems (Table 1.7 and Map 1.5).

1.5 Land Degradation

Land degradation refers to changes in the quality of soil, water, terrain, biotic resources and other characteristics that result in the loss of the biological or economic productivity of the land. Land degradation, whether on farm or off farm, adversely

AREA UNDER LEGUMES TO GROSS CROPPED AREA



Map No. 1.5

affects agricultural production. Forests and tree cover play an important role in watersheds. Degradation of forests and other natural habitats for expansion of agriculture, industrial and urban use and river valley projects threaten the sustainability of watersheds. Crop yields are dependant on certain soil characteristics—soil nutrient content, water-holding capacity, organic matter content, acidity, top-soil depth and soil biomass and so on. Degradation constitutes erosion, compaction and hard setting, acidification, declining soil organic matter, soil fertility depletion, and biological degradation and soil pollution (Lal 1990).

To evaluate the extent of soil degradation in thirteen Asia Pacific countries, the Food and Agricultural Organization (FAO) carried out a literature review in 1986. Thirty one per cent of the total geographical area in these countries was found degraded, with the highest incidence (>30 per cent) in China, India, Laos, Thailand and Vietnam. Soil nutrient depletion, water logging and salinity were the major problems in these areas. Seghal and Abrol (1994) studied the results of the National Soil Surveys of India and drew certain conclusions about the scale and productivity effects of soil degradation. They found that although no significant degradation affects 36 per cent of the land area in India, 5 per cent of the land is suffering from low degradation (<15 per cent loss in yield), 11 per cent from moderate degradation (15–33 per cent yield loss), 43 per cent from high degradation (33–67 per cent yield loss) and 5 per cent has become so degraded that soils are unusable.

The Soil and Conservation Division of the Department of Agriculture and Cooperation has come up with some rather disturbing figures concerning the extent of degradation in India. Almost 53 per cent of the geographical area of India is susceptible to soil erosion from wind and water and degradation, and is referred to as a problem area. Twelve per cent of the geographical area is flood-prone and 79 per cent is drought-prone.

A state-wise analysis reveals that the entire geographical area of Rajasthan and over 94 per cent of the geographical area of Haryana is susceptible to soil erosion and land degradation. In Gujarat,

Table 1.7

Percentage of area under leguminous crops

S.No	States	Percentage of Leguminous crops to gross cropped area (1998-99)
1	Andhra Pradesh	25.89
2	Arunachal Pradesh	0.00
3	Assam	3.14
4	Bihar	8.94
5	Goa	0.00
6	Gujarat	26.25
7	Haryana	6.77
8	Himachal Pradesh	3.60
9	Jammu and Kashmir	2.92
10	Karnataka	25.21
11	Kerala	1.37
12	Madhya Pradesh	37.60
13	Maharashtra	18.15
14	Manipur	0.00
15	Meghalaya	0.00
16	Mizoram	0.00
17	Nagaland	0.00
18	Orissa	9.56
19	Punjab	1.03
20	Rajasthan	26.42
21	Sikkim	0.00
22	Tamil Nadu	26.01
23	Tripura	0.00
24	Uttar Pradesh	11.21
25	West Bengal	2.49

Source: Department of Agriculture and Cooperation, Ministry of Agriculture, CMIE, “Agriculture”, - 2001, Page 106 -124 & 146-151, Legumes include Gram, Arhar, Other Pulses, and Groundnuts, data pertains to year 1998-99

Nagaland, Maharashtra and Punjab, the problem area constitutes over 60 per cent of the geographical area. The states that are better off in this respect are Tamil Nadu, Himachal Pradesh and the northeast states of Tripura, Mizoram, Arunachal Pradesh and Manipur, where the problem area constitutes between 27 per cent and 34 per cent of the geographical area (Table 1.8).

1.5.1 Factors Causing Land Degradation

The major causes of land degradation are

(1) Unsustainable agricultural practices such as extensive and frequent cropping of agricultural areas, excessive use of fertilizers, shifting cultivation without adequate period of recovery and inappropriate choice of crops and technologies.

(2) Unsustainable water management, which includes excessive use of ground water without recharge, causing depletion of the ground water-table and poor and inefficient irrigation practices. The over-abstraction of ground water, particularly in coastal areas, results in saline intrusions into aquifers.

(3) Land use changes such as converting prime forest land into agricultural land, diverting agricultural land and pastures and grazing land to other uses (for example, urbanization) result in degradation of the lands.

(4) Uncontrolled logging and illegal felling, forest fires, shifting cultivation without allowing for the regeneration of the forests, grazing in forest land and unsustainable use of fuel wood, all result in degradation of forests.

(5) Industrial and mining activities resulting in discharge of industrial effluents into water causes land degradation. This results in not only a loss in productivity but also in the degeneration of biodiversity. Disposal of solid and toxic wastes into land renders the land useless, and could also result in the contamination of ground water. Unplanned open-cast mining and dumping of

Table 1.8

Estimates of total problem area susceptible to soil erosion and land degradation as a percentage of the geographical area

S No	States	Problem area as a % of geographical area
1	Andhra Pradesh	44.47
2	Arunachal Pradesh	31.69
3	Assam	38.23
4	Bihar	37.68
5	Goa	54.05
6	Gujarat	64.21
7	Haryana	94.14
8	Himachal Pradesh	34.38
9	Jammu and Kashmir	8.81
10	Karnataka	59.46
11	Kerala	49.79
12	Madhya Pradesh	46.72
13	Maharashtra	64.50
14	Manipur	32.87
15	Meghalaya	49.13
16	Mizoram	28.94
17	Nagaland	62.61
18	Orissa	50.11
19	Punjab	64.14
20	Rajasthan	100.00
21	Sikkim	42.68
22	Tamil Nadu	29.39
23	Tripura	26.60
24	Uttar Pradesh	44.55
25	West Bengal	48.48

Source: GOI,"Indian Agriculture in Brief", 27th edition, Ministry of Agriculture

Note: For the state of Jammu and Kashmir, the area under illegal occupation by China and Pakistan is not considered for calculating the percentage mine refuse in the vicinity of agricultural lands causes these lands to turn into wastelands.

(6) Increased livestock pressure also causes large tracts of lands to degrade slowly and ultimately turned barren. The number of livestock grazing on forestlands has increased from 35 million in 1957–1958 to 90 million in 1995. This has resulted in degradation of substantial areas of forests. A third of the total feed intake is by grazing on Common Property Resources (CPR). Whereas the area of CPRs has come down between 1950 and 1997, the livestock population in this period has increased from 292 to 467 million (Velayutham 2000). Continuous overgrazing by herds has turned these lands into marginal or wastelands. The livestock population in India has been steadily increasing while pastures and grazing lands have been declining. Depletion of vegetation leads to a loss in the regeneration potential of these lands.

1.5.2 Common Types of Land Degradation

Soil erosion: Soil erosion is responsible for over 71 per cent of the land degradation in India. Of this 71 per cent, soil erosion due to wind contributes to about 61.7 per cent and soil erosion due to water contributes to about 10.24 per cent (GOI, Status of Desertification 1999). The factors involved in the initiation and course of wind erosion are the velocity of the wind at ground level and the direction of the wind, the soil characteristics, the vegetative cover and the length of the area along the direction of the wind (Chepil 1963). The severity of wind erosion increases when human beings interfere with the natural equilibrium conditions between soil, vegetation and climate.

Soil erosion by water occurs under the action of rainfall, melting snow, furrow irrigation and stream flow. When the intensity of rainfall exceeds the capacity of the soil to absorb it, this results in run off and hence erosion on sloping lands. Vegetative cover determines the exposure of the soil surface and the extent to which the topsoils are bound by roots. It reduces the impact of rain and retards run off and soil movement (Venkatraman 1992).

Soil salinity and alkalinity: Saline soils and alkaline soils contain excessive concentrations of soluble salts (sodium chloride, sodium sulphate etc.) and exchangeable sodium respectively. The main effects of salinity on plant growth are slow and insufficient germination of seeds, physiological drought, stunted growth, small leaves, short stems and branches, retarded flowering, sterility and smaller seeds, blue-green leaf colour and growth of salt-tolerant weeds, all of which result in low yields.[4] Some of the ways human beings are responsible for the accumulation of salts in the soils are irrigation with ground water containing excess of carbonate and bicarbonate ions, run off from adjoining undrained basins, indiscriminate use of irrigation waters of different qualities, and a rise in the ground water tables as a consequence of mismanagement of irrigation command.

Water logging: Water logging occurs when the total quantity of water introduced into the soils from various sources exceeds the total quantity disposed off through natural drainage processes plus the total quantity used by crops to meet their physiological needs. This may take the form of either surface ponding or ground-water levels rising. Excess water hinders plant growth by reducing aeration, which in turn decreases the water absorption and nutrient uptake by roots.

The Central Board of Irrigation and Power has defined a waterlogged area as one where the water table rises to an extent that the soil pores in the root zone of a crop become saturated, resulting in restriction of the normal circulation of air, decline in the level of oxygen and increase in the level of carbon dioxide. Whether a water table would be considered harmful depends on the crop, soil type and quality of water. The actual depth of water tables, when it starts affecting the yield of crops, may vary from zero for rice to 1.5 millimetres for other crops. The natural causes of water logging are poor natural drainage of subsoil, submergence under floods and deep percolation from rainfall and hydraulic pressures from saturated areas located at higher elevations. The artificial causes of water logging are high-intensity irrigated agriculture without considering soil and subsoil conditions, excessive closing of irrigated fields by embankments, seepages from canals, and blocking, choking and poor maintenance of natural drainage (Singh 1998). According to a World Bank study, India loses 1.2–2 million tonnes of food grain production every year due to water logging. (ICAR 1999) Geographical Representation shows the land degradation of various types (Geographical representation 1).

1.5.3. Wastelands in India

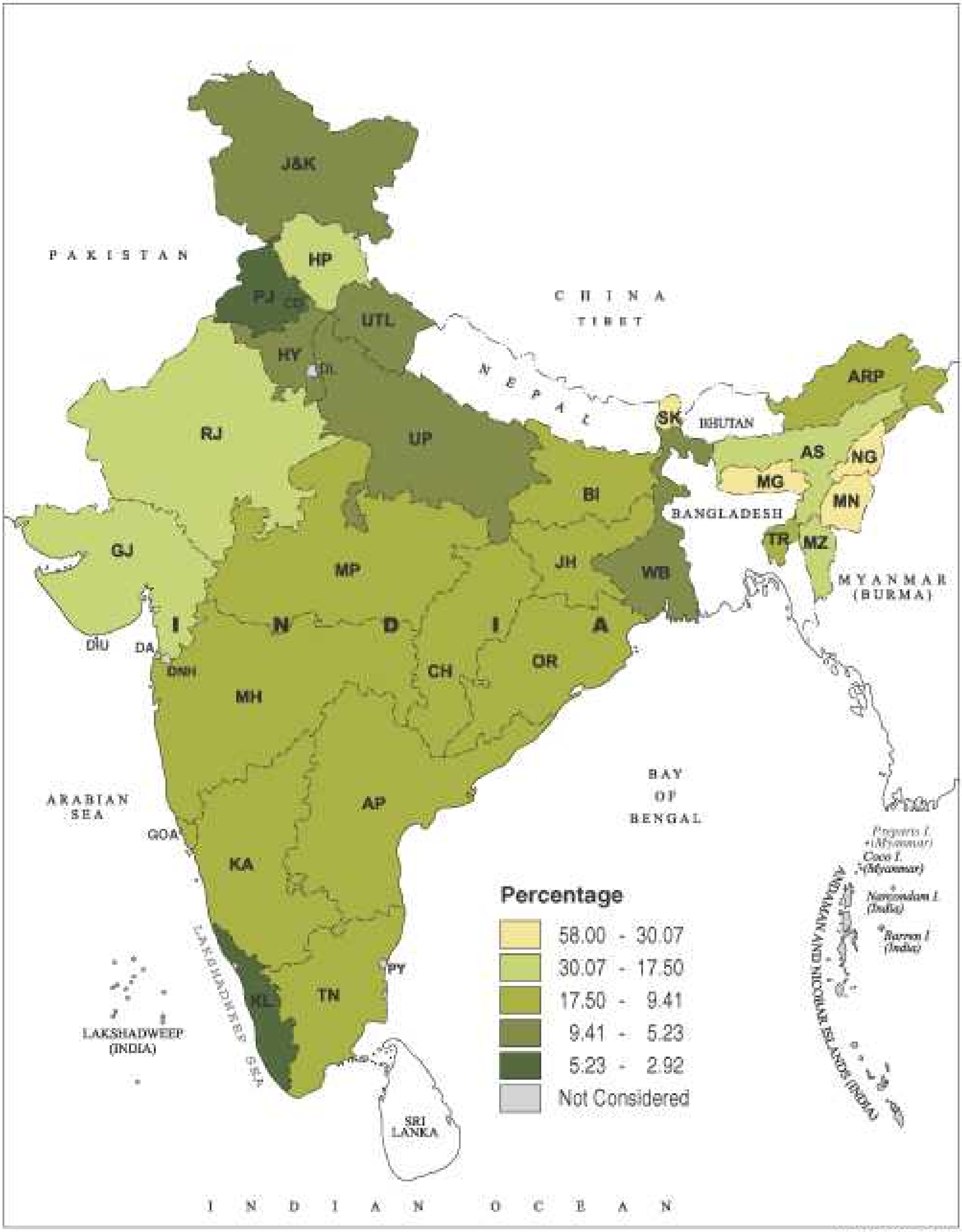
Wastelands are degraded lands that can be brought under vegetative cover with reasonable effort, and which are currently under-utilized. They are lands that are deteriorating for lack of appropriate water and soil management or on account of natural causes. Wastelands can result from inherent or imposed disabilities such as location, environment, chemical and physical properties of the soil or financial and management constraints (GOI, The Wasteland Atlas of India 2000). The eight categories of wastelands analyzed are degraded lands that can be reclaimed with reasonable amount of effort by 2020.

About 14.5 per cent of the total geographical area of the country comes under the eight categories of land that can be reclaimed. The states that are the worst as regards the extent of land degradation are Manipur, Nagaland, Meghalaya and Sikkim. The area of degraded lands as a per cent of the total geographical area in these states lies between 30.07 per cent and 58 per cent. Then come the states of Himachal Pradesh, Assam, Gujarat, Mizoram and Rajasthan. In these states, degraded lands as a per cent of the geographical area lie between 17.5 per cent and 30.07 per cent. Not very far behind are Andhra Pradesh, Tamil Nadu, Maharashtra, Madhya Pradesh, Orissa, Tripura, Goa, Bihar and Karnataka where the total degraded area as a per cent of geographical area lies between 9.41 per cent and 17.5 per cent. The states that are in the best position, i.e., have the least percentages of their geographical areas as degraded lands are Punjab and Kerala (5.23 per cent and 2.92 per cent). In Jammu and Kashmir, Uttar Pradesh, Haryana and West Bengal, the degraded area as a per cent of the geographical area is not very high (5.23 per cent to 9.41 per cent) (Table 1.9 and Map 1.6).

Types of wastelands: Gullied and ravined lands cover 20553.35 sq kms of the total geographical area of India. Localized surface run off affects the unconsolidated material and results in the formation of perceptible channels called gullies. Ravines are an extensive system of gullies developed along river courses. Madhya Pradesh and Rajasthan together have over half of India's gullied and ravined lands. The other states that have gullies and ravines on large tracts of their lands are Uttar Pradesh, Maharashtra and Gujarat.

[4] Oosterban R J, Soil salinity in www.waterlog.info/salinity

DEGRADED LANDS TO TOTAL GEOGRAPHICAL AREA



Map No. 1.6

Land with or without scrub is generally prone to deterioration as a result of erosion. It is the largest category of wastelands. About 6.13 per cent of the geographical area of India comes under this category. Madhya Pradesh, Maharashtra, Rajasthan, Gujarat and Andhra Pradesh together have over 70 per cent of the total land with or without scrub in India. As a percentage of geographical area, Nagaland tops the list with almost 19 per cent of its geographical area categorized as land with or without scrub.

About 16568.45 sq kms of the land in India comes under the category of Waterlogged and Marshy Land. Marsh is land that gets permanently or periodically inundated by water and is characterized by vegetation, which includes grasses and weeds. Thirty per cent of the water logged and marshy land is in Uttar Pradesh. Other states with large areas of waterlogged and marshy land are Gujarat, West Bengal, Assam, Bihar and Andhra Pradesh.

Salinity and alkalinity affects 20477.38 sq kms of the geographical area in India. Over 90 per cent of the lands affected with salinity and alkalinity are in four states: Gujarat, Uttar Pradesh, Rajasthan and Tamil Nadu.

Land under shifting cultivation is the result of cyclical land use, consisting of felling of trees and burning of forest areas for growing crops. The increasing population pressure has reduced the period of the cycle. This has caused extensive soil losses, land degradation and extinction of flora and fauna. Almost all (99.5 per cent) the total area under shifting cultivation in India is in the northeastern states of Manipur, Assam, Nagaland, Mizoram, Arunachal Pradesh, Meghalaya and Tripura. Over 53 per cent of the geographical area in Manipur is categorized as shifting cultivation area. For Nagaland, Mizoram and Assam, the percentages are 31.51 per cent, 17.84 per cent and 10.69 per cent respectively.

Degraded, notified forestland is the second largest category of wastelands and covers 4.4 per cent of the geographical area of the country. Over 65 per cent of the degraded, notified forestland in India is in six states: Andhra Pradesh, Madhya Pradesh, Maharashtra, Bihar, Rajasthan and Orissa. Degraded, notified forestland, as a per cent of the total notified forestland, is at 63.5 per cent the highest in Haryana. The other states where this percentage is very high are Rajasthan (48.6 per cent), Tamil Nadu (45.2 per cent), Bihar (44.3 per cent), Sikkim (41.3 per cent) and Meghalaya (38.5 per cent).

Approximately 25978.91 sq kms of area come under the category of degraded pastures and grazing lands. Almost 47 per cent of the degraded pastures in India are in Rajasthan. Over 70 per cent of its pastures and grazing land are degraded. Other states with large tracts of degraded pastures and grazing lands are Himachal Pradesh, Assam, Arunachal Pradesh and Maharashtra.

The total area under the category of degraded lands under plantation crops is 5828.09 sq kms. Over 80 per cent of the total degraded land under plantation crops in India is in four states: Himachal Pradesh, Madhya Pradesh, Maharashtra and Jammu and Kashmir. Himachal Pradesh alone accounts for around 42 per cent of the degraded land under this category.

The treatment and reclamation of wastelands and degraded lands is being done under the Watershed Development Programmes. Any programme to restore degraded lands must not be viewed only in terms of soil and water conservation. A holistic approach addressing livelihood issues will be more

Table 1.9

State wise and category-wise wastelands of India (Area in sq.kms)

S.No	State	Gullied/ Ravinous land	Land with or without scrub	Water logged / Marshy Land	Saline / Alkaline Area	Shifting Cultivation Area	Degraded Notified Forest Land	Degraded Pastures / Grazing Land	Degraded land under plantation crops	Total Degraded Area TDA	Total Geographical Area TGA	TDA as a % of TGA
1	Andhra Pradesh	692.68	20256.64	1035.02	603.26	13.80	22237.78	709.29	52.91	45601.38	275068.00	16.58
2	Arunachal Pradesh	0.00	3326.78	41.47	0.00	3088.08	1416.67	2134.99	6.07	10014.06	83743.00	11.96
3	Assam	0.00	843.72	1633.56	0.00	8391.48	3112.71	2217.85	0.00	16199.32	78438.00	20.65
4	Bihar	559.17	4689.93	1198.87	0.51	45.45	13066.53	164.97	79.80	19805.23	173877.00	11.39
5	Goa	0.00	292.83	41.02	0.00	0.00	71.99	2.47	32.19	440.50	3702.00	11.90
6	Gujarat	1013.39	21786.72	2656.26	7637.34	0.00	5443.02	387.45	78.32	39002.50	196024.00	19.90
7	Haryana	49.50	988.42	238.30	285.63	0.00	732.52	721.65	134.12	3150.14	44212.00	7.13
8	Himachal Pradesh	121.89	2056.50	15.69	1.36	0.00	4589.98	4278.17	2457.59	13521.18	55673.00	24.29
9	Jammu and Kashmir	21.25	4495.30	246.50	0.00	0.00	2491.66	267.51	640.56	8162.78	101387.00	8.05
10	Karnataka	301.52	9087.68	32.76	125.11	0.00	8299.41	97.46	104.74	18048.68	191791.00	9.41
11	Kerala	0.00	357.93	136.00	0.00	0.00	609.30	3.99	25.65	1132.87	38863.00	2.92
12	Madhya Pradesh	7569.11	36977.87	51.72	162.81	0.00	20437.77	302.44	910.40	66412.12	443446.00	14.98
13	Maharashtra	1700.37	31386.91	527.57	251.66	0.00	13430.67	1349.40	687.43	49334.01	307690.00	16.03
14	Manipur	0.00	1.32	324.60	0.00	12014.06	608.64	0.00	0.00	12948.62	22327.00	58.00
15	Meghalaya	0.00	4190.63	14.87	0.00	2086.77	3612.11	0.00	0.00	9904.38	22429.00	44.16
16	Mizoram	0.00	0.00	0.00	0.00	3761.23	310.45	0.00	0.00	4071.68	21081.00	19.31
17	Nagaland	0.00	1596.46	0.00	0.00	5224.65	1582.99	0.00	0.00	8404.10	16579.00	50.69
18	Orissa	185.82	8358.68	379.10	51.49	115.28	10014.07	13.43	193.93	19311.80	155707.00	12.40
19	Punjab	168.52	339.44	352.01	173.29	0.00	353.29	113.71	81.58	1581.84	50362.00	3.14
20	Rajasthan	4952.77	27152.76	289.66	2722.99	0.00	12541.89	12208.44	21.14	59889.65	342239.00	17.50
21	Sikkim	0.00	1073.11	0.00	0.00	0.00	1060.57	0.00	0.00	2133.68	7096.00	30.07
22	Tamil Nadu	226.12	7697.91	415.80	2479.73	0.53	9634.25	168.94	221.96	20845.24	130058.00	16.03
23	Tripura	0.00	286.87	0.11	0.00	400.88	588.18	0.00	0.00	1276.04	10486.00	12.17
24	Uttar Pradesh	2806.52	5498.99	4981.43	5811.94	0.00	3338.32	446.36	50.44	22934.00	294411.00	7.79
25	West Bengal	171.90	1245.16	1931.54	131.25	0.00	777.58	384.97	2.93	4645.33	88752.00	5.23
26	A & N Islands	0.00	0.00	11.01	0.00	0.00	206.75	5.05	46.34	269.15	8249.00	3.26
	All India	20553.35	194014.29	16568.45	20477.38	35142.20	140652.31	25978.91	5828.09	459214.98	3166414.00	14.50

Source: 1:50,000 scale wastland maps prepared from landsat thematic mapper/IRS/LISS II/III data

GOI, Ministry of Rural Development and NRSA,"Wastlands Atlas of India"-2000

Note: 12084900 Sq.Kms. In J&K is not mapped and hence not considered for calculating the Percentage effective. This participatory, bottom-up approach will have far reaching affects in solving the problems of poverty and land degradation as has been demonstrated in many a case (Babu 2002).

The focus must not be on bringing all wastelands under cultivation. Agricultural land that has been degraded may be reclaimed for cultivation. A policy of restoring degraded lands to their original ecological form must be followed. An attempt must be made to bring these wastelands into land uses that will strengthen and sustain food security of the country.

II. Water

For sustaining food production security as well as livelihood security, we need water. Land and water are inseparable in this context because "Land use decisions are water use decisions, and vice versa" (Swaminathan 2002). This is true at the micro level as well as at the macro level.

When land use changes, the water requirements differ. When land shifts from one use to another, the water availability and the replenishment capacity also change, depending on changes to the ecology of the area. When forestland is used for crop production and cropland and forestland for human habitation, ecology suffers; both the quality and the quantity of water available may be affected. In other words, land use determines the quantity and quality of water.

Ideally, there should be sufficient water for drinking, household use, agriculture, industry and other uses at all times. Rainfall, which is the major source of water, is received mostly during the monsoon season. The onset of the monsoon, the quantity of rainfall received and the spread of rainy days vary. Such variations lead to water shortages if water is not managed efficiently. Less and less water is available from rivers, tanks and water bodies because of environmental degradation. The availability of water depends not only on the rainfall but also upon the hydrology and the ecology of watersheds.

This section on water deals essentially with the availability and use of water for crop production. The first part of this section is on rainwater. It focuses on the impact of rainfall on soil moisture and on instability in crop production. The second part is about irrigation water. The issues considered include the ultimate potential of irrigation water—the potential created and utilized, the declining importance of surface irrigation, over-exploitation of groundwater resources and efficiency in water use for crop production. The third part deals with ocean water and its contribution to fish production.

Water Resources : Rainfall, snowfall and icy glaciers are the original sources of water in India. India appears to be rich in water resources. It has a network of rivers and groundwater resources. Besides, India has a long coastline. Seawater could be desalinated and used if need arises.

According to a 1993 assessment, the quantity of precipitation and snowfall in India is about 4000 billion cubic metres (BCM) per annum. Of this, the natural run off to rivers plus groundwater recharge add up to about 1869 billion cubic metres, as per the estimates of the Central Water Commission; but the portion that can be utilized is only 690 BCM, because of various constraints of topography and the uneven distribution of resources over space and time. India's groundwater resources are estimated at about 432 BCM. Together, the availability of surface and groundwater water resources in the country stand at 1122 BCM (National Water Policy 2002).

The per capita availability of water as of 1999 was estimated to be about 1905 cubic metres. But several parts of India are *water-stressed* with annual water availability below 1700 cubic metres per capita per year. Several other areas are *water-scarce*, with annual water availability less than 1,000 cubic metres/ capita/ annum.

However, the water demand per person is estimated to be only 634 cubic metres per annum at present. It is expected to increase to 813 cubic metres in 2010 and to about 1093 cubic metres by 2025. On the basis of such rough calculations, India appears to have enough water for now; but it may fall short in future when demand increases as expected.

1.6 Rainfall

Rainfall is one of the most important sources of water. That Indian agriculture is heavily dependant on rainfall is well known. Rainfall affects not only rain-fed agriculture but also the sources of irrigation. Drinking water and water for household use also depend on rainfall. Of the 329 million hectares of geographical area in India, only 92 million hectares belong to the sparse-rainfall zones of 100–500 millimetres and 500–750 millimetres. The rest of the country receives adequate to excess rainfall.

The first issue concerning water and sustainable food security is the measurement of rainfall adequacy for crop growth in different states. The second issue is year-to-year fluctuations in rainfall and how they impact instability in crop production. Instability in production leads to severe hardship for people reliant on agriculture for their sustenance.[1] We need to investigate the extent to which monsoon failure causes fluctuations in production. How production instability relates to the quantum of rainfall, fluctuations in rainfall and land degradation have been studied to determine the role of land degradation in production instability.

1.6.1 Adequacy of Rainfall for Crop Growth

Given the spread and quantum of rainfall, one would like to know the extent of crop production that can be supported under rain-fed conditions. The actual water available for crops from rainfall depends on a number of factors such as the quality of the soil, the temperature, the natural vegetative cover and so on. These determine the soil-climate-water balance.

The potential evapotranspiration (PET) is the amount of water lost through evaporation and transpiration from a soil covered by vegetation under conditions of permanent and adequate moisture supply.[2] PET is thus a function of temperature, the length of the day, humidity, soil quality and so on.

The difference between precipitation (P) and potential evapotranspiration (PET) is the water balance. When PET is equal to the water supply P, it means that all the water has been used up for evapotranspiration; soil moisture remains at field capacity (saturation point).[3] When the water supply P exceeds PET, it means that all the water has not been used for evapotranspiration; a part of it infiltrates into the soil. After the soil water-retention reaches field capacity, the additional supplementary water from precipitation percolates into deeper layers, carrying soluble salts along with it. The amount that reaches the deeper layers is regarded as a water surplus. A part of the surplus percolates to the ground water-table; the rest goes into the river system as run off.

When the water supply is less than the water need, the roots of a crop draw up the soil moisture for evapotranspiration, until the crop's wilting point is reached. A real water deficit occurs when the roots cannot draw the water they need from the stored soil moisture. At this point in rain-fed agriculture, it is not possible to grow crops. Hence, it may be regarded as the end of the cropping season. From the standpoint of crop production and planning, it is important to know in advance the period of moisture availability for crop growth.

[1] This issue has been elaborated in the chapter on Sustainability of Food Access and Livelihood Access.

[2] PET is different from the actual evapotranspiration (AET) that depends on the consumptive water needs of vegetative cover. PET is more important than AET, as AET declines in periods of moisture stress. PET is thus an indicator of the water needs of the plant.

[3] The Thornthwaite system demonstrates this.

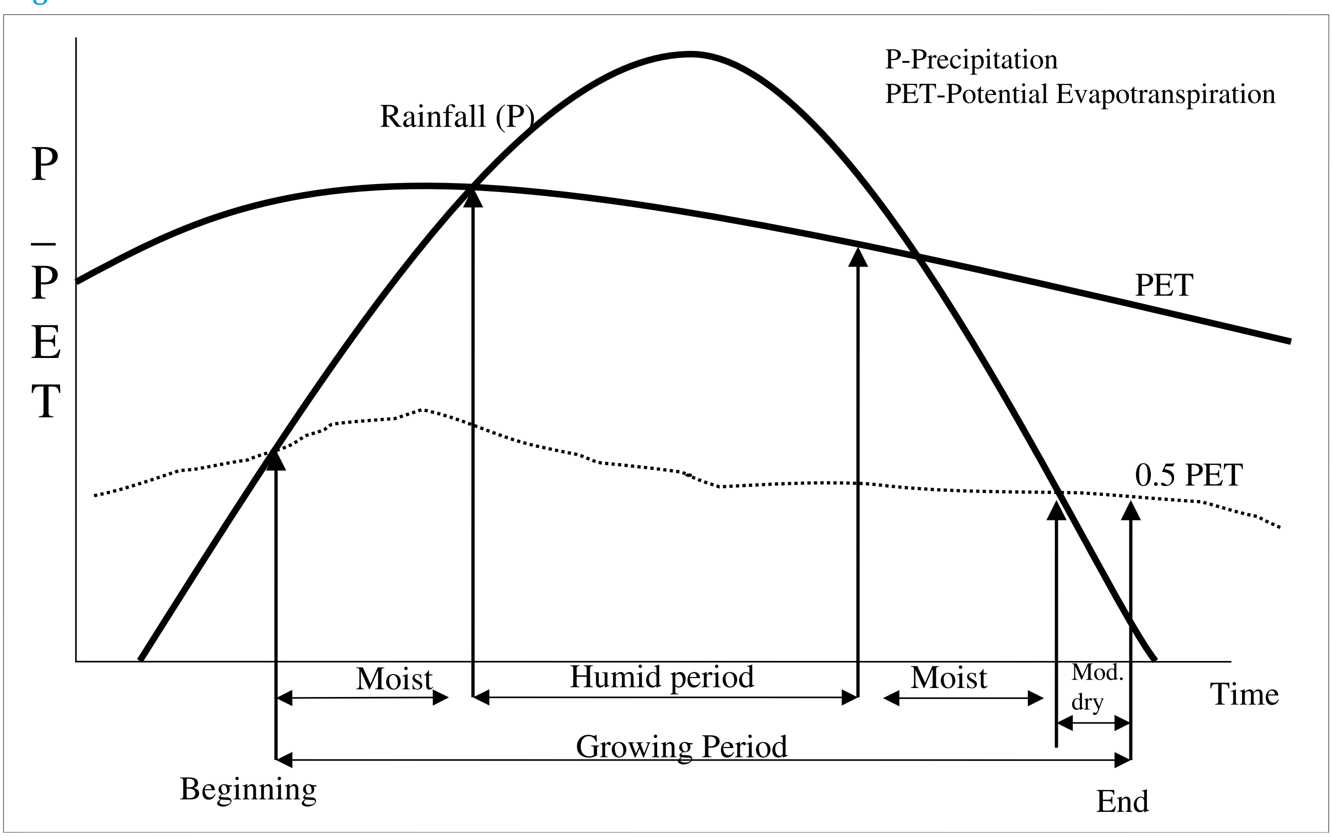
The moisture availability period is the period when precipitation exceeds 50% of potential evaporation plus the time required to evapotranspire an assumed 100 mm of water from the moisture stored in the soil. During a normal growing season, the crop experiences a humid period when P is greater than PET, a moist period when P is more than 0.5 PET and a moderately dry to dry period when P is less than 0.5 PET (Higgins and Kassam 1981).

Typically, the rainfall pattern, the pattern of the ratio of precipitation to potential evapotranspiration (P/PET) and the crop growth pattern are similar, shaped like an inverted U in a diagrammatic representation. At the beginning and the end of the monsoon, rainfall is relatively less and the P/PET ratio is low. At the beginning of the crop-growing period, as little as 0.35 PET is sufficient for crop growth. During the peak of the rainy season, moisture availability is high, so is the P/PET ratio, and P exceeds PET. During this period, the full demand of the crop for water is met. This period also replenishes the moisture deficit in the soil. At the end of the rainy season, P is generally less than PET, and the crop starts drawing water from the stored moisture. The crop needs much less water before harvesting (Figure 1.4).

Taking averages for the whole year, if precipitation is higher than half the potential evapotranspiration, moisture availability is considered sufficient for one crop a year in the rainy season, without irrigation. Wherever the precipitation exceeds potential evapotranspiration, two crops can be grown.

The estimation of potential evapotranspiration requires a number of field measurements. Hence it is normally computed from weather data. The Evaporative Power of Air (EPA) determines not only

Figure 1.4 : Water Balance



the quantum of evaporative depletion of rainfall, but also the soil moisture needs of a crop for potential transpiration. Potential evaporation from an open water surface (mesh-covered pan evaporation) is normally estimated and equated to potential evapotranspiration. It provides the integrated effect of radiation, air temperature, air humidity and wind on evapotranspiration. It is a commonly used method and believed to be a close approximation to the accurate estimate (Frere 1986). This study uses the estimates of the National Bureau of Soil Survey on precipitation and potential evaporation, based on estimates of Pan Evaporation for twelve months in 1700 meteorological stations. Data collected for over thirty years formed the basis for monthly average precipitation at each meteorological station. The ratio calculations include average annual precipitation and average annual potential evaporation in all the twelve months.

An annual average of the ratio of precipitation to half the evapotranspiration was worked out for the study. If it is equal to 1, or exceeds 1, the rainfall is likely to be sufficient for at least one crop in a year. Since the data pertains to meteorological stations, the observations are valid for areas in the vicinity of the stations. Ideally, we must know, for every state, the percentage of the geographical area of the district for which these observations hold good. The proportion of geographical area where precipitation exceeds 50 percent of potential evapotranspiration can then be worked out.

The present analysis takes into consideration the percentage of such stations, where the precipitation exceeds 0.5 potential evapotranspiration, to the total number of meteorological stations in the state. The higher the percentage of stations with ratio exceeding one, the better the rainfall situation for crop growth. States where hundred per cent of the stations fall in this category are naturally better off than those with only a few stations in this category.

If we presume that each meteorological station represents a certain area, the greater the number of stations that have precipitation higher than potential evapotranspiration, the larger is the area in which crop growth is possible under rain-fed conditions. The stations may not be spread uniformly across a state—there may be too many stations in one location and too few in some others. Maps showing the locations of the 1700 meteorological stations are not available.

The study provides an idea of the capacity of a state to support rain-fed agriculture, even if the state actually uses irrigation for agriculture. An idea of the adequacy of rainfall for growing at least one crop helps to conserve water and optimize rainwater use.

The soil-climate-water balance and the length of the crop-growing period in a place are often calculated for crop planning. Such calculations are crucial for assessing the potential problems of each ecosystem and for optimum utilization of rainfall and soil resources for crop production. The percentage of Indian Meteorology Department 's Meteorology Stations (IMD) in which, the precipitation exceeds half of the potential evapotranspiration gives us an idea of the adequacy of rainfall in the state. Data reveal that Orissa, Bihar, the northeastern states and West Bengal can grow at least one rain-fed crop in a year with minimum risk, as all the meteorological stations in these states record precipitation higher than evapotranspiration. The other states that are in a comfortable position are Kerala, Madhya Pradesh and Uttar Pradesh—where 98, 90 and 81 percent respectively of the stations have a P/0.5PET ratio equal to or higher than 1. States with very little scope for rain-fed agriculture to succeed are Haryana, Rajasthan and Punjab, where only 15, 25 and 23 percent of the stations have precipitation higher than

0.5PET. They can hardly support one rain-fed crop without risk. It is interesting that Tamil Nadu has better scope for rain-fed agriculture than Andhra Pradesh or Karnataka and Maharashtra, because the rainfall is spread more evenly across two monsoons. The scope in Gujarat is higher than in Rajasthan. Analysis reveals that there is indeed some scope for rain-fed agriculture in India, something that is not widely recognized (Table 1.10 and Map 1.7).

Table 1.10

Percentage of IMD Stations having rainfall higher than half the Potential Evapotranspiration

S.No	State	Percentage
1	Andhra Pradesh	58.08
2	Bihar	100.00
3	Gujarat	40.00
4	Jammu & Kashmir	66.67
5	Karnataka	52.63
6	Kerala	98.31
7	Madhya Pradesh	90.86
8	Maharashtra and Goa	56.79
9	Arunachal Pradesh	100.00
10	Assam	100.00
11	Manipur	100.00
12	Meghalaya	100.00
13	Nagaland	100.00
14	Tripura	100.00
15	Haryana	15.15
16	Himachal Pradesh	100.00
17	Punjab	25.00
18	Orissa	100.00
19	Rajasthan	23.11
20	Tamil Nadu	69.23
21	Uttar Pradesh	81.67
22	West Bengal	100.00
23	New Delhi	0.00
24	Lakshadweep	100.00
25	Dadra Nagar & Hevali	100.00
26	A & N Islands	100.00
27	Mizoram	N.A
28	Sikkim	N.A

Source: National Bureau of Soil Survey & Land Use Planning, "Soil-Climatic Database For Crop Planning in India"-1999

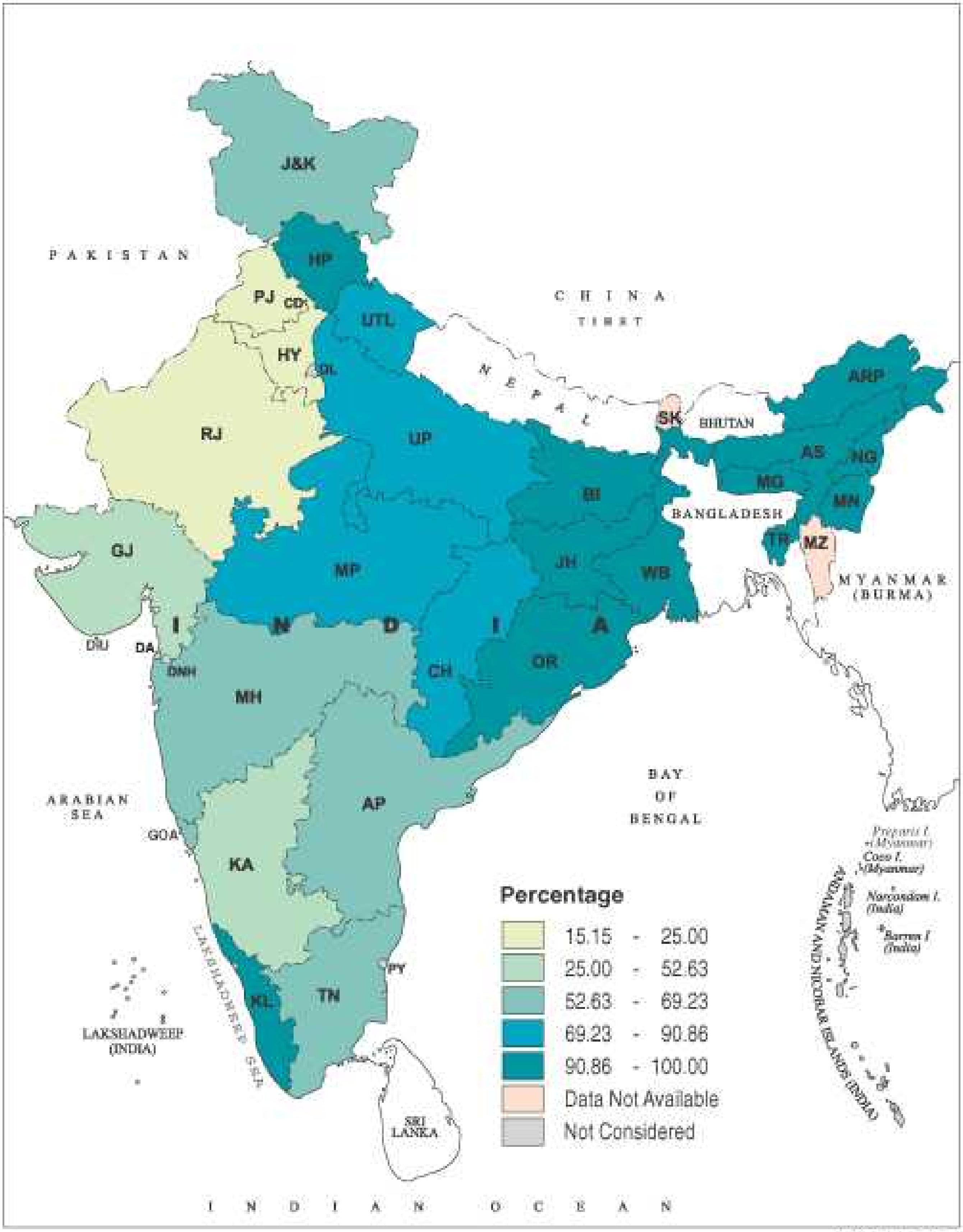
Substantial gains can be attained in production and productivity by synchronizing technology with rainfall. For example, if rainfall predictions are accurate, an early monsoon can accommodate a long-duration variety of crop. Similarly, a drought-resistant variety can be grown in deficient rainfall year. For sustainable agriculture, more research is needed in rain-fed areas on short-duration crops, crops with improved pest and drought resistance, and drought resistant crops such as pulses and millets.

1.6.2 Rainfall, Drought and Production Instability

Monsoon failure is not the only cause of droughts, water shortages and fluctuations in food production. During the decade from 1990–1991 to 1999–2000, rainfall was not deficient, nor did it show wide fluctuations. However, the country was not spared from droughts and water shortages in this decade of normal or excess rainfall. (Economic Survey 2003) A close examination of the relationship between rainfall fluctuations and instability in food grain production highlights the role of other factors such as land degradation.

India as a whole has had fairly good rainfall during the past ten years. The southwest monsoon, the most abundant source of rain, has been satisfactory over the past decade, but for a marginal shortfall of 10 percent from the normal that occurred in three years (Agricultural Statistics at a Glance 2000). The decade ending 1999–2000 has seen the lowest deviation from mean rainfall (Table 1.11). In the 1990s, mean rainfall for the country as a whole was slightly lower than the long-term average, but higher than the average of the 1980s and 1970s. In addition, the standard deviation during this decade has been the lowest over the past five decades. It is important to note that the decadal rainfall averages are not very different from the 130-year average (1871–2000). This indicates that

PERCENTAGE OF IMD STATIONS HAVING RAINFALL HIGHER THAN HALF THE POTENTIAL EVAPOTRANSPIRATION



Map No. 1.7

rainfall over the years has been more or less consistent.

The agricultural years 1997–1998 and 1998–1999 had good monsoons. In 1998 the average rainfall for the country was six percent above normal, and in 1997 it was two percent above normal. Out of 35 meteorological subdivisions, only two subdivisions during the southwest monsoon (June to September) and two divisions during the northeast monsoon (October to December) received below-normal rainfall in 1999. All-India rainfall was deficient in 2001 and 2002 compared to 1999. Seven subdivisions during the southwest monsoon and nine subdivisions during northeast monsoon received below normal rainfall in 2001, and as many as 31 divisions received below-normal rainfall between October and December 2002 (Economic Survey 2003). In consequence, widespread damage occurred to crops, livestock and people. (Table 1.12) What is obvious from the above table is that even in a year with fairly good rainfall, as in 1998–1999, drought has hit a large number of people, crop area and livestock.

Table 1.11

All India decadal mean and South West Monsoon (June, July, August, September)

Decade	MEAN	STDEV
1951-60	871.86	78.88
1961-70	844.76	97.27
1971-80	840.57	94.4
1981-90	831.8	101.29
1991-2000	842.99	54.24
1871-2000	851.88	82.7

Source: GOI, Dept of Meteorology.

It is true that even as some districts experience drought, others face floods. Good rainfall for the country as a whole offers little consolation to people hit by drought. The reason for the drought in some areas cannot be explained by rainfall alone. Other factors are location-specific, and include type of soil, level of land degradation, facilities available for water collection and conservation, the types of crops grown and so on. Obviously the villages hit by drought have had other problems that made drought much more severe. Thus it appears that there are factors other than poor rainfall that causes water shortage. Further research is required to fully understand the causes of water shortages in the years of good rainfall. Some of the damage done by land degradation is permanent and irreversible and makes it impossible to conserve the water received. Topsoil erosion has been severe and hence the land does not support vegetation. Cherrapunji in Assam is a case in point. This region receives more than 10000 millimetres of rain every year, but suffers from severe drinking-water shortages.

Table 1.12

Loss due to Droughts in 1999 - 2001

Year	Districts	Villages	Population affected in lakhs	Crop area affected in lakhs	Livestock affected in lakhs
1999	125	54883	369.88	134.22	345.6
2000	110	22255	378.14	367	541.67
2001	103	77138	88.19	67.44	34.28

Source: GOI, "Economic Survey", 2002-2003

As per data in the NSS 54th round (January to December 1998), drinking water was not available to many in both rural and urban areas. Some 13 percent of rural households and 15 percent of urban households do not get sufficient water even for drinking. About 8.3 percent of the rural population and 2.7 percent of the urban population, constituting more than 69 million people, will have to walk long distances of at least a quarter kilometre to collect water (National Sample Survey 1999).

Water for drinking and household use is transported over long distances through tankers in many parts of the country. All these areas probably did not need water transportation a decade ago. Thirty four million people in rural and urban areas depended on water tankers. Deficient rainfall is not the main reason for water shortage in many areas. Inadequate facilities for replenishment of groundwater and ineffective trapping of the surface water storage and distribution are some of the major reasons for water shortages. Problems of water shortage are also problems of water conservation and water management, rather than of deficient rainfall.

1.6.3 Rainfall and Production Fluctuations

The dependence of Indian agriculture on rainfall is well known. Rainfall affects not only rain-fed agriculture but also irrigated agriculture to some extent. Rainfall, snowfall and glaciers are the main sources of surface water as well as groundwater. About 80 percent of the rainfall during the southwest monsoon, the main season for crop production—known as the kharif season—extends from June to September (Table 1.13). Hence the reservoirs of river projects are low in summer months. The water level in seventy major reservoirs in the country in 2001 as well as 2002 during the pre-monsoon months of April and May dipped to as low as 16 BCM and rose to about 65 to 78 BCM in November–December (Economic Survey 2001).

Only 40 percent of the net sown area has been irrigated for the country as a whole. The remaining 60 percent of the area is rain-fed. In addition, the rainfall varies across regions, in the same region from one year to the other and in the same year from one season to another. In some areas of low rainfall, deficient rainfall may occur over consecutive years. We take a look now at the levels of rainfall and fluctuations across the states and relate them to production instability.

Table 1.13

Contribution of Southwest Monson to Total Rainfall-Normal (mm)

Sl. No	State	Total Rainfall	Southwest Monsoon	Rest of the year	Pect. of Southwest Monsoon
1	Andhra pradesh	862.89	572.84	290.05	66.39
2	Assam	2380.74	1447.74	933.00	60.81
3	Bihar	1267.45	1062.43	205.02	83.82
4	Gujarat	665.50	622.23	43.27	93.50
5	Haryana	558.60	457.60	101.00	81.92
6	Karnataka	1088.10	773.95	314.15	71.13
7	Kerala	2879.50	1943.50	936.00	67.49
8	Madhya Pradesh	1183.80	1057.34	126.46	89.32
9	Maharashtra	1069.57	916.49	153.08	85.69
10	Orissa	1480.10	1171.10	309.00	79.12
11	Punjab	642.10	496.10	146.00	77.26
12	Rajasthan	462.09	420.64	41.45	91.03
13	Tamil Nadu	974.50	308.50	666.00	31.66
14	Uttar Pradesh	1012.96	848.97	163.98	83.81
15	West Bengal	1782.80	1356.62	426.18	76.09

Source: GOI, Indian Meteorology Department

The southwest monsoon is the important crop season for most states. Data on the southwest monsoon is available for fifteen major states from the meteorological subdivisions concerned. Using the area of each subdivision as weight, the rainfall of the state has been derived as the weighted average for the agricultural year June to May.

Among the states, the mean rainfall is high for Kerala, Assam, West Bengal, Orissa, Bihar and Madhya Pradesh. All these states receive an average of more than 1000 mm of rainfall during the southwest monsoon. Goa is included in Maharashtra. Uttar Pradesh, Maharashtra and Karnataka receive around 700 to 900 mm on the average, while Andhra Pradesh and Gujarat get 500 to 600 mm. Punjab and Haryana receive between 400 and 500 mm; Tamil Nadu receives rather low rainfall during this season: about 300 mm. Tamil Nadu is the only state that receives more rain during the northeast monsoon than the southwest. Assam, Kerala and Andhra get 30 to 40 percent of their rain during the northeast monsoon. In every state, the geographical spread of rainfall differs across the state. But everywhere the rainfall helps rain-fed crops, boosts river water and replenishes groundwater. At present, 55.7 percent of the irrigated area in India relies on groundwater sources, which depend on rainfall. Hence, one would expect the instability in food grain production to be related to fluctuations in rainfall.

To be comparable with aggregate production at the state level, rainfall was also aggregated at the state level. Variations in crop production and rainfall have been taken into account to draw conclusions regarding the relationship between rainfall and production (Table 1.14).

The state-wise rainfall figures presented in the table are average rainfall figures weighted with the geographical area of the meteorological subdivisions. During the past ten years, the coefficient of variation in the rainfall was the highest for Haryana, Gujarat, Rajasthan, Punjab and Tamil Nadu. They show a high level of variation, between 25 and 36 percent. Orissa and Andhra Pradesh show moderate variations around 19 percent. Maharashtra and Karnataka show very low variations, though both states have high as well as low rainfall regions.

Table 1.14

Instability in foodgrain production and rainfall variation

		1	2	3	4	5	6
S.No	States	Growth Rate of foodgrain production (Pect.)	Instability in produciton of foodgrains (Pect.)	Coefficient of variation in Rainfall (Pect.)	Percentage of area irrigated (Pect.)	Normal Annual rainfall (mm)	Per Consumer unit calorie intake of the lowest decile (Kcal)
1	Andhra Pradesh	1.11	14.17	18.91	38.76	862.89	1749.53
2	Assam	0.59	5.57	12.58	20.58	2380.74	1650.02
3	Bihar	2.86	14.25	15.52	50.27	1267.45	1857.04
4	Gujarat	1.56	30.27	29.80	31.24	665.50	1758.31
5	Haryana	2.74	7.51	36.18	76.99	558.60	2027.32
6	Karnataka	2.97	12.38	9.26	22.09	1088.10	1723.13
7	Kerala	-3.49	16.42	14.07	15.09	2879.50	1631.83
8	Madhya Pradesh	1.72	11.29	17.63	30.01	1183.80	1827.00
9	Maharashtra	0.82	28.79	7.66	14.33	1069.57	1833.57
10	Orissa	-3.26	21.82	17.98	33.66	1480.10	1967.00
11	Punjab	1.85	5.39	27.26	92.94	642.10	2045.84
12	Rajasthan	3.12	33.22	27.93	31.56	462.09	2182.46
13	Tamil Nadu	1.60	15.90	25.89	49.13	974.50	1515.83
14	Uttar Pradesh	2.23	4.52	11.33	67.10	1012.96	2072.03
15	West Bengal	3.02	6.51	13.39	34.98	1782.80	1812.98
	All India	1.84	5.23	6.36	37.62	_	1883.64

Source: Col 1-2 and 5, Calculations based on GOI, Ministry of Agriculture, "Agriculture in Brief", 2000.

Col 3 and 5, India Metrological Department

Col 6, NSS 55th Round, "Nutritional Intake in India" 1999-2000

Rainfall fluctuations do cause fluctuations in food grain production. However, many other factors influence instability in production. The measurement of fluctuations differs between the rainfall and the food grain production. Coefficient of variations adequately captures the variations in the annual rainfall. Food grain production shows a time trend in production, whereas rainfall has no time trend. Hence, one has to study fluctuations in food production around the trend. In the literature, the time series are de-trended and the variations around the trend are studied (Hazell 1984). We have adopted a slightly different method, which is simple and more effective.

We study the standard deviation of the annual growth rates of food production. If the production has a steady annual growth of a certain percentage, the fluctuations will be minimal. If the annual growth rates change wildly and move from positive to negative, the instability in food grain production will be high. The annual growth rate in production is given by the first difference in the natural logarithms of the production figures. Standard deviation in the annual growth rates shows the level of instability. It can be expressed in percentage terms. Coefficient of variation is not an added advantage over standard deviation while dealing with natural logarithms (Vepa 1994).

Examination reveals that fluctuations in food production exceed fluctuations in rainfall and the irrigation facility in Karnataka, Kerala, Maharashtra, Orissa and Rajasthan. Instability in food grain production has not fallen substantially in Bihar, Andhra Pradesh and Tamil Nadu, despite almost 40 to 50 percent of the net area sown being irrigated. We expect instability to be low in states where the average level of rainfall exceeds 1000 mm and the irrigated area is more than 30 percent. Yet we find that instability is high in Bihar, Orissa and Kerala. Thus, instability in cereal production is not related to variations in rainfall, the coefficient of correlation being insignificant. We find instability even in assured water supply areas. On the whole, food grain instability does not seem to depend solely on rainfall variations and irrigation. This is not to deny a relationship altogether. It is to show that other factors such as land and forest degradation and degradation of vegetative cover could also cause water shortages and induce production instability despite good rainfall.[4] Cross-section analysis, for instance, shows that land degradation is a significant factor for instability (Appendix 1.6).

The foregoing analysis shows that rainfall impact should be studied in conjunction with other factors such as degraded lands and deforestation. While the Rain God has not failed man, man has failed nature and has hence had to suffer the consequences of drought.

This brings to the fore the importance of watershed management. Watershed is a geo-hydrological area that drains at a common point. The watershed approach is a project-based development plan that follows a ridge-to-a-valley approach to water harvesting and conservation. Watershed programmes normally take up a micro watershed of about 500 hectares each. However, the actual project area could vary depending upon the terrain.

As noted by the evaluation report of the Planning Commission (Planning Commission 2002) the watershed management programme has to yet to become a success. There have been a few success stories, and substantial benefits. The major problems seem to be lack of continuous interest in developing, maintaining and monitoring the system on the part of the government as well as the people. The financial

[4] Production instability of staple food in the country affects the rural poverty groups. Hence livelihood dimensions of instability have been taken up in the chapter on food access.

allocations also appear to be very small in relation to the dimension of the problem. The chapter on policy implications takes up this issue in detail.

1. 7 Irrigation

There are a number of important issues related to irrigation in India. Irrigation is seen as the key to higher crop productivity, and there is pressure to increase the irrigated area. The foremost issue is the availability of irrigation potential, its creation and utilization. The second issue is irrigation efficiency of which there are two types: one, efficiency of the irrigation system and two, crop use efficiency, that is, improving crop productivity per unit of water. The third issue is the increase in cropping intensity and irrigation intensity on the one hand, and the decelerating yield growth in some areas for some crops on the other. This is closely related to water use efficiency. The fourth issue is the increasing demand for water. While water resources are dwindling, the demand for irrigation water is going up. This has implications for sustainable food production. A related issue is pricing of water, fuel and equipment used for pumping water. The fifth issue is about the problems of water sharing, not only within a community but also between states and countries. The following discussion attempts to put these issues in proper perspective in the context of sustainable food production.

1.7.1 Irrigation Potential Available, Created and Utilized

Ultimate irrigation potential (UIP) corresponds to the gross area that could theoretically be irrigated in a year on the basis of the assumed cropping pattern and the given probability of rainfall. The UIP in India stands at about 139.9 million hectares. About 66 percent has already been created, about 60 percent is already utilized. State-level figures show that Uttar Pradesh has the highest potential, which makes up about 22 percent of the total potential in the country. Madhya Pradesh, Bihar and Andhra Pradesh come next. Together, these four states seem to account for more than half of the country's total irrigation potential. All the other northeast states except Assam have relatively little irrigation potential. The irrigation potential of Haryana, Rajasthan, Tamil Nadu and Punjab is quite low compared to that in some other states. Orissa, Maharashtra, West Bengal, Gujarat and Karnataka fare better (Table 1.15).

When it comes to creation of available potential, Uttar Pradesh and Punjab top the list with hundred percent and more.[5] Rajasthan, Nagaland and Haryana seem to have created most of their irrigation potential. Assam, Madhya Pradesh, Orissa, Meghalaya and Tripura seem to have created only between 30–40 percent of the potential available. Other states such as Bihar, Jammu and Kashmir, Himachal Pradesh, Sikkim and Kerala appear to have about 40–50 percent of available potential. However, one should not jump to the conclusion that all the potential in these states can be exploited profitably. Pushing the irrigation potential to the ultimate available level may be unsustainable in some cases, particularly in the hilly areas of Madhya Pradesh, Orissa, Jammu and Kashmir, Himachal Pradesh and some of the northeastern states. The sustainability of such exploitation has to be carefully considered, lest water sources dry up permanently. Sometimes, problems of technical and economic feasibility may prevent the use of water in a productive manner. In some states with high potential such as Assam, Bihar, Madhya Pradesh and Orissa, there seems to be unutilized or

[5] In some years of good rainfall, it is possible to irrigate more acreage than expected, due to better water availability.

Table 1.15

Ultimate irrrigation Potential ('000 hectares)

S.No	States	Ultimate Irrigation Potential (UIP)	Potential Created, 1997-98 (Anticipated)	Potential Utilised, 1997-98 (Anticipated)	Ultimate Potential to All India Potential	Pect. Of potential created to UIP	Pect. Of potential Utilised to potential created	Potential used to UIP (pect.)	Gross Irrigated Area 1998-99
1	Andhra Pradesh	11260	6364	5888	4007.12	56.52	92.52	52.29	5158
2	Arunachal Pradesh	168	88	75	59.79	52.38	85.23	44.64	36
3	Assam	2870	886	654	1021.35	30.87	73.81	22.79	572
4	Bihar	13347	8507	7256	4749.82	63.74	85.29	54.36	4579
5	Goa	116	34	30	41.28	29.31	88.24	25.86	36
6	Gujarat	6103	3379	3097	2171.89	55.37	91.65	50.75	3779
7	Haryana	4512	3685	3384	1605.69	81.67	91.83	75.00	4829
8	Himachal Pradesh	353	166	136	125.62	47.03	81.93	38.53	180
9	Jammu and Kashmir	1358	555	512	483.27	40.87	92.25	37.70	446
10	Karnataka	5974	3248	3005	2125.98	54.37	92.52	50.30	2912
11	Kerala	2679	1179	1088	953.38	44.01	92.28	40.61	417
12	Madhya Pradesh	17932	5477	4437	6381.49	30.54	81.01	24.74	6527
13	Maharashtra	8952	5104	3802	3185.77	57.02	74.49	42.47	3352
14	Manipur	604	126	103	214.95	20.86	81.75	17.05	75
15	Meghalaya	168	53	45	59.79	31.55	84.91	26.79	54
16	Mizoram	70	13	12	24.91	18.57	92.31	17.14	10
17	Nagaland	85	68	58	30.25	80.00	85.29	68.24	70
18	Orissa	8803	3193	2786	3132.74	36.27	87.25	31.65	2318
19	Punjab	5967	6007	5895	2123.49	100.67	98.14	98.79	7487
20	Rajasthan	5128	5053	4756	1824.91	98.54	94.12	92.75	6676
21	Sikkim	70	30	24	24.91	42.86	80.00	34.29	16
22	Tamil Nadu	5532	3741	3731	1968.68	67.62	99.73	67.44	3519
23	Tripura	281	101	94	100.00	35.94	93.07	33.45	60
24	Uttar Pradesh	30499	30825	27738	10853.74	101.07	89.99	90.95	17322
25	West Bengal	6918	4756	4021	2461.92	68.75	84.55	58.12	2491
	All India	139893	92742	82720	49783.99	66.29	89.19	59.13	73007

Source: GOI,"Central Water Commission", 2000
GOI,"Department of Agriculture and Cooperation", 2002

under-utilized river water from the Godavari, Ganga and Mahanadi.

Most states have attained 80 percent utilization of potential and some states 80 to 90 percent, but several others have lagged behind in this respect. Tamil Nadu tops this list with almost hundred percent utilization of its created potential. Maharashtra, Assam and some of the states have larger gaps in potential created and utilized.

More research is required to examine gaps and fluctuations in the actual irrigation water available and the potential created. As irrigation has been increasing through creation of new potential, it is difficult to assess trends in water availability from the same potential created over years.

Further, the actual acreage irrigated differs from the potential utilized. In a good-rainfall year, more water is available in wells, tanks and canals than during an average-rainfall year and more acreage can be irrigated. In a deficient year, there will be less water and lower irrigated area. These fluctuations are on account of rainfall, but unutilized potential is a different matter. It arises mainly because there aren't enough field channels; consequently, some areas are out of reach of irrigation. However, these areas could be brought under irrigation with appropriate amount of investment.

A look at the irrigation potential utilized and the gross area irrigated in 1998–1999, a year of good rainfall, reveals that eleven states out of twenty-five have shown gross irrigated area above the average potential utilized. However, in Kerala, Bihar, Uttar Pradesh, West Bengal and some of the northeast states, the gross irrigated area is far lower than the potential utilized. It is not clear whether this is due to discrepancies in statistics collected by different agencies or some deeper causes that require in-depth investigation. Interestingly, these states are also the ones with large areas under canal irrigation and good rainfall. Probably, there is less need for irrigation and lower utilization of irrigation potential when rainfall is good.

Another interesting fact is the relative importance of surface water and groundwater potential vis-à-vis the actual areas irrigated. It was pointed out earlier that surface water potential (62 percent) is higher than groundwater potential (38 percent) in terms of billions of cubic metres. The picture seems to change when the irrigation potential is estimated in terms of actual crop area that can be irrigated and broken up into minor and major irrigation potential. Ultimate potential in area terms has been estimated at 139.89 million hectares of total irrigated area about 64 million hectares from groundwater resources, and about 75 million hectares from surface water resources. On the basis of these figures, surface water potential may be estimated at 54 percent and groundwater potential at 46 percent. The proportion of groundwater potential to surface water potential has been increasing as a source of irrigation. Groundwater sources seem to have been over-exploited. The proportion of surface water available to groundwater available was 62:38, while the irrigation potential in hectares was 46:54. We may conclude that more in-depth analysis on water availability and the realistic estimates of the possibility of its sustainable use are required.

The actual net area irrigated in 1998–1999 has tilted towards groundwater use. Groundwater sources account for 62 percent of the irrigation whereas canals and tanks constitute only 38 percent. The main reason could be that private investment in groundwater is going up but public investment in surface water facilities is going down (The section on sources of irrigation elaborated this aspect). The composition of irrigation sources highlights the need for more realistic estimates of the potential and limits of exploitation to ensure effective control of water use, after taking technical and economic feasibility into consideration.

1.7.2 River Basins, Watersheds and Utilizable Surface Water

Wherever reservoirs and dams are constructed, river basins are the principal sources of irrigation. Most of the major and medium irrigation projects are developed from these reservoirs. Water availability in the catchments decides the ultimate irrigation potential in these river basins. In India, major and medium river-based irrigation projects are designed for 75 percent dependability. It means that the designed quantity of water is available in the reservoir for at least seven and a half years over a period of ten years (Second Irrigation Commission 1969). Geographical representation 2 shows the major rivers and the quality of water in them.

The highly variable nature of the flow and other limitations imposed by physiographical factors means that the entire quantum of water in the rivers cannot be utilized. The utilizable quantum depends on the availability of good quality water, land suitable for cultivation and the dependability of the flow in the river.

A decline in reservoir capacity as well as a reduction in river water flow has been reported in some case studies (Vaidyanathan 2001), but these have not been substantiated with statistical data at the state and national levels. Sufficient comparable and reliable data over a period of time on river flows and on changes in reservoir capacities will have to be analyzed more systematically. Data from the National Remote Sensing Agency (NRSA) on these factors enable comparisons for different years. However, such data are not available in the public domain.

The Central Water Commission provides data on the annual average water resource potential in river basins and on the estimated utilizable flows in the country's major river basins (Table 1.16).

The data pertains to 1989. More recent data, which will enable the assessment of changes in the flow of various rivers, are not available. There is a large gap between the potential average annual flow in rivers (1869 BCM) and the utilizable flow (690 BCM).

In terms of surface run off, the water resource potential seems to be the highest for the Ganga and Brahmaputra basins. However, the utilizable water from the Brahmaputra River is estimated at 24 BCM out of the flow of 585 BCM. The utilizable flow is the highest for the Ganga basin at 250 BCM out of the 525 BCM available. Information is not available about the actual utilization of water at present for these two rivers. Other large rivers such as the Godavari, the Mahanadi, the Narmada and the Tapti have much lower levels of flow than the Ganga and the Brahmaputra, but higher percentages of utilizable flow. The actual utilization of water from these rivers has also been relatively low, between 20 and 40 percent of the utilizable flow. The Godavari has a higher utilizable flow in actual terms.

For smaller rivers such as the Indus, the Cauvery, the Krishna and the Pennar, the utilizable flow is very close to the average annual flow. The present levels of water use also appear to be high, and very close to the utilizable potential. About 80 to 95 percent of the utilizable flows have been used up. The smaller west-flowing rivers in Western India, the Sabarmati and the Mahi, have also shown high rates of utilization (more than 80 percent for the Mahi, 93 percent for the Sabarmati). Thus, smaller rivers have been exploited the most. The smaller the river, the closer the utilization to 100 percent. This may not be sustainable over long periods unless watersheds and drainage points are ecologically healthy.

The All-India Watershed Atlas published in 1991 provides data for important drainage basins of major rivers in terms of the area of the basins and the number of watersheds in each basin. The entire country is divided into six important water resource subregions.

The water resource subregion (No. 4 in Appendix 1.7) is formed from four rivers: the Mahanadi, the Godavari, the Krishna and the Cauvery, and is the biggest. These rivers flow across eight states and drain into the Bay of Bengal. The states spread from West Bengal to Tamil Nadu and Maharashtra to Andhra

Table 1.16

Water resources potential in the river basins of India in cubic km

S.No	Name of the River Basin	Average Annual Potential in the River	Estimated Utilisable Flow Excluding Groundwater	Present Use of Surface Water [1989]	Present Stage of Utilisation in Percentage
1	Indus [upto border]	73.31	46.00	40.00	87.00
2	Ganga	525.02	250.00	_	_
3	Brahmaputra, Barak & others	585.60	24.00	_	_
4	Godavari	110.54	76.30	38.00	50.00
5	Krishna	78.12	58.11	47.00	81.00
6	Cauvery	21.36	19.00	18.00	95.00
7	Pennar	6.32	6.86	5.00	73.00
8	East flowing rivers between Mahanadi and Pennar	22.52	13.11	_	_
9	East flowing rivers between Pennar and Kanyakumari	16.46	16.73	_	_
10	Mahanadi	66.88	49.99	17.00	34.00
11	Brahamani & Baitarani	28.48	18.30	_	_
12	Subernarekha	12.37	6.81	_	_
13	Sabaramati	3.81	1.93	1.80	93.00
14	Mahi	11.02	3.10	2.50	81.00
15	West flowing rivers of Kutch, Saurashtra including Luni	15.10	14.98	_	_
16	Narmada	45.64	34.50	8.00	23.00
17	Tapi	14.88	14.50	_	_
18	West flowing rivers from Tapi to Tadri	87.41	11.94	_	_
19	West flowing rivers from Tadri to Kanyakumari	113.53	24.27	_	_
20	Area of Inland drainage in Rajasthan desert	NEG	_	_	_
21	Minor river basins draining into Bangladesh and Burma	31.00	_	_	_
	Total	1869.35	690.31	_	_

Source: Central Water Commission "Water Related Statistics of India"- 2000

Pradesh. This water resource subregion spans 113 million hectares of geographical area and has 1150 watersheds in different states. The health of these watersheds in terms of luxuriant natural vegetation determines the strength of river water flow and groundwater recharge in the area. A watershed is a geo hydrological area that drains at a common point. The watershed approach is a project-based development plan that follows a ridge-to-valley approach to water harvesting and water conservation. Watershed development has to be organized through rainwater harvesting, afforestation, contour-grade bunding fortified by plantations, drainage line treatment with a combination of vegetative and check dams, agro forestry, increase in pasture lands and so on. The watershed atlas becomes an important starting point for project development in the watersheds of river basins. (Appendix 1.7)

1.7. 3 Utilizable Surface Water Resources for the Future

Utilizable Surface Water reflects the potential available for future use. This is expressed as a percentage of the Ultimate Irrigation Potential estimated (Table 1.17

and Map 1.8). The estimates of utilizable potential represent the sustainability of water availability. This has to meet future demands for agriculture, industry and domestic consumption. The map shows state-wise distribution of utilizable surface water. For the country as a whole, the unutilized surface water potential was 39 percent in 1998–1999. The state with the lowest unutilized surface water potential is Tamil Nadu, with only 10.4 percent of the potential remaining unexploited. The states that have very little scope for expansion and low unutilized potential (between 10 and 20 percent) are Punjab, Rajasthan and Jammu and Kashmir. Other states with 20–30 percent unutilized potential are Karnataka, Haryana

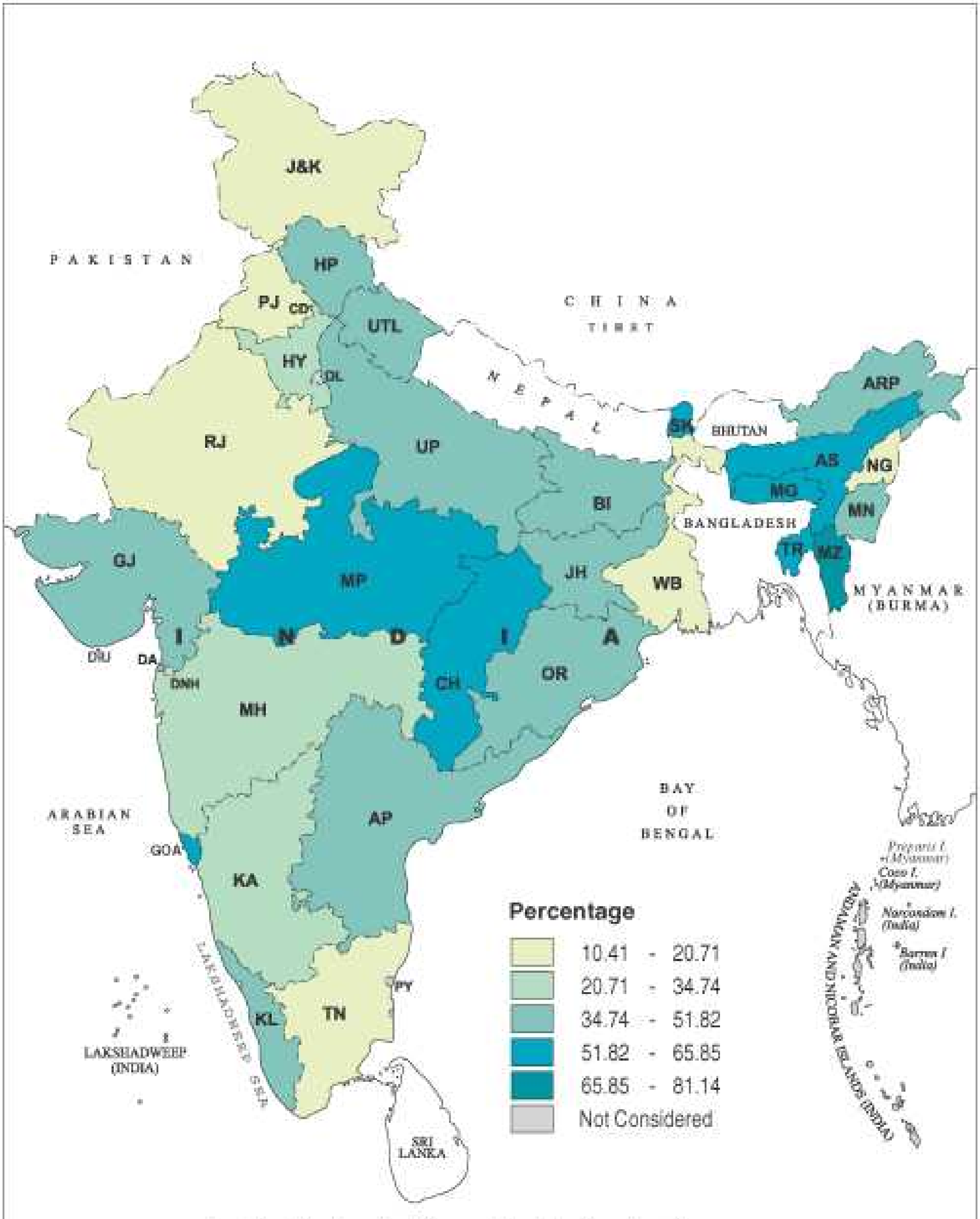
Table 1.17

Statewise Ultimate Irrigation Potential in Surface Water ('000 hectares)

S.No	States	Major & Medium irrigation		Minor irrigation		Total Ultimate Irrigation Potential	Total Unutilised Potential	Utilisable Surface Water Potential (pect.)	Major Irigation-Unutilised Potential as % to total Unutilised Potential
		Ultimate Irrigation Potential	Unutilised potential Anticipated 1997-98	Ultimate Irrigation Potential	Unutilised potential Anticipated 1997-98				
1	Andhra Pradesh	5000	1924	2300	876	7300	2800.00	38.36	68.71
2	Arunachal Pradesh	0	0	150	66	150	66.00	44.00	0.00
3	Assam	970	770	1000	527	1970	1297.20	65.85	59.36
4	Bihar	6500	3693	1900	521	8400	4213.80	50.16	87.64
5	Goa	62	49	25	6	87	55.30	63.56	88.61
6	Gujarat	3000	1635	347	99	3347	1734.30	51.82	94.27
7	Haryana	3000	921	50	8	3050	929.20	30.47	99.12
8	Himachal Pradesh	50	39	235	96	285	135.30	47.47	28.82
9	Jammu and Kashmir	250	74	400	34	650	107.70	16.57	68.71
10	Karnataka	2500	789	900	144	3400	933.30	27.45	84.54
11	Kerala	1000	455	800	317	1800	772.10	42.89	58.93
12	Madhya Pradesh	6000	3648	2200	964	8200	4611.70	56.24	79.10
13	Maharashtra	4100	1636	1200	205	5300	1841.20	34.74	88.86
14	Manipur	135	71	100	39	235	109.50	46.60	64.84
15	Meghalaya	20	20	85	42	105	62.20	59.24	32.15
16	Mizoram	0	0	70	57	70	56.80	81.14	0.00
17	Nagaland	10	10	75	8	85	17.60	20.71	56.82
18	Orissa	3600	1921	1000	236	4600	2156.90	46.89	89.06
19	Punjab	3000	474	50	5	3050	478.50	15.69	99.06
20	Rajasthan	2750	410	600	114	3350	523.70	15.63	78.29
21	Sikkim	20	20	50	20	70	40.20	57.43	49.75
22	Tamil Nadu	1500	0	1200	329	2700	329.10	10.41	0.00
23	Tripura	100	98	100	22	200	119.60	59.80	81.94
24	Uttara Pradesh	12500	5301	1200	136	13700	5437.30	39.69	97.49
25	West Bengal	2300	835	1300	0	3600	835.00	20.34	100.00
	All India	58465	24826	17378	4784	75843	29609.80	39.04	83.84

Source: Central Water Commission "Water Related Statistics of India"- 2000

UTILISABLE SURFACE WATER



Map No. 1.8

and West Bengal. The states with a large scope for expansion are Assam (65 percent), Madhya Pradesh (56 percent), Gujarat (52 percent) and Bihar (50 percent). Northeastern states present a mixed picture. Most states show a high percentage of untapped river water potential, but this potential relates to a small geographical area. The exceptions are Nagaland (very little possibility of expansion in potential) and Assam (high expansion possibility in terms of area). The states with some scope for expansion (between 30 and 50 percent) are Uttar Pradesh, Orissa, Andhra Pradesh and Himachal Pradesh.

If we look at the untapped potential from the actual area that could be irrigated, the highest capacity of more than 5 million hectares is in Uttar Pradesh. Madhya Pradesh and Bihar can provide surface irrigation for 4 to 5 million hectares respectively. In Andhra Pradesh and Orissa, the figure is 1 to 2 million hectares.

Unutilized water potential is available in major and medium irrigation projects as well as in minor projects. However, most of the potential available for the future seems to exist only in major and medium irrigation projects. The share of the major and medium irrigation projects in the available unexploited potential was about 84 percent for the country as a whole. The potential future use from minor irrigation is only 16 percent of the potential available for expansion in future (Central Water Commission 2000)

Tamil Nadu has already over-exploited its entire major and medium irrigation potential for surface water resources, and there is no scope for further expansion. If anything, the present over-exploitation may create permanent damage to water availability, leading to further fall in availability. Barring the northeastern states and Himachal Pradesh, the minor surface irrigation potential for future expansion is no more than 1 to 15 percent. Andhra Pradesh is the only non-hilly region that still seems to have some potential for expansion in future from minor irrigation projects (about 32 percent). The hilly regions (Himachal Pradesh, Arunachal Pradesh, Meghalaya and Sikkim) still have some scope for minor irrigation in future.

Thus, it is obvious that as far as surface water is concerned, most of the potential available from smaller rivers and minor irrigation projects has been exploited, and there is not much scope for expansion. The future potential lies only in the large rivers, hence the talk about interlinking of rivers. A detailed discussion of irrigation efficiency, water use efficiency, watershed degradation and reduced water flows in rivers is necessary before considering the desirability, feasibility and environmental impact of such a major step. A detailed cost-benefit analysis, which covers social costs and externalities, is a prerequisite for a meaningful debate on this topic.

1.7.4 Utilizable Groundwater Resources for the Future

The assessment of groundwater resources is much more complex, as it entails evaluation of various hydrological components within the framework a complex geological environment. The replenishable groundwater resource is essentially a dynamic resource replenished periodically by precipitation, irrigation return flow, canal seepage, tank seepage and influent seepage. Estimation of the resource requires the measurement of inflow and outflow and of changes in the storage in aquifers.[6] The estimate of groundwater used in any given year is the ratio of net draft to the total utilizable groundwater resource. Net draft is 70 percent of the quantity of the water withdrawn from groundwater reservoirs. Thirty percent is presumed to go back into the aquifers as

[6] Water-bearing rock formations are called aquifers

seepage. Utilizable groundwater is the percentage of balance groundwater available for future use in net terms to the total available groundwater resource for irrigation. Utilizable groundwater reveals the sustainability of groundwater use. The higher the unutilized percentage of groundwater, the higher the sustainability.

The annual groundwater resources in the country that could be replenished were estimated at 432 BCM. The Minor Irrigation Department in the Ministry of Water Resources provides statistics on the ultimate minor irrigation potential from groundwater, in terms of area irrigated. For all of India it stands at 64 million hectares. At the end of the Eighth Plan, a total of 46.5 million hectares worth of potential had been created. The remaining unutilized potential is 19.5 million hectares in irrigation capacity (Planning Commission 2002). State-wise figures of groundwater potential and utilization are available from the Central Water Commission as well as from the Groundwater Board.

The Central Water Commission's data on minor irrigation potential of groundwater is in hectares. The Central Groundwater Board provides data on groundwater potential in cubic metres as well. This information is more detailed than that relating to minor irrigation. Hence, the present study prefers the Central Groundwater Board statistics to that of the Central Water Commission for calculating unutilized potential. The Central Groundwater Board classifies groundwater potential on the basis of level of exploitation into four categories. These are (a) safe level of exploitation, with an exploitation level of less than 65 percent (white), (b) semi-critical areas, levels of exploitation between 65 and 85 percent (gray); (c) critical areas, level of exploitation more than 85 percent (dark); and (d) over- exploited, 100 per cent or more.

It is important to keep the extraction levels much lower than the maximum to ensure sustainability of water availability in future (Central Groundwater Board 1995). Thus, the lower the extraction, the better the sustainability of groundwater use.

The available groundwater is estimated in net terms. Data show that for the country as a whole, the dark and over-exploited blocks have been increased from 253 in 1984–1985 to 428 by 1997–1998. The maximum number of such blocks seems to have occurred in Tamil Nadu, with 103 blocks. Rajasthan and Punjab follow with 94 and 83 blocks. In Punjab, 60 percent of the blocks show exploitation levels of more than 85 percent. In Rajasthan, about 40 percent of the blocks show exploitation levels of more than 85 percent (Table 1.18, Appendix 1.8).

Accordingly, the unutilized ground-water potential available for the future is the lowest in Punjab: at about just 1.7 percent. The remaining 98.3 percent of the potential is already being utilized. Haryana has about 24.39 percent unutilized potential, Rajasthan about 27.16 percent, followed by Tamil Nadu (37.45

Table 1.18
Status of over-exploitation in India

S.No	State	No. of Dark and over- exploited blocks		
		1984-85	1995	1997-98
1	Andhra Pradesh	0	30	26
2	Bihar	14	1	11
3	Gujarat	6	26	28
4	Haryana	31	51	41
5	Karnataka	3	18	16
6	Madhya Pradesh	0	3	3
7	Punjab	64	70	83
8	Rajasthan	21	56	94
9	Tamil Nadu	61	97	103
10	Uttar Pradesh	53	31	40
	Total	253	383	445

Source: Chadha, D.K. 2002.

percent). Gujarat, Uttar Pradesh, Bihar, Karnataka and West Bengal have also exploited groundwater, but their unutilized capacity is moderately high (up to 50 to 60 percent). Orissa, Madhya Pradesh and Kerala have around 80 percent unutilized potential, while Andhra Pradesh has 74 percent unutilized capacity (Table 1.19 and Map 1. 9).

In states such as Andhra Pradesh, Punjab, Haryana and Jammu and Kashmir, the canal irrigation system helps recharge aquifers to the extent of 43 to 50 percent. In Uttar Pradesh and Tamil Nadu, such recharge is far lower (less than 30 percent). It is even lower in other states. In the areas where canal irrigation recharges the groundwater, conjunctive use

Table 1.19

Utilisable groundwater for irrigation, in million hectare meter / year

Sl.No	State	Available Groundwater Resource for Irrigation in net terms-1998	Level of groundwater development 1998	Balance Groundwater Resource for future use in net terms-1998	Groundwater available as % to total available for irrigation-1998
		MHaM	%	MHaM	%
1	Andhra Pradesh	3.00	26.10	2.22	73.90
2	Arunachal Pradesh	0.12	0.00	0.12	100.00
3	Assam	1.91	7.46	1.77	92.54
4	Bihar	2.85	33.16	1.91	66.84
5	Goa	0.19	8.30	0.02	91.70
6	Gujarat	1.73	49.27	0.88	50.73
7	Haryana	0.95	75.61	0.23	24.39
8	Himachal Pradesh	0.02	16.63	0.02	83.35
9	Jammu and Kashmir	0.38	1.07	0.37	98.93
10	Karnataka	1.38	33.06	0.92	66.94
11	Kerala	0.66	18.99	0.53	81.01
12	Madhya Pradesh	4.33	18.84	3.51	81.16
13	Maharashtra	2.55	34.70	1.66	65.30
14	Manipur	0.27	Neg	0.27	100.00
15	Meghalaya	0.46	Neg	0.04	96.03
16	Mizoram	N.A	N.A	0.00	0.00
17	Nagaland	0.06	Neg	0.06	0.00
18	Orissa	1.71	15.22	1.45	84.78
19	Punjab	1.64	98.34	0.03	1.66
20	Rajasthan	1.06	72.84	0.29	27.16
21	Sikkim	N.A	N.A	0.00	0.00
22	Tamil Nadu	2.24	62.55	0.84	37.45
23	Tripura	0.06	33.43	0.04	66.57
24	Uttar Pradesh	7.26	41.95	4.21	58.05
25	West Bengal	1.96	32.19	1.33	67.81
	Total	36.20	37.24	22.73	62.76

Source: Central Groundwater Board, 2000.

of surface and groundwater in canal-irrigated systems is common in non-hilly areas. This is the reason for the increase in irrigation intensity and cropping intensity in Punjab, Haryana and irrigated parts of Andhra Pradesh. Sikkim and Mizoram have not been assessed for groundwater resources and there has been no utilization either. Hence, we have taken the groundwater resources as zero. Nagaland has negligible groundwater potential and none has been used; hence, we have assumed the groundwater resource there as zero. In Manipur, whereas the available potential was higher than in Nagaland, and about half the potential of Meghalaya, none of the potential has been tapped. Hence, potential availability has been assessed as 100 percent.

In Kerala, Assam, Manipur, Meghalaya and Jammu and Kashmir, groundwater is hardly used though it is available. In some of the northeastern states, Jammu and Kashmir and Himachal Pradesh, it is technically difficult to extract groundwater because of the topographical set up, inaccessibility, depth of the aquifers, etc. It is economically unviable to extract groundwater in hilly areas as percussion rigs have to be deployed. Another reason for non-use of groundwater is the availability of water from good rainfall and sufficient surface water, especially in states such as Kerala. In Assam, the reason for under-exploitation is insufficient power and insufficient awareness. Higher levels of groundwater exploitation occur only when it is technically feasible and economically profitable.

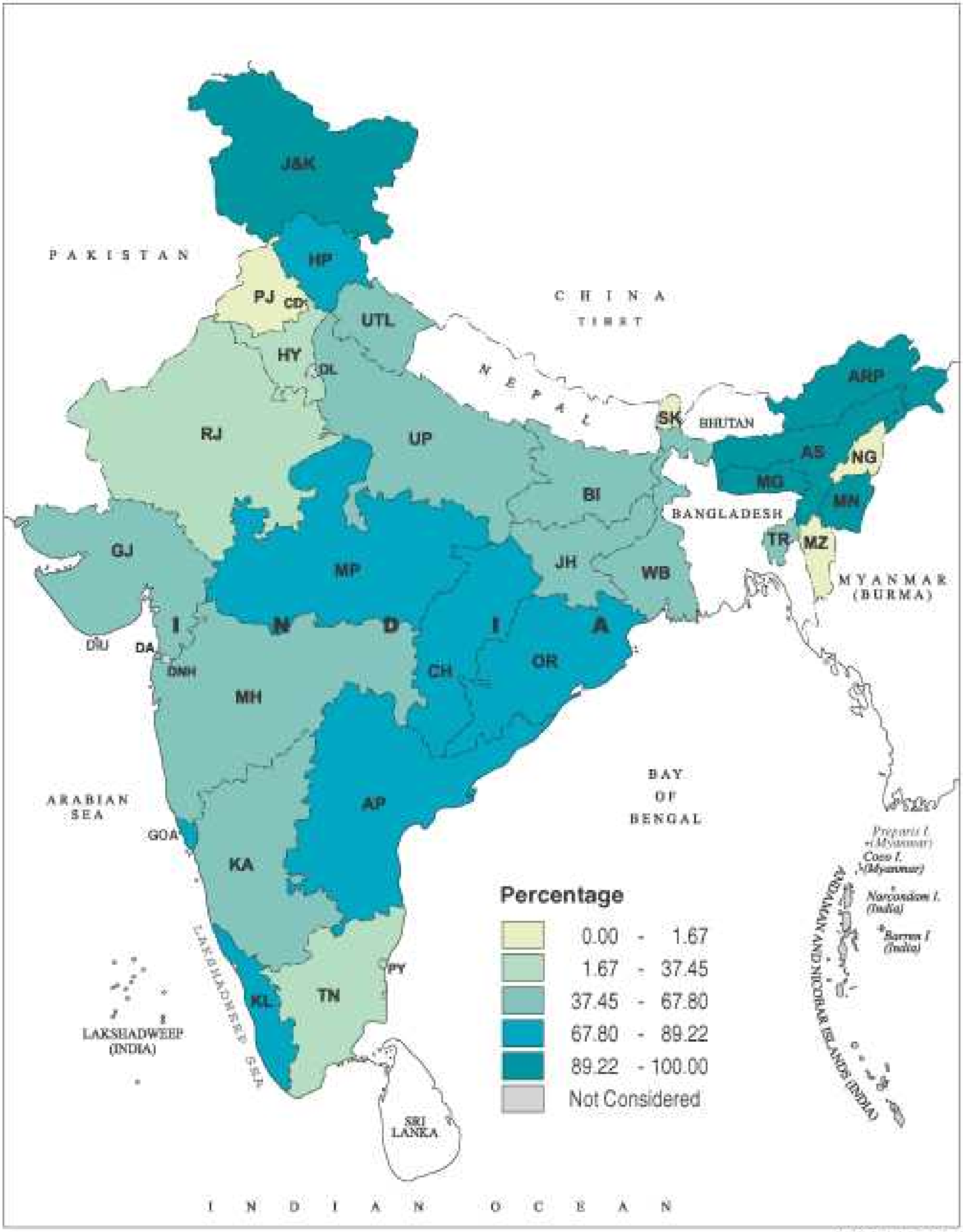
Similarly, higher levels of exploitation even beyond 65 percent are sometimes sustainable when the replenishment levels are very good and watersheds are ecologically healthy. It is interesting to note that the untapped groundwater resource in net terms for Tamil Nadu is 37.45 percent, higher than the comparative figures for Punjab (1.6 percent) and Rajasthan (27.16 percent) in a good rainfall year such as 1998. Good rainfall over two years strengthens the groundwater resource. In years of deficient rainfall, the resource gets depleted. Taking India as a whole, land degradation has aggravated problems created by droughts. While the degree of groundwater exploitation by itself cannot show how unsustainable the situation is, the receding water tables and the statistics of 100 percent exploitation underscore the gravity of the situation. Hence, the lower the level of unutilized potential, the higher the levels of groundwater extraction and the lower the sustainability of water use, as in Punjab, Rajasthan, Haryana and Tamil Nadu.

Regulating the extraction of groundwater in over-exploited regions and creating more options for exploitation in under-utilized areas are important to augment groundwater resources for the future. Further, it is important to develop groundwater resources in conjunction with surface water resources, as they form part of a single watershed system.

1.7.5 Changes in the Sources of Irrigation and Sustainability of Water Use

The major sources of irrigation are surface water through canals and tanks and groundwater through dug wells and deep tube wells. A visible trend in irrigation relates to changes in the proportion of land irrigated by these three principal sources—canals, tanks and wells. Major surface water irrigation works, such as the development of canal and tank irrigation, undertaken during the four decades since 1960, have helped to augment water supply for agriculture. Where surface water was insufficient to meet agricultural production, the need was met by drawing on groundwater resources. It may be noted that of the total irrigation potential created between 1951 and 1998, groundwater accounts for a little over 50 percent. Canal irrigation is undertaken through major

UTILISABLE GROUND WATER



Map No. 1.9

and medium irrigation projects with a command area above 2000 hectares, whereas irrigation by tanks is predominantly through minor irrigation projects covering less than 2000 hectares.

A significant increase has been noticed in groundwater irrigation during this period. Canal irrigation in the country as a whole has shown an overall increase over the years, but has tended to stabilize during the last decade. Tank irrigation has steadily declined over the years. Changes in the sources of irrigation from 1981 to 1992 and to 2000 show changing trends in the composition of water sources (Table 1.20).

State-wise analysis reveals that although the contribution of canal irrigation is substantial in Uttar Pradesh, Punjab, Bihar, Andhra Pradesh and Tamil Nadu, these states had registered a decline in canal irrigation till the year 2000. Even in states where canal irrigation has gone up, its contribution to overall irrigation during the 1990s has been substantially less than the previous decade.

The stagnation in the growth of canal irrigation over the last decade can be explained in several ways. One of the most important reasons is the high cost of construction, operation and maintenance of major and medium canal irrigation systems. The average cost per hectare of irrigated land through major irrigation projects is estimated to be over Rs. 100,000 per hectare. By comparison, the average cost of watershed schemes is about Rs.5,500 per hectare, that of tank renovation about Rs.15,000 per hectare and that of groundwater schemes is about Rs.10,000 per hectare (Planning Commission 2002).

Public investment in irrigation development has been coming down in India. Of the total public sector investment, the allocation for major and medium sector irrigation projects was about 19 percent during the First Plan and just about 5 percent in the Eighth Plan.[7] A conscious shift toward minor irrigation has been advocated.

Secondly, large irrigation projects face public opposition on the grounds of ecological imbalance and human suffering owing to displacement. There is a growing concern about seismic instability whenever major dams are erected in geologically sensitive areas. Large-scale rehabilitation of people is expensive; schemes to effect such rehabilitation often remain on paper. The ecological devastation wrought by submerged forest areas far outweighs the benefits from irrigated areas. The large gestation periods of these projects are also a major drawback.

Tanks are the other source of surface water irrigation. Tanks are predominant in Tamil Nadu, Orissa, Andhra Pradesh, Karnataka and West Bengal. In the peninsular states, tank irrigation has been an age-old practice and accounts for more than one-third of the total irrigated area. In Tamil Nadu and Karnataka, there are more than 39,000 tanks each, which supplement canal irrigation for the predominant crop, rice. In all these states except Orissa, tank irrigation has declined drastically. Madhya Pradesh, Bihar and Orissa registered an increase in tank irrigation in 1992–1993 over 1981–1982, but it declined by 1999–2000. Tanks do not play any significant role in irrigation in Punjab and Haryana.

Serious inefficiencies in tank irrigation are the most important cause for the decline in the area irrigated by tanks. These are caused by excessive siltation in tanks and channels, choked, leaky or broken sluices with missing shutters, damaged weirs, damaged tank bunds and broken canal structures. Eighty percent of the tank beds are infested with weeds. The tank foreshores have been severely encroached for various uses—agriculture, tree plantations and housing.[8] A

[7] Nath, Vikas. http://www.cddc.vt.edu/knownet/vikas-investment.pdf

Table 1.20

Statewise net irrigated area as per the major source of irrigation, 1981-82, 1992-93 and 1999-2000 ('000 hectares)

Sl.No	State	Canal			Tank			Well			Total		
		1981-1982	1992-1993	1999-2000	1981-1982	1992-1993	1999-2000	1981-1982	1992-1993	1999-2000	1981-1982	1992-1993	1999-2000
1	Andhra Pradesh	1756	1727	1634	1045	729	651	786	1411	1900	3692	4029	4384
2	Assam	363	362	362	-	-	-	-	-		572	572	572
3	Bihar	1170	934	1136	100	128	155	996	1701	2093	3001	3344	3625
4	Gujarat	421	557	602	40	26	25	1690	2056	2430	2155	2642	3082
5	Haryana	1183	1359	1441	-	1	1	1056	1239	1432	2248	2628	2888
6	Himachal Pradesh	2	9	3	1	1	0	4	6	13	92	99	102
7	Jammu & Kashmir	290	288	278	3	2	3	3	2	1	307	311	303
8	Karnataka	580	903	994	321	257	245	402	725	959	1471	2194	2548
9	Madhya Pradesh	1084	1686	1804	135	177	193	1000	2322	3856	2421	4775	6740
10	Maharashtra	871	562	1051	-	385	-	1154	1348	1921	2025	2470	2972
11	Orissa	801	938	949	207	298	305	207	834	836	1215	2070	2090
12	Punjab	1323	1365	1269	-	-	-	2073	2398	2705	2408	3861	4004
13	Rajasthan	946	1428	1619	85	207	78	1827	2804	3867	2903	4471	5612
14	Tamil Nadu	901	851	867	739	629	633	1045	1201	1453	2709	2698	2972
15	Uttar Pradesh	3203	3239	3109	186	84	95	5882	7638	9255	9541	11322	12692
16	West Bengal	628	717	717	373	263	263	444	712	712	1684	1911	1911
	India	15678	17084	17995	3296	3243	2706	18613	26538	33632	40031	50101	57238

Source: GOI, Anon 1997, Directory of Indian Agriculture, Ministry of Agriculture, New Delhi number of tank beds are even being used as cattle sheds and dumping yards.[9] Pollution of tanks with human, cattle and domestic waste has made tank water unfit for drinking and irrigation. Severe water scarcity in most of the tanks, although initially limited to the dry season only, is n

Government of India (GOI), Planning Commission, 2002. The Tenth Five Year Plan, 2002 – 2007.

monsoons when the rains are less than normal. Poor water supply in system tanks previously dependant on river flow has affected the other tanks that are hydrologically linked to each other. Village-level institutions that looked after the maintenance of tanks have slowly become inactive. This has resulted in lack of interest and action in maintaining and repairing of tanks. The tanks slowly go out of use and become defunct.

The facts mentioned above about changes in the sources of irrigation reflect the growing water scarcity in river basins, inefficiency of canal irrigation, over-exploitation of groundwater and growing social and environmental opposition to large irrigation projects. They reflect a scenario of degraded watersheds and disturbed hydrological regimes. They also reflect changing socio-economic perceptions and eroding traditional customs and practices. The steady decline in the contribution of canals and tanks to net irrigation in the country have serious implications for the sustainability of food security in these individual states and in India as a whole.

1.7.6 Efficiency in Irrigation Systems

There are two aspects to efficiency of water use. The first aspect is the efficiency of the irrigation system; the second is the efficiency of water use in crop production. One of the inefficiencies in the irrigation system is reflected in the under-utilization of potential created. There are several reasons for time lags and gaps between potential created and utilized, as elaborated in the Tenth Plan document (Planning Commission 2002). Non-construction of on-farm

cropping pattern toward more intensive crops, over-estimation of run off in hydrological planning of reservoirs (as a result of which they do not get filled to their full potential) are some of the reasons for reduced efficiency of utilization.

It is important to simultaneously improve the efficiencies of canal and tank irrigation systems. Maintenance and repair of canal systems to prevent breaches of water, regulation of water supply through sluices and to farms, construction of sufficient storage structures to contain surplus water and minimize water scarcity—these measures will improve the efficiency of water supply. Evaporation of water from the canals can be minimized by sound engineering practices to suit climatic conditions. It is critical to modernize and recharge the tanks and revitalize the traditional village institutional activities (*kudimaramathu*). Modernization of tanks includes desilting of tanks to the desired levels[10] and excavation of link channels, reclamation of foreshore lands, improving bunds, repairing damages, construction of anicuts, checking weed growth and infestations, clearing underwood, and adopting soil conservation measures like such vegetative growth and tree cover.

There are two types of tanks: *non-system* tanks and *system* tanks. Non-system tanks are those that depend on rainfall in catchment areas and are not connected

[8] Wooler lake of Kashmir valley suffered the maximum encroachment from agriculture and house construction.

[9] *Shaping farmers perspectives: Conservation and development of Irrigation Tanks in Tamil Nadu,* Excerpts, Dhan Foundation, www.dhan.org

[10] De-silting of tanks need to be carefully carried out. Usually, in a 10-year cycle, tanks get filled up fully only for an average of three years. For another two years, the tanks are partially full, whereas for the remaining period, the tanks fail to meet the average irrigation requirement. Thus de-silting will help only during the three years of full water storage. Moreover, the earth removed during de-silting is difficult to dispose of. De-silting is also costly. It is therefore considered advisable to de-silt only partially and to the desired level, based on the local irrigation and consumption requirements.

to major streams or reservoirs. System tanks, on the other hand, are those that receive supplemental water from major streams or reservoirs in addition to the yields in catchment areas. Most of the tanks (90 percent) are non-system tanks. Proper maintenance of watersheds is necessary to maintain the system tanks that are hydrologically connected to each other and to the major river basins. Regulating groundwater extraction in the cultural command areas and tank ayacuts and ensuring adequate water in tanks through sufficient storage is also important. Flood management and management of water scarcity in river basins is an integral part of improving the efficiency of canal and tank irrigation systems. Water users associations (WUA) play an important role in equitable and scientific appropriation of water in the tanks and their maintenance. Command Area Development Programmes (CADP), integrated water resources management schemes and watershed development programmes initiated by the Government of India strive at a multidisciplinary focus in addressing the problems of water use.

1.7.7 Water Use Efficiency in Crop Production

Inefficiency is growing in the use of irrigation water

Palanisami, K. and Chandrasekharan, 2001. "Improving Irrigation Efficiency", Water Technology Center, Tamil Nadu Agricultural University:Coimbatore.

Steering Committee looked into irrigation for drafting a proposal for the Tenth Plan (Planning Commission 2002) and reported that different forms of inefficiencies exist: such as inability to irrigate the entire command area envisaged under the project at the time of creation; insufficient, untimely and unplanned quantities of water supplied through the irrigation network; inefficient conveyance of water through distribution channels; lack of field channels and drainage and inequity in water allocation in the command area. Silt formation in reservoirs because of degraded watersheds and disturbed moisture regimes have further contributed to reduced efficiencies. These are possibly some of the important factors that have led to the decline in canal irrigation in some states.

Water Use Efficiency (WUE) in crops is the productivity of crops per unit of water consumed. This is measured in terms of kilograms per hectare centimetre. It is a function of the soil type, potential evaporation from land and the water requirement of the crop. Crop water use efficiency can be expressed as the ratio of crop yield (Y) to the amount of water depleted by the crop in the process of evapotranspiration (ET).

$$WUE = Y / ET$$

Field water use efficiency (FWUE) measures the productivity from land per unit of water applied to the land and is the ratio of crop yield (Y) to the total amount of water used in the field (WR). Thus,

$$FWUE = Y / WR$$

Water requirements and water use efficiency differ for various crops in clayey loamy soils. WUE is expressed as the yield in kilograms per hectare

very low (Palanisami and Chandrasekharan 2001). Rice appears to have the lowest efficiency of 4, while ragi has the highest efficiency of 10.5. Hardy crops that require less water seem to have a higher water use efficiency than crops such as rice that require more water. Rice needs 1240 millimetre hectares of water while ragi requires as little as 310 millimetre hectares. Though sugarcane requires more water than rice, its requirement is spread over 360 days. Hence, the intensity of water requirement is lower for sugarcane than for rice. Sugarcane has a water use efficiency of 6 (Appendix 1.9)

Three factors reduce water application and utilization efficiency at the farm. The first is the lack of coordination between canal water supply and its application at the farms. The second is improper drainage and the third is water quality. Absence of irrigation scheduling to correspond with a crop's water requirements, inappropriate agricultural practices and inappropriate technology result in large wastages of water. There is no proper accounting for water use in agriculture. Studies on per-unit productivity of crop are still conducted only at experimental stations. Improper drainage leads to severe water logging leading to accumulation of salts in the soil. It results in salinization and alkalinization of the land and the consequent loss of productivity of the soil per unit of water consumed. This affects not only the existing crop but also subsequent harvests. Prime agricultural lands have been rendered wastelands; these lands have had to be abandoned. Improper drainage is also one of the primary factors contributing to unsustainability of the rice-based and rice-wheat–based cropping patterns. About 8.52 million hectares of land surface have been affected because of waterlogging in the country. This is more prominent in the intensively irrigated, rice-wheat dominated, canal command areas in the country. The problem of waterlogging is severe in the Indira Gandhi Canal Command Area in Rajasthan. It is also severe in the canal command areas of Uttar Pradesh (Sarda Sahayak Command Area, for example), Andhra Pradesh (Nagarjun Sagar Command Area), Punjab (Upper Bari Doab) and Haryana. Studies on the extent of waterlogging in northwest Punjab have reported a substantial increase in waterlogged areas since 1987 (Sondhi and Khepar 2000). Waterlogging in some of the major wheat-producing areas of northwest India is expected to increase five-fold over the next thirty years (Kulkarni *et al*. 1989). This has important implications for India's future food and water security.

1.7.8 Quality of Irrigation Water

The third factor that affects water use efficiency of crops and decreases yields is the poor quality of irrigation water. This is closely linked to improper drainage from fields. Water quality parameters such as Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Electrical Conductivity (EC) and Soluble Sodium Percentage (SSP) decide the suitability of water for irrigation purposes. Soils are vulnerable to different types of hazards based on the type of water used for irrigation. (1) Alkalinity hazard occurs when the water used for irrigation has high sodium content, causing alkalinity. (2) Salinity hazard is the accumulation of soluble salts in the crop root zone, when the water applied for irrigation has high soluble salts. (3) Carbonate hazard in the soil is the build-up of calcium and magnesium carbonates or bi-carbonates in the soil, which also increases alkalinity in the soil and reduces permeability. (4) Specific Ion Toxicity occurs when the soil contains traces of ions of chloride, nitrate, potash, sulphate, boron, etc in irrigation water. Irrigation with saline water, with groundwater having high sodium ions or with wastewater that has toxic substances etc. affects soil texture, clogs soil pores and reduces the permeability of the soil. These soils become hard and get sticky when wet. This reduces yields and causes crop failure (Palanisami *et.al*. 2002). The soil gradually becomes unfit for agriculture.

It is believed that water management and water-saving technologies can conserve water to the extent of 15 to 40 percent. Some important water-saving management practices and irrigation technologies are now being used. The idea is to improve yields and save water as well. Sprinkler irrigation and drip irrigation are examples (Appendix 1.10). Providing drainage facilities during irrigation and maintaining the quality of irrigation water are important steps towards improving the efficiency of the irrigation system as well as overall basin efficiency.

1.8 Sea Water

While analyzing the various surface and groundwater resources in India, it is also very important to look at the vast ocean resources the country is endowed with. It has important implications for future developments in sea-water farming. The states of West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Goa, Maharashtra and Gujarat share India's large coastline. The shelf area is about 0.5 million sq km. The length of the coastline is 8041km. The Exclusive Economic Zone covers 2.02 million sq km. For millions of fishermen, these marine resources are the main source of livelihood. The islands of Lakshadweep and Andaman and Nicobar also enjoy the benefits of coastal resources. A large network of rivers, swamps, marshy lands and wetlands supports inland fisheries in almost all the states of the country.

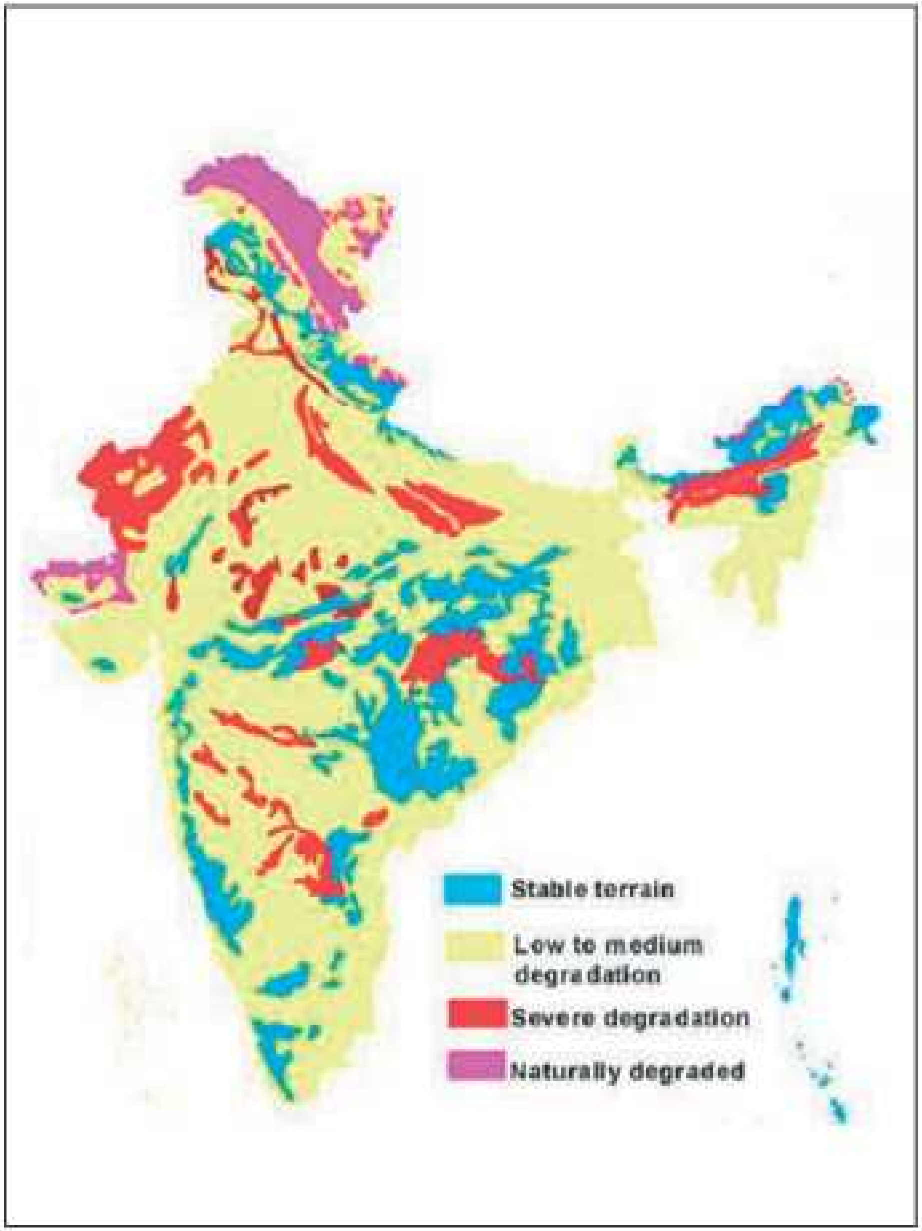
Fisheries are a major source of food, of nutrition (through protein), of livelihood and of foreign exchange earnings through export. With 2.40 million full-time fishermen, 1.45 million part-time fishermen and 2.11 million occasional fishermen, the number of people who depend on coastal resources for their livelihood adds up to 5.96 million (Tietze 2000).

Under the five-year development programmes, emphasis has been given to increasing fish production, exporting seafood products and improving the socio-economic status of fishermen. Major achievements have been recorded in introducing technology to add value to products, improving the fishing efficiency, increasing exports etc. Coastal fisheries in India are still an open-access activity without any catch limits. A number of developments over the years have threatened the sustainability of fisheries resources, both marine and inland.

Fisheries resources have been exploited indiscriminately without any scientific or sustainable utilization methodologies. Of the annual marine harvestable potential of 3.9 million tonnes, 2.8 million tonnes or nearly three-fourths is harvested. The largest marine fish catch is from Gujarat, followed by Kerala and Maharashtra (Appendix1.11). Deep-sea fishing is still primitive, carried out by ignorant, unorganized and ill-equipped fishermen (Yadava 2000). The advent of motorized boats for marine fishing saw uncontrolled and excessive fishing even in shallow regions of the sea; fishermen using these boats compete with small-scale fishermen who use dugouts, canoes, etc. The use of small-mesh nets results in the capture of juveniles and non-targeted species. Such phenomena are rapidly exhausting the fish population.

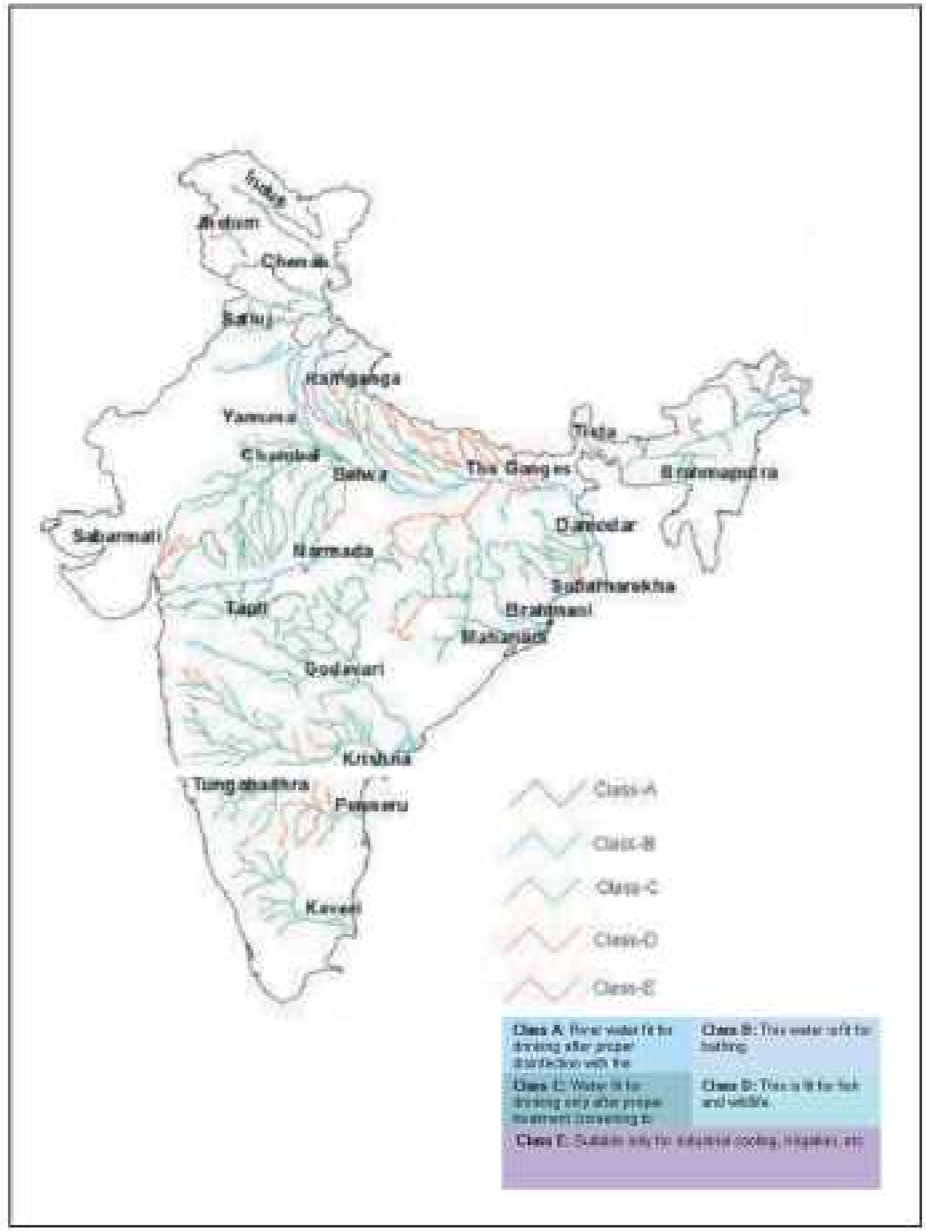
Pollution of rivers, streams and oceans by untreated industrial wastes and sewage from growing urban cities have threatened and killed several fish species. Coral reefs, mangrove wetlands and marshes are important feeding and breeding grounds for several migratory and endemic fishes and other aquatic species. Changes in land use and pollution have degraded and destroyed these habitats. Though there are strict rules to prevent over-fishing, and pollution norms prescribe maximum permissible standards for effluent emissions, enforcement by the authorities has been poor. Frequent clashes occur between fishermen and the local government.

SOIL DEGRADATION



Geographical Representation 1

WATER QUALITY IN MAJOR RIVERS



Geographical Representation 2

CHAPTER 2

Forests and Biodiversity

I. Forests

Forests constitute an important land use in India, the second largest land use after agriculture. Natural forests are extremely complex ecosystems. They differ from human-managed agricultural ecosystems with respect to two important functional attributes, namely, energy flow and nutrient cycling. Natural ecosystems are self-sustaining whereas human-managed systems depend largely on energy inputs externally supplied to the system (Ramakrishnan 2001). Forests help shape our biophysical environment in numerous ways. Forest products are a source of food and fodder; they sustain livelihoods and provide valuable inputs to agriculture and industry. Forests perform a multitude of ecological functions that help to maintain the stability and resilience of the earth's ecosystems. These include maintaining the hydrological balance of watersheds, stabilizing topography, preserving topsoil, maintaining soil fertility, preserving the local climate, and mitigating climate change by sequestering carbon. Forests are very closely linked to traditional agro-ecosystems, watersheds and river valley systems. Riparian forests stabilize riverbanks, regulate water flow to the sea and estuaries and improve oxygen levels in water. This enhances water quality for drinking and permits greater aquatic diversity. Forests also act as vast genetic treasure houses, preserving and creating biological diversity and providing the genetic base for evolution. A typical multilayered, multispecies forest is a huge biological industry constantly churning out newer and newer genetic material, using all possible recombination of species. Much of the future demand for genetic material for crop modifications can be met from the gene pool preserved in these forests (WCFSD 1999; Woodwell 2002).

Apart from forests, trees are also functionally significant. Trees are important in rural areas of low forest cover, as also in agricultural lands and urban areas. They minimize soil erosion and augment soil fertility, they detoxify soil by absorbing toxic heavy metals let out from fertilizers and pesticides, they filter and recharge groundwater and provide energy and biomass. They are an important source of timber, fuel wood, fruit, fodder, shade and shelter and protect biological diversity, crops and settlements (FAO 2003.).

Human cultures in India have always interacted very closely with forests. The sacred groves that can be seen in different parts of the country are remnants of dense virgin forests. They stand testimony to the deep respect and understanding that traditional communities have for forests. In the tribal population who live in the forests, one can glimpse the close interdependence of man and forests. To a very large extent, tribal economies depend on forests. A variety of minor forest produce are gathered by tribal people and sold to cooperatives or middlemen. The livelihood security of these populations depends on the health of forest ecosystems.

This chapter on forests looks at the extent of forest cover in all the states of India and the union territory of Andaman and Nicobar Islands, and the changes in forest cover over the past decade. It addresses these issues in the context of ensuring ecosystem stability for sustained agricultural production in the country. The first section examines the extent of total forest cover, dense and open forests, weighted forests, per capita forests, trees outside forests and changes in the extent of forest cover. The second section addresses the extent of degradation of forests, its causes and concerns.

2.1 Forest Cover

2.1.1 Total Forest Cover

Forest cover assessment serves to assess the extent to which the forests in each state are able to meet the various functions that sustain agricultural production and livelihoods in the country. It also lays the ground for assessment of the extent of degradation of forests, which has been analyzed in the next section. Assessment of forest cover by the Forest Survey of India is based on the crown density of trees (Geographical Representation 3). Crown density represents the extent of coverage of leaf canopy. A forest consists of all lands having a tree crown density of more than 10 percent. Dense forests have a crown density of more than 40 percent. Open forests have a crown density less than 40 percent but more than 10 percent. Those with less than 10 percent are called scrub. Scrub has been classified as a separate category and has not been included under forests (Forest Survey of India 2001). The 40 percent crown density has been adopted as the dividing line between dense and open forest because, at this density, the distance between two crowns equals the mean radius of a tree crown (Central Statistical Organisation 1998).

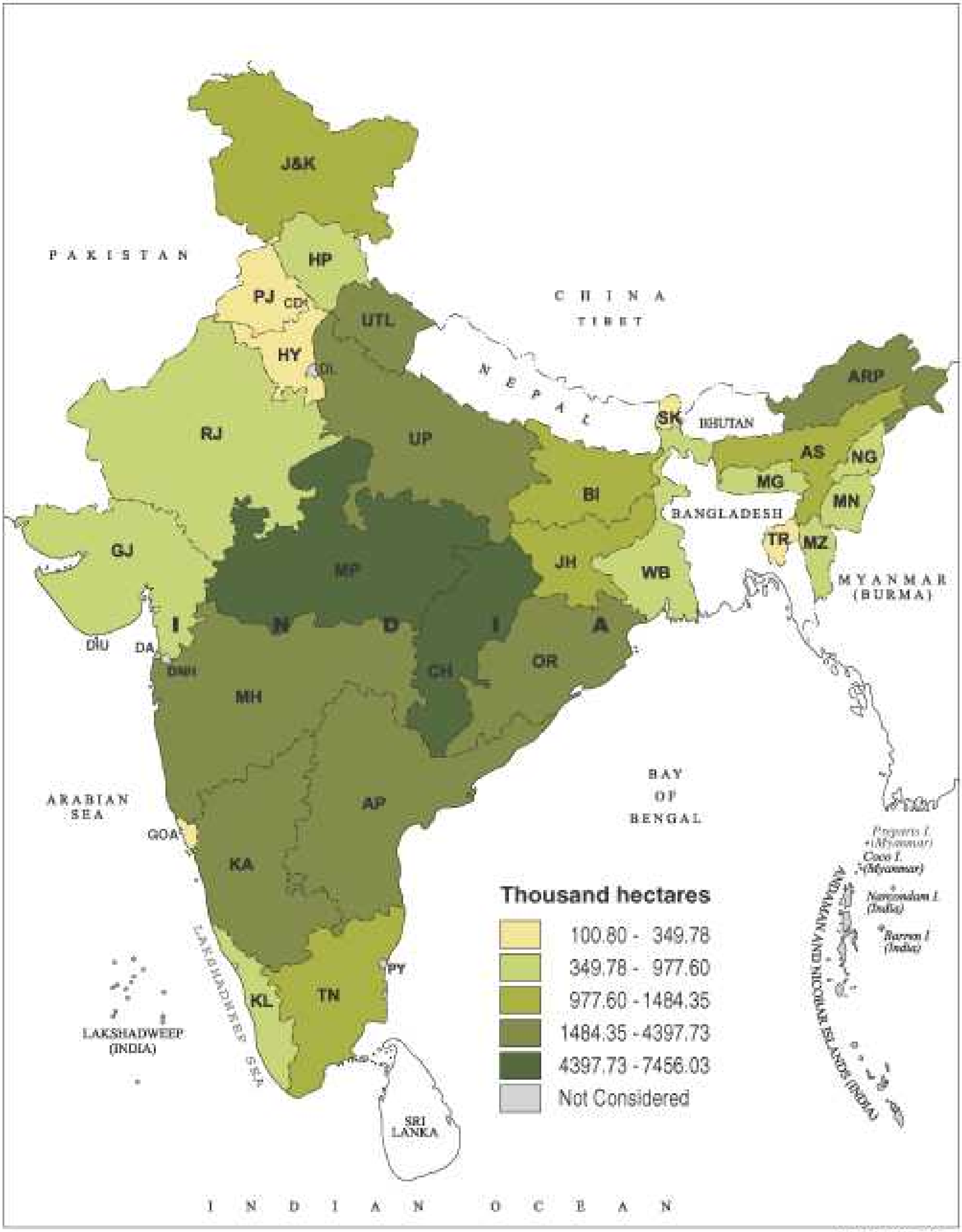
The total forest cover in India, made up of dense forests, open forests and mangroves, stands at 67.55 million hectares. Dense forest extends to 41.68 million hectares and open forest to 25.87 million hectares. Mangroves are spread over an area of 0.45 million hectares along the coasts of peninsular India. Scrublands occupy 4.7 million hectares. Taken as a percentage of the total geographical area (TGA), total forest cover constitutes to 20.55 percent. Dense forests constitute about 12.68 percent of TGA and open forests 7.87 percent of the TGA (Table 2.1).

Forests are unevenly distributed in India. The state-wise distribution of forests shows that Madhya Pradesh has the highest area under forests with a total of 13.371 million hectares. Arunachal Pradesh ranks second with 6.804 million hectares of forest cover and Orissa third with 4.883 million hectares. The semi-arid peninsulas of Andhra Pradesh and Tamil Nadu claim 4.464 million hectares and 2.148 million hectares of forests respectively. The arid and semi-arid States of Rajasthan, Gujarat, Punjab and Haryana have very little land under forests, about 1.636 million hectares, 1.515 million hectares, 0.243 million hectares and 0.175 million hectares respectively.

However, forests taken as a percentage of the total geographical area present a different picture. Madhya Pradesh, which has the highest area under forests with 13 million hectares, has only 30 percent of the TGA under forests. On the other hand, Arunachal Pradesh and most of the other northeastern states have more than 70 percent of their land under forests. Uttar Pradesh, West Bengal, Jammu and Kashmir, Gujarat, Rajasthan and Punjab have less than 15 percent. The Andaman and Nicobar Islands have a substantial area under forests, constituting 84 percent of the total geographical area.

Weighted Total Forest Cover: In order to evaluate the density of forests more qualitatively, the total forests have been converted into weighted forest area. Thus, different weights have been assigned to dense and open forests. Dense forests including mangroves have been assigned a weight of 0.75, and the open forests a weight of 0.25. Dense forests are given three times more weight than open forests as they are considered to be three times more functionally significant than open forests. The composite value of forests in each state is given by the weighted average of forest area (Table 2.1, Map 2.1).

FOREST COVER (WEIGHTED)



Map No. 2.1

Table 2.1

State-wise forest cover 2000, and per capita forests, 2001*

S.No	States	Forest Cover in ('000 Ha)			Forests to TGA	Weighted Forest Cover	Dense forest to TGA	Per Capita Forest
		Dense	Open	Total	Percent	000 ha	Percent	ha
1	Andhra Pradesh	2582.70	1881.00	4463.70	16.23	2407.30	9.39	0.06
2	Arunachal Pradesh	5393.20	1411.30	6804.50	81.25	4397.70	64.40	6.24
3	Assam	1583.00	1188.40	2771.40	35.33	1484.40	20.18	0.10
4	Bihar *	1515.90	1319.80	2835.70	16.31	1466.90	8.72	0.03
5	Goa	178.50	31.00	209.50	56.62	141.60	48.24	0.16
6	Gujarat	867.30	647.90	1515.20	7.73	812.50	4.43	0.03
7	Haryana	113.90	61.50	175.40	3.97	100.80	2.58	0.01
8	Himachal Pradesh	1042.90	393.10	1436.00	25.78	880.50	18.72	0.24
9	Jammu and Kashmir	1184.80	938.90	2123.70	9.56	1123.30	5.33	0.21
10	Karnataka	2615.60	1083.50	3699.10	19.29	2232.60	13.64	0.07
11	Kerala	1177.20	378.80	1556.00	40.00	977.60	30.26	0.05
12	Madhya Pradesh *	8226.40	5144.90	13371.30	30.16	7456.00	18.55	0.16
13	Maharashtra	3089.40	1658.80	4748.20	15.43	2731.80	10.04	0.05
14	Manipur	571.00	1121.60	1692.60	75.90	708.70	25.61	0.71
15	Meghalaya	568.10	990.30	1558.40	69.57	673.70	25.36	0.68
16	Mizoram	893.60	855.80	1749.40	82.91	884.20	42.35	1.96
17	Nagaland	539.30	795.20	1334.50	80.39	603.30	32.49	0.67
18	Orissa	2797.20	2086.60	4883.80	31.37	2619.60	17.97	0.13
19	Punjab	154.90	88.30	243.20	4.83	138.30	3.07	0.01
20	Rajasthan	632.20	1004.50	1636.70	4.78	725.30	1.85	0.03
21	Sikkim	239.10	80.20	319.30	44.97	199.40	33.68	0.59
22	Tamil Nadu	1249.90	898.30	2148.20	16.51	1162.00	9.61	0.03
23	Tripura	346.30	360.20	706.50	67.29	349.80	32.98	0.22
24	Uttar Pradesh *	2798.80	969.60	3768.40	12.80	2341.50	9.51	0.02
25	West Bengal	634.60	434.70	1069.30	12.06	584.60	7.15	0.01
26	Andaman& Nicobar	659.3	33.7	693.0	85	502.9	79.92	1.97
	Total	41680.90	25872.90	67553.80	20.55	37728.90	12.68	0.07

TGA - Total Geographic Area, ha - hectares

* Forest cover for Madhya Pradesh includes the forest cover of Chattisgarh. Similarly forest cover for Bihar includes forest cover of Jharkhand. Forest cover for Uttar Pradesh includes forest cover of Uttaranchal.

Source: GOI, "Forest Survey of India - 2001" State of Forest Report.

The comparative position of states for weighted forest cover reveals that composite forest cover in terms of actual quality of the existing forests in the country is only 37.7 million hectares. Madhya Pradesh, with the maximum weighted forest cover, is in the first category (range: 4397.73 to 7456.03 '000 hectares). It is followed by Arunachal Pradesh, Maharashtra, Orissa, Andhra Pradesh, Uttar Pradesh and Karnataka in the second-best category (1484.35 to 4397.73 '000 hectares). The northeastern states present a degraded picture. Goa, Punjab and Haryana with the least weighted forest cover represent the worst category (100.80 to 349.78 '000 hectares).

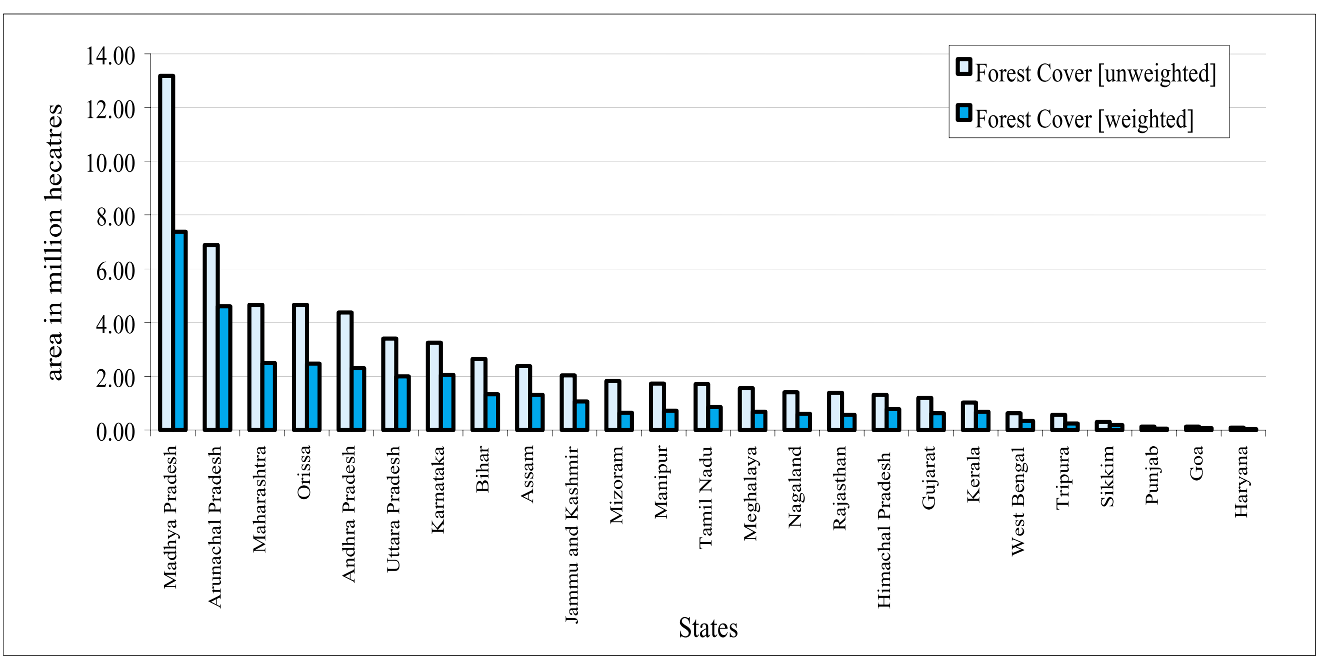
A comparison of weighted and unweighted forest cover for all the states of India comes up with an interesting fact. Although Madhya Pradesh has 13 million hectares under forest cover, a composite evaluation only shows 7.5 million hectares. A similar situation exists in all the states of the country (Figure 2.1). This leads to the interpretation that almost half of the forests, especially in the naturally forested belt, are functionally inferior.

Dense and open forest cover: This picture of weighted forest cover warrants a closer look at the dense and open forests in the country. Dense forest cover is an important measure of the health of forest ecosystem. Dense forests on hills and mountains are important watersheds. Forested watersheds are highly stable hydrological systems that influence the availability and quality of both surface water and groundwater. Except the Himalayan Rivers that are also fed by glaciers, all the river valley systems are fed solely by watersheds. Sustainability of agriculture in these watersheds is closely intertwined with the health and functionality of watersheds that are in turn preserved by healthy dense forests.

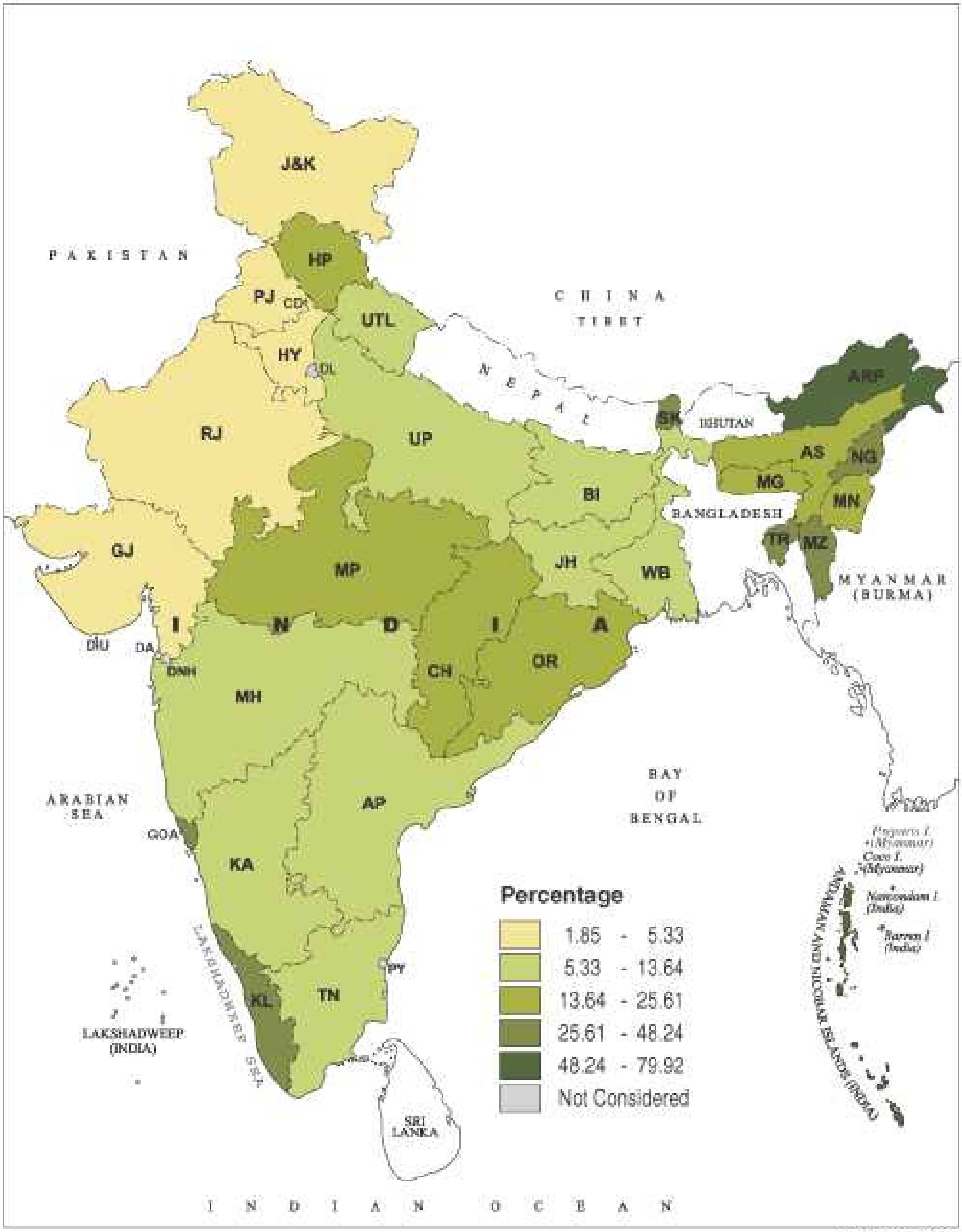
For the current assessment, dense forest cover has been taken as a percentage to the total geographical area. Data reveal that Andaman and Nicobar Islands, at about 80 percent, have the largest percentage of dense forests. Arunachal Pradesh ranks second with 64.4 percent. Madhya Pradesh has more dense forest area than any other state (8.2 million hectares). But this figure makes up only 18.55 percent of the state's total geographical area. The northeastern states, apart from Arunachal Pradesh, have an average of only 30 percent of forest area. In Punjab, Haryana and Rajasthan, forests constitute only about 1 percent of the geographical area (Table 2.1, Map 2.2).

Open forests are less functional than dense forests in tropical climates. In arid and semi-arid regions,

Figure 2.1: Weigthed And Unweighted Forest Cover- 2000



DENSE FOREST COVER TO TOTAL GEOGRAPHICAL AREA



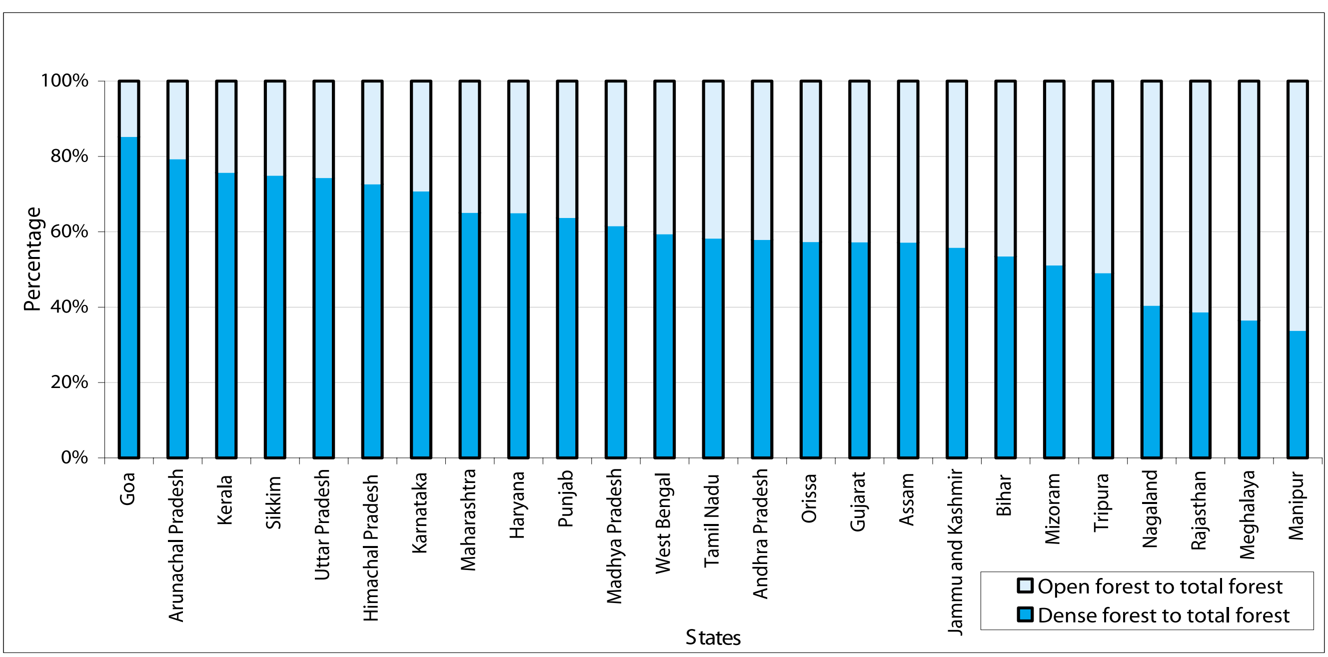
Map No. 2.2

however, the significance of open forests as a source of food, timber, fuel wood and fodder cannot be underestimated. Open forests have been assessed as a percentage to the total forests. They take up a greater share of total forest cover in most of the northeastern states of Manipur, Meghalaya, Nagaland, Tripura and Mizoram. More than 50 percent of the forests are open forests. Rajasthan too has open forests to the extent of about 60 percent. In Goa, Arunachal Pradesh, Kerala, Sikkim, Uttar Pradesh, Himachal Pradesh and Karnataka, open forests occupy less than 30 percent of the total forest area. Madhya Pradesh and Orissa have about 60 percent of dense forests and 40 percent of open forests (Figure 2.2).

Dense and open forests may be related with the data about forests on the hills. Jammu and Kashmir, Himachal Pradesh and almost all the northeastern states, except Assam, have 100 percent of the forests in the hills. Kerala has 90 percent, Uttar Pradesh 66.7 percent and Karnataka 71 percent of their forests in the hills. They exist in the Western Ghat areas of Kerala, Karnataka and sub-Himalayan Uttar Pradesh, and in the Eastern Ghat areas of Tamil Nadu, Andhra Pradesh and Orissa. In the northeastern states, the extent of dense forests in hills and mountains is very low, only about 40 percent. Here, much of the forests exist as open forests (Figure 2.2). This can destabilize the watersheds quite significantly. Much more needs to be done if 60 percent of the hills have to be brought under dense forests to meet the ecological needs of watersheds.

Per Capita Forest: Per capita measurements are an ideal indicator of demographic and developmental pressures. The rising human and livestock population confront forests with a grim challenge. Besides the one billion-plus human population, India has to support 470 million livestock. More than 90 million cattle graze in the forests that can support only 30 million (Lal 1992). Needless to say, forests are being hugely pressured for space, goods and services. Per capita forest is the forest area available for man to meet all his fuel wood, timber, food, fodder, medicinal,

Figure 2.2 : Dense and Open Forests as Percentage to Total Forests



recreational and other requirements. The assumption is that everybody is in one way or the other touched by forest services, and therefore suffers from the lack of it.

To calculate per capita forest, the forest cover assessment for 2000 and the population of 2001 were taken into account. India's population has grown exponentially since 1950. Consequently, there has been a downward spiralling of per capita forest cover. The availability declined from 0.127 hectares per capita in the mid-1960s to the current level of 0.06 hectares per capita. Demand for round-wood has been increasing because of both population increase and increasing demand for timber and paper. Per capita availability of fuel wood and timber has also declined consistently since 1980–1981 (UNFPA 2000).

An examination of the distribution of per capita forests among the states of India reveals that Arunachal Pradesh records the highest forest area per capita with 6.24 hectares per person. Mizoram, Manipur, Nagaland, Meghalaya and Sikkim have more than 0.50 hectares of forest per person. This is largely due to the low population densities in these tribes-dominated states. Per capita forest in Orissa and Madhya Pradesh is very low. Most other states in India record a forest cover of less than 0.1 hectare per person (Table 2.1, Map 2.3).

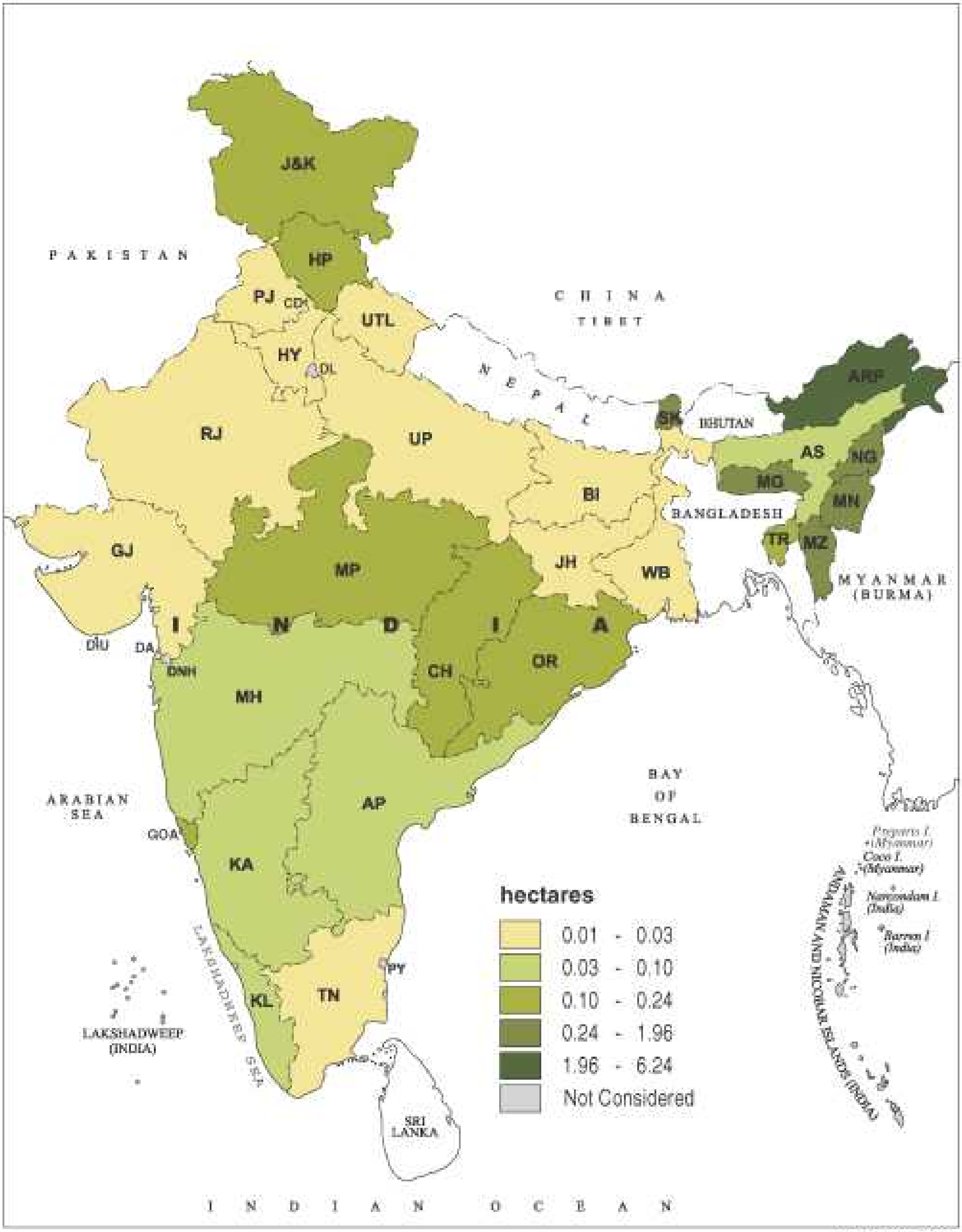
It has been suggested that ideally 0.47 hectares of forest per person is necessary to meet a person's complete requirements, although it may not be possible to achieve this level (Lal 1992). Increasing per capita availability of forests is equivalent to increasing tree density per person. This can be achieved by improving tree cover in degraded forests and by planting more trees outside forests.

2.1.2 Health and Productivity of Natural Forest Ecosystems

Forests in India show wide heterogeneity. The northeastern states, the Himalayan and the sub-Himalayan belt, the Western and Eastern Ghats and the Central Indian belt are the naturally forested zones of India. The Western Himalayas extends from Kashmir to Kumaon in Uttaranchal (earlier northern part of Uttar Pradesh) and has temperate forests made of chir, pine, fir, deodar, spruce etc. The forests of Arunachal Pradesh and Assam in the northeast are evergreen, with occasional thick clumps of bamboo and tall grasses. The Ganga plain is alluvial; only small areas support forests. The Indus plain on the other hand is dry and supports dry shrubby vegetation. The Deccan plateau is a mix of scrub jungles and deciduous forests. The Western Ghats and the Andaman Islands are humid and support evergreen forests (Champion and Seth 1968). Mangrove vegetation stretches along the east and west coastline of peninsular India and along the Andaman and Nicobar Islands in the Bay of Bengal. Together, they occupy about 450,000 hectares. Among the coastal states, they occur predominantly in the southern part of West Bengal, which accounts for almost half of the total mangrove area. Gujarat ranks next, with slightly less than 100,000 hectares of mangroves spread mostly in the Kutch region. In the Andaman and Nicobar Islands, mangroves stretching across the coastline occupy about 80,000 hectares, about 10 percent of the islands' total geographical area. Mangroves are halophytes that occur in the tidal and inter-tidal regions in the tropics and subtropics. According to the Forest Survey of India, sixteen forest types or forest ecosystems exist in India (Appendix 2.1).

There is an inherent complexity in the ecological functions of forests. The health of forest ecosystems is a function of the individual trees, the site and the climate in its totality. Healthy forests have high rates

PER CAPITA FOREST



Map No. 2.3

of turnover of biomass, both above and below the ground. The dense microbial growth in the soil recycles almost all the nutrients and the heavy root structure of the trees absorbs them quickly. Litter depth in forest soils, tree species with an extensive root biomass, layers of vegetation comprising shrubs and herbs, a diversity of lichen and bird communities supported by forest ecosystems—all these sustain a complex web of life. They are functions of good and healthy forests (Terborgh 1992).[1] They are 'bio-indicators' that represent the functional efficiency of forest ecosystems. The health of forests is also indicated by the quantity and quality of water generated and the topsoil preserved. The extensive root system can extract subsurface water through capillary action and bring it to the surface, making it available for other crops.

Healthy forests can be directly correlated to the productivity of forests. Dense and healthy forests are more productive than sparse and degraded forests. The productivity of forests is an economic indicator where forest outputs can be measured against the inputs. Typically, the outputs taken into account are timber, fuel wood, fodder and non-wood forest produce. Productivity is also expressed as the Mean Annual Increment (MAI) of Current Annual Increment (CAI) of forest stands expressed as cubic metres per hectare per year (Appendix 2.2). Productivity calculations of forests in the major forest types in India show that different forest ecosystems have different levels of productivity. Coastal and mountain forest systems are more productive than those in the plains of the Deccan or Gangetic regions (Table 2.2).

Productivity expressed as increments in forest biomass can be correlated with the amount of carbon sequestered. Forests can sequester carbon in large quantities through photosynthesis, thus helping maintain the carbon balance in the atmosphere. Studies have revealed that forests store more than 50 percent of the total carbon, while agro-forested areas store only 35 percent. Croplands can sequester only about 8 percent of the total (Gupta *et.al.* 2000). Studies conducted on the carbon pools in natural forests, manmade forests (through agro-forestry) and croplands reveal that the carbon input in forests in the form of litter fall and fine roots (401 g/m^2) was greater than the carbon root in crop residues in the form of stubbles and roots (192 g/m^2) (Table 2.3). When forest is converted to cropland, there is a marked decrease in soil carbon storage. The age and the successional stage of forest stands are very relevant in deciding the net carbon sequestered. Young and growing forest stands and tree plantations are more efficient than mature forest ecosystems in sequestering carbon (Clark *et.al.* 2003).[2]

Table 2.2

Productivity of forests in different geographic regions of India

Region	Productivity (cum/ha/yr)
Western Himalayas	2.21
Eastern Himalaya	2.03
North east	1.66
Western Coast and Andaman and Nicobar Islands	3.85
Deccan	1.35
Central India	1.05
Gangetic plain	0.80
Dry forests of the Indus plain	0.41

Source: J.B.Lal in Anil Agarwal (eds),1992, The Price of Forests, Center for Science and Environment

[1] The root biomass is an excellent indicator of soil quality. The poorest soils often have the highest root biomass and the richest soils, the lowest. This may be because of the high rate of turnover by the microorganisms that are symbiotic with the roots, which leaves the soil devoid of organic matter and micronutrients.

[2] The study has shown that in mature forests, respiration leading to a release of carbon matches photosynthesis where carbon is 'fixed'. The net carbon fixed can therefore be negligible.

Table 2.3

Carbon pools in Plant biomass and soil in the forest, cropland, and agro forestry ecosystems

Carbon type	Forest	Cropland	Agroforestry
Plant Biomass (gC/m^2)	6300.00	100.00	3425.00
Soil Organic Carbon (g/m^2)	1980.00	980.00	1499.00
Carbon Inputs (g/m^2)	401.00	192.00	288.00
Turnover (/yr)	4.93	5.10	6.57
Microbial C (g/m^2)	57.00	23.00	41.00

Source: S.R. Gupta et. al., 2000

2.1.3 Trees Outside Forests

While studying forests, it is also necessary to look into trees outside forests: in agricultural and grazing lands, plantations, homesteads, wastelands and fallow lands, public lands and common village lands. They come outside the purview of recorded forest cover. An inventory of the trees outside the forests in the rural areas was initiated by FSI in 1992 (Forest Survey of India 1997 and Panday and Kumar 2000). The states covered were Haryana, Uttar Pradesh, Karnataka and West Bengal. The principal aim was to take stock of the trees planted in various areas by social forestry programs, and which did not fall in the 'forest' category. The study classified the planted trees into eight categories: farm forestry, village woodlots, block plantations, roadside, pond-side, rail-side and canal-side plantations and others. The results showed that farm forestry accounted for the highest percentage of plantations in most of the states, followed by block plantations. While all the other states showed a high percentage of farm trees, studies in Kerala revealed that homestead farming dominated in Kerala as the people preferred multipurpose trees to monocultures of specific trees[3] (Appendix 2.3).

Growing trees in home gardens, farms and agricultural lands and along river banks is an old Indian tradition. Trees form a part of religious ceremonies. Myth and tradition have helped preserve trees in several 'sacred groves'. Social forestry and agro-forestry initiatives by the government in association with farmers and villagers have also helped develop trees outside forests. Maintaining and improving tree density outside forests will also play an important role in meeting the target of 1/3rd forest cover, apart from contributing to sustainable agriculture. With the increasing demand for fuel wood and timber, and with greater emphasis than before on conservation of natural forests, a shift to trees outside forests as a source of timber and fuel wood is critically important.

2.1.4 Change in Total Forest Cover

Trends in forest cover over the years reflect a change in attitude to forests, a higher awareness of its services and greater knowledge about the consequences of loss of forests. Forest cover interpreted from satellite imagery by the Forest Survey of India for 1987–1989 forms the base year for a comparison with the forest cover assessment for 2000 (Forest Survey of India 1991 and 2001). The two sets of figures roughly span a decade and enable an interesting comparison.[4] It is clear that the total forest cover in the country has increased by 3.6 million hectares (5.69 percent), thus reversing the trends of previous decades. Forest cover has increased for 18 out of the 25 states. Among them, the states that have registered the highest increase in terms of area are Kerala with more than 500,000 hectares (51 percent), Karnataka with 470,000 hectares (15 percent) and Uttar Pradesh with about 400,000 hectares (12.12 percent) (Table 2.4).

[3] The study of trees outside forests was carried out by the Kerala Forest Research Institute, situated in Peechi, Kerala (Panday and Kumar, 2000)

[4] Although, NRSA (Source: Centre for Science and Environment, Citizens Fifth Report Database, p 62) has published state-wise figures for dense and open forests for the year 1980–1982, this has not been taken as the base year as we wanted to systematize the source of data and its assessment methodology for comparative assessment of data. Therefore, Forest Survey of India reports have been used, roughly corresponding to a decade, for the comparative analysis.

Table 2.4

Comparative assessment of forest cover from 1987-89 to 2000 (‘000 hectares)

Sl.No.	States	Change in total forest area 1987-89 to 2000	Percent change in total forest area	Change in dense forest area 1987-89 to 2000	Percent change in dense forest area	Change in open forest area 1987-89 to 2000	percent change in open forest area
1	Andhra Pradesh	-265.30	-5.61	41.10	1.62	-306.40	-14.01
2	Arunachal Pradesh	-71.20	-1.04	-61.00	-1.12	-10.20	-0.72
3	Assam	296.30	11.97	-1.20	-0.08	297.50	33.39
4	Bihar	168.90	6.33	187.40	14.11	-18.50	-1.38
5	Goa	84.20	67.20	78.60	78.68	5.60	22.05
6	Gujarat	324.50	27.25	205.20	30.99	119.30	22.57
7	Haryana	124.10	241.91	81.00	246.20	43.10	234.24
8	Himachal Pradesh	258.00	21.90	151.80	17.04	106.20	37.02
9	Jammu and Kashmir	117.30	5.85	86.20	7.85	31.10	3.43
10	Karnataka	479.20	14.88	130.00	5.23	349.20	47.56
11	Kerala	526.80	51.19	335.10	39.79	191.70	102.46
12	Madhya Pradesh	-207.20	-1.53	-1312.10	-13.76	1104.90	27.35
13	Maharashtra	343.80	7.81	460.90	17.53	-117.10	-6.59
14	Manipur	-75.90	-4.29	40.10	7.55	-116.00	-9.37
15	Meghalaya	-29.10	-1.83	237.60	71.89	-284.70	-22.33
16	Mizoram	-135.90	-7.21	465.70	108.83	-601.60	-41.28
17	Nagaland	-97.60	-6.82	186.20	52.73	-283.80	-26.30
18	Orissa	163.30	3.46	42.80	1.55	120.50	6.13
19	Punjab	108.90	81.09	106.80	222.04	2.10	2.44
20	Rajasthan	353.20	27.52	329.50	108.85	23.60	2.41
21	Sikkim	16.00	5.28	-1.20	-0.50	17.20	27.30
22	Tamil Nadu	376.90	21.28	269.50	27.49	107.40	13.58
23	Tripura	153.00	27.64	163.80	89.75	-10.80	-2.91
24	Uttar Pradesh	407.50	12.12	533.90	23.57	-126.40	-11.53
25	West Bengal	267.80	33.41	84.60	15.38	183.20	72.84
26	Andaman & Nicobar	-69.20	-9.08	-96.10	-12.72	26.90	395.59
	Total	3635.60	5.69	2755.70	7.08	879.90	3.52

Source: GOI, “Forest Survey of India - 1991” State of Forest Report.GOI, “Forest Survey of India - 2001” State of Forest Report.

However, Andhra Pradesh, Arunachal Pradesh and the northeastern states of Manipur, Meghalaya, Mizoram and Nagaland have shown a decline. The decline is most noticeable in Andhra Pradesh and Madhya Pradesh (more than 200,000 hectares). Andaman and Nicobar Islands have also registered a decline of about 70,000 hectares, amounting to 9 percent. Among the northeastern states, Mizoram has seen the highest decline of over 130,000 hectares (7 percent), followed by Nagaland with about 100,000 hectares (6.8 percent) decline in total forest cover. Arunachal Pradesh has registered a decline of 70,000 hectares (1 percent). From the above data, it is obvious that forest cover has been declining in the naturally forested belts of India.

Dense forest cover for the country has registered an increase of 7 percent over the period evaluated for the study. Most states in the country have also registered an increase in dense forest cover. Uttar Pradesh has recorded a maximum increase of over 530,000 hectares (23.57 percent). On the other hand, Madhya Pradesh and Arunachal Pradesh have registered a decline in dense forest cover. The highest decline has been observed in Madhya Pradesh, of about 1,300,000 hectares—a decline of almost 14 percent.

Open forests in India have also registered an increase of 3.5 percent. This rise is the highest in Madhya Pradesh where an increase of more than 1,100,000 hectares (27.35 percent) has been registered. Karnataka follows, with an increase of 350,000 hectares (47.56 percent). Most of the northeastern states, except Assam, have registered a decline in open forest area.

The change in weighted forest cover has also been worked out to reflect both dense and open forests. The percentage change has been calculated as the difference between the two years taken as the ratio to the base-year data. The changes have been weighted at 0.75 for dense forests and 0.25 for open forests.[5] The percentage changes in forest cover show that most of the states have registered an increase. Madhya Pradesh, Andhra Pradesh and Arunachal Pradesh, on the other hand, have registered a decline. Andaman and Nicobar Islands have registered the largest decrease by about 11 percent followed by Madhya Pradesh by about 9 percent (Table 2.5, Map 2.4).

Table 2.5

Percentage change in forest cover

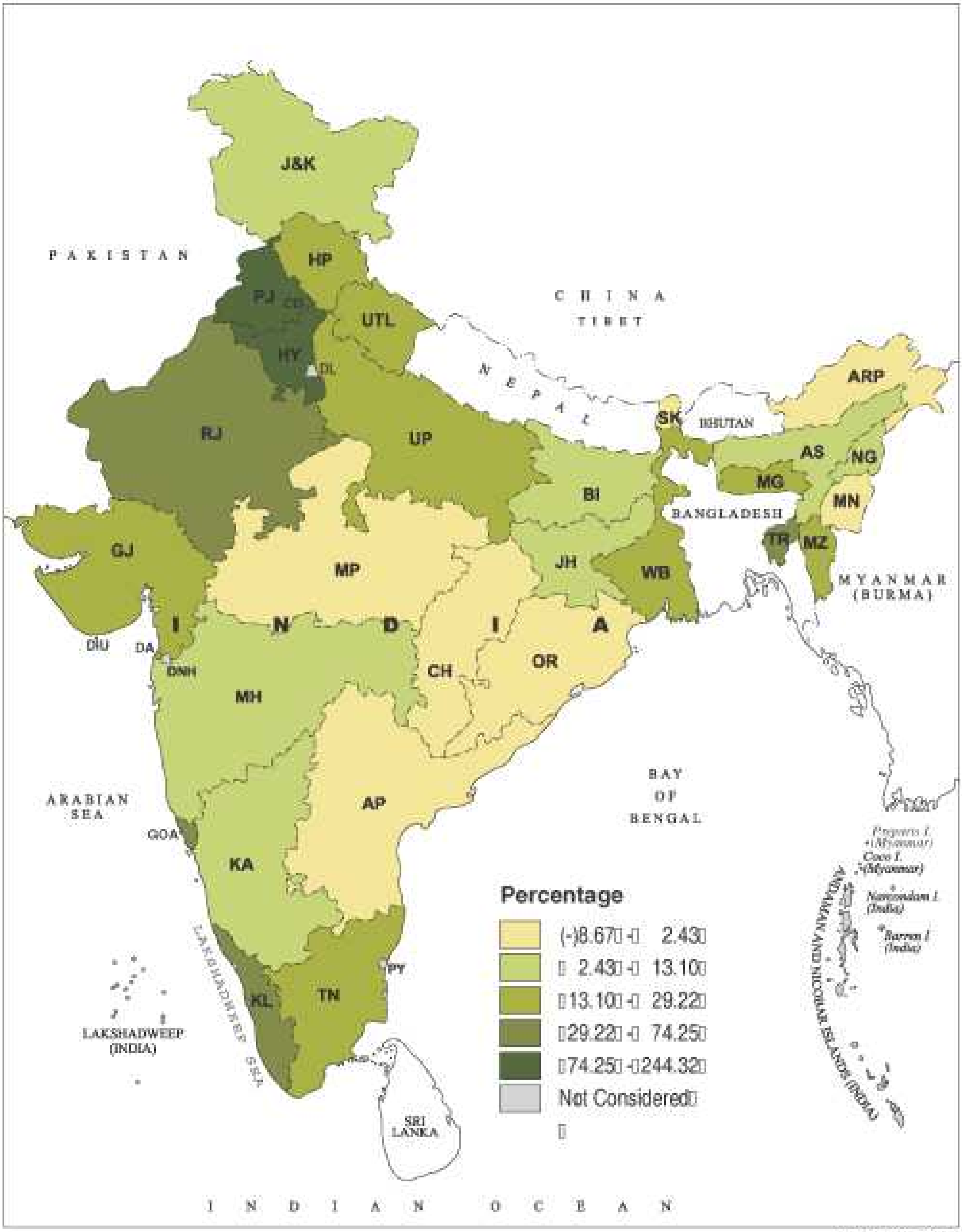
		1	2	3
Sl.No	States	Weighted Forest Cover 2000 ('000) Ha	Weighted Forest Cover 1987-89 ('000) Ha	Change in weighted forest cover Col.(2-1)2 Percent
1	Andhra Pradesh	2407.28	2453.05	-1.87
2	Arunachal Pradesh	4397.73	4446.03	-1.09
3	Assam	1484.35	1410.88	5.21
4	Bihar	1466.88	1330.95	10.21
5	Goa	141.63	81.28	74.25
6	Gujarat	812.45	628.73	29.22
7	Haryana	100.80	29.28	244.32
8	Himachal Pradesh	880.45	740.05	18.97
9	Jammu and Kashmir	1123.33	1050.90	6.89
10	Karnataka	2232.58	2047.78	9.02
11	Kerala	977.60	678.35	44.11
12	Madhya Pradesh	7456.03	8163.88	-8.67
13	Maharashtra	2731.75	2415.35	13.10
14	Manipur	708.65	707.58	0.15
15	Meghalaya	673.65	566.63	18.89
16	Mizoram	884.15	685.28	29.02
17	Nagaland	603.28	534.58	12.85
18	Orissa	2619.55	2557.33	2.43
19	Punjab	138.25	57.63	139.91
20	Rajasthan	725.28	472.25	53.58
21	Sikkim	199.38	195.98	1.73
22	Tamil Nadu	1162.00	933.03	24.54
23	Tripura	349.78	229.63	52.32
24	Uttar Pradesh	2341.50	1972.68	18.70
25	West Bengal	584.63	475.38	22.98
26	Andaman & Nicobar	502.90	568.25	-11.50
	Total	37728.90	35442.15	6.45

Source: GOI, "Forest Survey of India - 2001" State of Forest Report.

It is obvious from the assessment of change in forest cover, that for the country as a whole and for most of Gujarat, Karnataka, Maharashtra, Orissa,

[5] It is to be noted that the 1991 report gives dense and open forests and mangroves for the years 1987–1989 separately. However, in the 2001 report, dense forests and mangroves are clubbed together. Therefore, for the purpose of calculating weighted forest cover for 1987-1989, dense forest cover and mangroves have been added and then weighted with open forests using the same weights.

CHANGE IN WEIGHTED FOREST COVER (1987-89 TO 2000)



Map No. 2.4

Tamil Nadu and West Bengal, total forest cover has gone up over the years because of an increase in dense and open forests. Similar trends have been noted for Punjab and Haryana. The sub-Himalayan states of Jammu and Kashmir, Himachal Pradesh and Kerala have also shown similar trends. It is likely that increase in open forest area is due to the regeneration activities of participatory forest management in these states. However, there is a strong possibility of overlap of forest area with that of plantations and horticultural tree crops, especially in Punjab, Haryana, Himachal Pradesh, Jammu and Kashmir and Kerala. These states have witnessed large-scale diversification into plantations and tree crops. A closer look at the change in acreage in plantations and horticultural crops for the country as a whole provides support for this conclusion. The area under plantation crops such as tea, coffee and rubber went up from 0.672 million hectares in 1970–1971 to 1.269 million hectares in 1995–1996. The area under fruit trees and under coconut, areca nut and cashew nut have also gone up. In 1995–1996, the area under fruit tree crops such as banana, citrus, apple, grapes, guava, litchi, mango, sapota and papaya alone added up to about 2.7 million hectares. The area under coconut, areca nut and cashew nut plantations in the major growing states alone is about 25.83 million hectares. The area under coffee and rubber constitutes 0.73 million hectares. At least some of this area might have overlapped with dense forest area in some states such as Kerala (GOI, Agriculture in Brief 2000). The extent of overlap between dense multilayered forests and plantations will have to be carefully looked into. The existing data do not differentiate between naturally occurring dense forests and plantations in hills and mountains. In this context, it must be stressed that dense monocultures of forests can never replace multilayered multispecies forests in terms of functionality. Replacing natural forests with uniform plantations is therefore not a solution, especially in hills and mountains.

2.2 Forest Degradation

The previous section has brought out the huge population pressure on forests and the low cover of dense and healthy forests in critical areas, such as watersheds, and in naturally forested areas where there is significant dependant population. This is despite the fact that there has been an actual increase in forest cover over the last decade. The following section attempts to understand the actual extent of degradation of forests and its impact on sustainability of agriculture and livelihoods.

The broad concept of forest degradation includes the depletion of forest biomass in natural forest ecosystems whereby they are converted from dense multilayered canopies to simpler grasslands or scrub vegetation, through fires, uncontrolled felling and forest diversion for non-forest purposes. To pinpoint the exact reason for degradation of forests is not easy. Many factors have disturbed the same tract of forest at different points of time. These include political motivations, developmental pressures, livelihood insecurity of the dependant population arising out of insecurity of land tenure (Singh and Hudson 1995), increasing human population, uncontrolled grazing by unproductive cattle (Lal 1992), replacing of natural forests with monoculture plantations, unsustainable shifting cultivation, forest fires, diversion of forests and encroachment of the forests by marginalised farmers facing low agricultural productivity in their lands.

2.2.1 Diversion of Forestlands

The decline in total forest area in Arunachal Pradesh and Madhya Pradesh can be attributed mostly to reduction in dense forest area. In Madhya Pradesh, parts of dense forests may have been converted to open forests. But data reveal that about 200,000 hectares of dense forest area might have been converted to non-forest area. Arunachal Pradesh too has seen an increase in open forest area. However, this does not correspond directly to conversion of dense forest to open forest. This may also mean conversion of forest to non-forest area. In the northeastern states of Manipur, Meghalaya, Mizoram and Nagaland, the decline in total forest cover is explained in terms of decline in open forest cover, which offsets the slight increase in dense forest cover.

Although the 1988 National Forest Policy led to strict rules against forest diversion, large-scale diversions of forest for non-forest purposes has continued to increase till 1997–1998. The central forested belt in India has faced maximum diversion for non-forest purposes. For example, Maharashtra, Karnataka, Gujarat and Madhya Pradesh experienced the highest rate of forest diversion for non-forest purposes during 1997–1998, mainly because of the practice of leasing out forested area to industries to carry out mineral mining. Geographic Information Systems (GIS) data reveal that about 53,000 hectares with 71 percent dense forest cover and 29 percent open forest cover presently fall under mining leases in Orissa, Bihar and Madhya Pradesh. Bauxite, copper, iron, chromites and manganese are the main metals mined. The other reasons cited for forest diversion are construction of roads and railways, irrigation works and power generation (ICFRE 1996 and ICFRE 2000). For instance, thousand of hectares of forests were submerged and permanently lost to irrigation projects—but the benefits of irrigation were short-lived and often far less impressive than expected. Of the uses of forestland permitted by the government, a large percentage is for major and medium irrigation projects in all the states.

2.2.2 Forest Encroachments

The other visible factors of degradation are forest fires, encroachment into forests by permanent agriculture and unsustainable shifting cultivation practices. Fires have affected the forests of Uttar Pradesh the most (14.5 percent) followed by Orissa and Himachal Pradesh. Arunachal Pradesh, Meghalaya, Assam and Andhra Pradesh are least

Table 2.6

Factors directly causing degradation of forests

		1	2	3
Sl. No	States	Percent forest area affected by fires	Forest area under Encroachment 1998 hectares	Forest Land Diversion 1997-98 hectares
1	Andhra Pradesh	0.07	327749.00	#438.91
2	Arunachal Pradesh	0.01	*51703.96	#412.00
3	Assam	0.10	**251771.91	N.A
4	Bihar	1.94	2177.26	28.13
5	Goa	N.A	6316.78	532.52
6	Gujarat	1.64	77837.70	6307.20
7	Haryana	3.51	573.00	61.62
8	Himachal Pradesh	3.84	1357.00	22.35
9	Jammu and Kashmir	0.45	13237.00	N.A
10	Karnataka	0.33	107064.00	#16949.25
11	Kerala	0.25	*48612.00	#10.21
12	Madhya Pradesh	2.38	*1757.00	4528.42
13	Maharashtra	1.33	72811.00	51531.20
14	Manipur	1.55	N.A	N.A
15	Meghalaya	0.04	3743.14	#0.0025
16	Mizoram	1.59	12.76	#54.24
17	Nagaland	3.12	N.A	Nil
18	Orissa	5.49	27949.24	#3583.10
19	Punjab	2.01	NA	N.A
20	Rajasthan	2.41	7933.32	621.33
21	Sikkim	N.A	N.A	9.26
22	Tamil Nadu	0.50	18283.00	12.26
23	Tripura	0.67	8620.00	6.84
24	Uttar Pradesh	14.49	36813.97	148.88
25	West Bengal	0.26	N.A	20.05

*: Data corresponds to 1997, **: 1996, #: 1997-98, NA: Not assessed

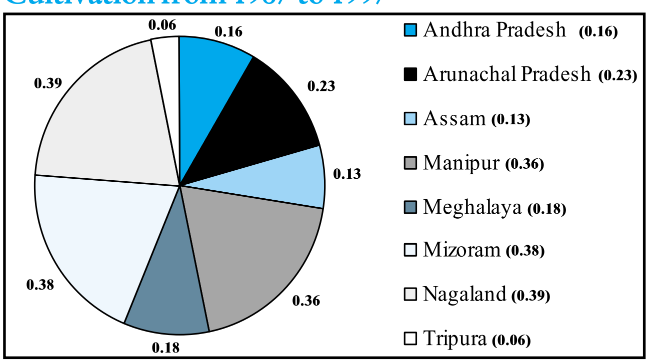
Source: Col.1 FSI, 1995

Col.2 ICFRE, Forestry Statistics 1996, 2000

Col.3 ICFRE, Forestry Statistics, 2000 Table 3.7

affected by fires (less than 0.1 percent). Andhra Pradesh has faced the highest encroachment of its forests, followed by Assam and Karnataka (Table 2.6). Shifting cultivation has been the predominant survival strategy of the agricultural population, especially of the northeast states. However, the sustainability of this practice is now increasingly being questioned. It is estimated that 0.45 million families in the northeast states annually cultivate 10,000 sq km of forests (IIRS 2002). The cumulative area affected by this practice is 1.73 million hectares. Nagaland records the largest area under shifting cultivation. Most of the northeastern states continue to practise shifting cultivation although it is no longer considered to be a viable option, mainly because of the shortening of the *jhum* cycle. Traditionally, the cultivated area would be left fallow for 20 to 30 years before being cultivated again, but now the fallow period is hardly 3 to 4 years. Wasteland Atlas of India has recorded these regions as having the maximum degradation of forests due to this practice (GOI, Ministry of Rural Development 2000). The cumulative area under shifting cultivation from 1987 to 1997 is represented in Figure 2.3.

Figure 2.3: Forests Area under Shifting Cultivation from 1987 to 1997



State governments control most of the forests; the exception being the northeastern states where forests are community-owned and governed by clans (Table 2.7). Accession of forestlands by the state, alienation of local communities and insecurity of land tenure have together led to massive forest destruction (Poffenberger 1998). Illegal felling and transport of timber from forests continue. Protected and reserved forests are not free from felling. Even the forests of the high profile and well-funded Tiger Parks face extensive degeneration. Mismanagement by the state

Table 2.7

Percent of forest area under government ownership

Sl.No	States	Forest* under Government Ownership %
1	Andhra Pradesh	98.48
2	Arunachal Pradesh	38.57
3	Assam	66.84
4	Bihar	99.89
5	Goa	19.28
6	Gujarat	75.27
7	Haryana	90.52
8	Himachal Pradesh	94.35
9	Jammu & Kashmir	100.00
10	Karnataka	84.04
11	Kerala	100.00
12	Madhya Pradesh	96.69
13	Maharashtra	92.69
14	Manipur	32.37
15	Meghalaya	11.84
16	Mizoram	67.12
17	Nagaland	9.46
18	Orissa	71.99
19	Punjab	37.79
20	Rajasthan	90.84
21	Sikkim	98.20
22	Tamil Nadu	94.29
23	Tripura	65.10
24	Uttar Pradesh	93.23
25	West Bengal	91.14
	Total	83.20

* Reserved and Protected Forests taken as percentage to total recorded forests

could be one reason for forest destruction in reserved and protected forests (Uniyal *et.al.* 2001).

2.2.3. Impact of Forest Degradation

As forests degrade, they lose much of their inherent complexity as they lose biomass, diversity and topsoil. They become simplified ecosystems losing their ability to sustain life. Repeated disturbances without sufficient time for regeneration can alter forest ecosystems as a whole. Degradation disrupts essential ecological functions resulting in substantial water run off, severe soil erosion, accumulation of wastes, degradation of water quality, inefficient carbon and nutrient recycling and climate instability. Susceptibility to fires also increases as the soil moisture retention declines. Higher incidence of forest fires is another indication of reduced forest wealth. Forest degradation in watersheds affects the hydrological water regime resulting in cyclic floods and droughts. Siltation of rivers, erosion of soil fertility, sudden disasters such as landslides and flash floods are all-too-common problems resulting from heavy destruction of forests. Destruction of watershed forests can seriously affect the stability of the mountain terrain. The Himalayas, for instance, is a young and growing mountain. The soil is loose and highly susceptible to wind and water erosion. Disturbances to the forests in any form like jhumming or large-scale felling for timber will have serious impact on the forest ecosystem. Any chance of the region recovering to the initial state of complexity is lost. From what was initially a multilayered, multispecies, thick forest what will ultimately result during regeneration is at best a bamboo or grassland ecosystem (Ramakrishnan 2001).

The functionality of forest ecosystems as the major terrestrial carbon sink is disrupted as forests are destroyed. As forests are felled and burned, they release carbon dioxide thereby contributing to carbon build-up in the atmosphere. Instead of acting as carbon sinks, they become a major source of carbon dioxide. The suspected overlap between dense monocultures and dense tropical forests in forest cover assessments by satellite imagery can have serious repercussions while assessing the health and functionality of dense forests. Admittedly, trees can add valuable inputs to land, soil and water. But in the other typically forested areas where they are very often a part of a watershed, replacement of multilayered multispecies ecosystems with dense monocultures can be devastating to the overall functionality.

Forest degradation poses a serious threat to sustained productivity of downstream agricultural lands. Removal of surface vegetation reduces water retention by the soil. This causes extensive surface run off. Flash floods during the monsoon destroy crops and livelihoods. Agricultural lands lose their productivity as the water carries away most of the topsoil. Forest degradation also impacts the quality and availability of water for agriculture and domestic purposes. Once these forests disappear, reservoirs and local ponds silt up, village wells start drying up and perennial rivers become seasonal. Water scarcity in irrigation tanks, river basins and wells has led to conflicts between upper riparian and lower riparian users. As trees are cut down, recharging of ground water in the aquifers is reduced. The groundwater table goes down drastically and mineral precipitation makes groundwater unfit for drinking and agriculture.

Forest degradation also affects the economies and livelihoods of rural communities that depend on forests. Forests are symbols of the country's natural wealth, but they are inhabited by some of the poorest people in India. This is very evident in the forested belts of Central India in Madhya Pradesh, Orissa and Bihar. Forests, poverty and livelihood insecurity are tightly linked in India's thickly forested areas. Forest decline reduces access to forest products and threatens the forest-dependant population. A decline in the amount of forest produce collected marginalizes these tribal populations further. The steady supply of fuel wood for energy is also affected as forests and common property areas degrade, and wood supply gets depleted. It is the poorest who suffer the most. Poverty also drives landless and marginal farmers to cultivate forestland close to habitations. Forest destruction aggravates the hardships of the dependant population, especially women. They have to spend more time collecting enough fuel-wood and minor forest produce for their daily earnings. During lean months, they have to forego even the little they manage to collect normally for their daily bread.

In conclusion, forests maintain strong inter-linkages with agricultural production systems, river and groundwater systems and rural livelihoods. Though forests constitute a vitally important land use, they have been mismanaged and neglected. There has been some increase in forest cover, but it is not clear how much of it exists as dense monoculture, which is functionally inferior, especially in watersheds. A mere increase in forest cover is not sufficient. The full functionality of forests should be maintained, so that forests deliver environmental services efficiently and meet the subsistence livelihoods of the rural and tribal communities who live near the forests. Ensuring rich and healthy forests in watersheds and maintaining an adequate distribution of trees in agricultural lands, homesteads, industrial lands and public lands is vital to meet the growing need for forest products and environmental services. This in turn will ensure the sustainability of agriculture and rural livelihoods.

II. Biodiversity

Biodiversity refers to the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems (UNEP, Convention on Biological Diversity 1993 and GOI, Biological Diversity Act 2002). Biodiversity includes the totality of genes, species and ecosystems within a region and encompasses all life forms that exist on earth today (Dale 2000). Genetic diversity refers to the variation of genes; species diversity refers to the variety of species within a region, measured in terms of species richness; ecosystem diversity measures the diversity of communities or populations in the ecosystem.

India is one of the 12 mega-diversity centres of the world and one of the eight Vavilovian centres of the origin of crop plants. Changes in topography, altitude, precipitation, temperature, and soil conditions throughout India's geography have created innumerable niches where life forms including man have adapted and thrived. No ecosystem is devoid of biodiversity. They vary only in degrees of richness.

India's biological diversity is reflected in eight phyto-geographical zones, 15 agro-climatic zones, 20 agro-ecological zones, and 16 major forest types with 221 minor subdivisions. The 45,000 plants and 75,000 animal genetic resources identified in India are the most important visible manifestations of biodiversity (Paroda and Arora 1992). Diversity of crops and their wild relatives, diversity of micro-organisms that contribute to soil fertility, diversity of natural habitats that house much of this biodiversity, diversity of foods obtained from them, the several birds, bees and insects that pollinate our crops and the enormous genetic diversity within them directly or indirectly influence agriculture and industry. They are also the backbone of crop improvements necessary for sustaining agriculture. The vast genetic resources contribute much to the food, nutritional and livelihood security of our people.

It is very clear that the very survival of our species is vitally dependant on other species and on the ecosystem. Its widespread loss is one of the most serious global crises today. There are no accurate estimates of how much biodiversity exists and where. There are no current estimates of the annual loss of biodiversity.

Despite the lacunae in data, the first part of this section attempts to assess biodiversity and its contribution to sustaining food security in India. The second part looks at the loss of biodiversity and addresses the possible consequences of the loss of biological wealth.

2.3 Assessing India's Biodiversity

The three important aspects of biodiversity are natural biodiversity, agro-biodiversity and human cultural diversity. Natural biodiversity includes plants, animals and microorganisms, and the natural ecosystems that they are a part of. Agricultural biodiversity refers to that part of biodiversity that feeds and nurtures people. Human cultural diversity is an integral dimension of biodiversity.

2.3.1 Agro-biodiversity

Agro-biodiversity is a fundamental feature of farming systems around the world. It encompasses many types of biological resources tied to agriculture. It includes many ways in which farmers can exploit biological diversity to produce and manage crops, land, water, beneficial insects, and pests (Table 2.8). It also includes habitats and species outside of farming systems that benefit agriculture and enhance ecosystem functions.

These components of agro-biodiversity yield an array of benefits. They reduce risk and contribute to resilience, food security and income generation. They also improve the health of soils and benefit nutrition and productivity (WRI 1997).

Table 2.8

Various components of agricultural diversity

AGROBIODIVERSITY		
Field	Wild	Pastures / Grazing land
Crop biodiversity	Biodiversity of wild relatives	Domestic animal biodiversity, Biodiversity of pasture species
Harmful biodiversity: weeds / pests / deleterious microorganisms		
Useful biodiversity: pollinators / IPM agents / useful microorganisms		

Agro-species Diversity and their Genetic Diversity: Some 1,500 food plants have been enumerated that form important sources of food. Based on the plant parts consumed, these plant genetic resources are represented by 375 species of fruits, 280 species of vegetables, 80 species of tuberous/root crops and 60 each of edible flowers, seeds and nuts. Some of them form very important dry land crops like sapota (*Achras zapota*), papaya, custard apple (*Annonna squamosa*), pomegranate, ber (*Zizyphus jujube*) etc. Apples of Himachal Pradesh, oranges of Nagpur, the citrus of the northeast, spices from the Western Ghats, tea from the hills, varieties of banana, etc., are examples of adaptations to various ecological regimes. Over 200 cultivars of banana have been identified in India. There is also a rich diversity in fodder crops that form an important feed for livestock. The Indian coast harboures a variety of locally adapted species of horticultural crops such as mango, cashew nut, coconut, palmyra, jack fruit, guava, sapota and citrus (Paroda and Arora 1992).

An enormous diversity exists even within crop varieties. The National Bureau of Plant Genetic Resources (NBPGR), New Delhi has identified more than thirty richly diverse crops in India including rice, wheat, legumes, vegetables and fruits. In the northeast, the genetic resources include varieties of coir, jute, *saccharum*, cucurbits, rice, soybean, maize, citrus, buckwheat and several beans. The central tribal belt is rich in genetic diversity of minor millets, pigeon pea, rice, niger, sesame and forage grasses. The western tribal belt displays a striking diversity in buckwheat, amaranth, soybean, lentil, cowpea, etc (Swaminathan 1998). A total of 1,76,402 germplasm collections of economically important agri-horticultural crops and their wild relatives have been made between 1946 and 2001 from different states of India (Dhillon *et. al.* 2001). The research station of the NBPGR in Shimla covered the entire Himalayan region from Jammu and Kashmir in the west to Arunachal Pradesh in the east. It has collected crop varieties from 45 explorations including 11,000 accessions for about 80 plant species (Table 2.9). These varieties are ecologically distinct, have diverse compositions, and adapt to local climatic conditions. Their hardiness is evident from the varieties of genes they possess to combat the vagaries of climate and local pests.

India is an important rice centre. The rice belt extends along the east and northeast, beginning from Orissa. The primary gene pool consists of more than 3000 cultivars and landraces. For example, the Jeypore tract in Orissa is recognized as the centre of origin and genetic diversity of rice. Some 340 varieties of paddy have been recorded from the area (Swaminathan 1998a). Tribal villages in the hills of Nagaland have been known to grow over 20 rice varieties within a single year in their terraced fields (Kothari 1994).

Several crop varieties have been introduced from other countries. They have adapted well to local climates and have become an important part of local food and culture. Estimates by NBPGR reveal that a

Table 2.9

Germplasm accessions from the Himalayas

Accessions	Number	Accessions	Number
Rice	741	French Bean	320
Wheat	402	Green Gram	60
Maize	856	Horse Gram	128
Barley	261	Black Gram	228
Amaranth	2,800	Soybean	69
Buckwheat	562	Cowpea	218
Proso millet	33	Pea	79
Finger millet	48	Lentil	143
Foxtail millet	115	Broad bean	15
Barnyard millet	115	Rice bean	24

Compiled from: NBPGR, 2001

total of 16,66,257 samples of seeds or plant material have been received from 102 countries during the past 25 years. As many as 76,566 samples have been exported to 85 countries. Every year, 50,000 to 80,000 germplasm accessions are being introduced. Some of the crops that have adapted to our environment and dominated the Indian markets are sunflower, soybean kiwi fruit, sea buckthorn etc. About 4,52,356 germplasm of rice and 2,95,140 germplasm of wheat introduced during the last 25 years and being used to develop new varieties have helped boost agricultural production in India (Dhillon 2001).

The enumerated animal genetic resources that are economically important include approximately 40 varieties of sheep, 26 varieties of cattle, 20 varieties of goat, 40 sheep varieties, 7 varieties of buffaloes, 4 varieties of camels, 6 varieties of horses and 18 varieties of poultry (Swaminathan and Jana 1992). India's agro-biodiversity in relation to pollinator insects, pests and predators, and soil micro flora and fauna is rich though less documented.

Microbial Diversity: Soil teems with microorganisms that improve the fertility of the soil. Microorganisms decompose organic matter and make it available to plants, thereby forming an important link in the complex food chain of the ecosystem. Free-living or symbiotic nitrogen-fixing bacteria, blue-green algae and phosphate-soluble bacteria contribute to soil fertility and plant growth. Biodiversity helps control pests and pathogens and is an important part of integrated pest management (IPM). Several microorganisms are effective herbicides. Innumerable antibiotics that exist today are developed from microorganisms. Their bactericidal properties are immensely useful to man and crop alike. The diversity studies of microorganisms made of bacteria, fungi and algae show that these are extremely site-specific. So consolidated studies of numbers and of the character of biodiversity have not been possible. Some of these microorganisms are described below.

Azotobacter is a free-living aerobic bacterium that fixes atmospheric nitrogen and makes it readily available for the plant. *Rhizobium* is a symbiotic bacterium that lives in the root nodules of leguminous plants like pulses, groundnut, soybean etc. Blue-green algae (BGA) also fix nitrogen. They may be free-living or symbionts with fungi or higher plants. *Anabaena* and *Nostoc* are examples of algae with crop plant/ fern associations. Various strains of nitrogen-fixing bacteria exhibit host specificity to different varieties of legumes. Enumeration of microorganisms in the field has been conducted by the Department of Microbiology, Indian Agricultural Research Institute (IARI). A *Rhizobium* map of India has been generated.

Micorrhizal associations with the crop root system are also well-studied. They solubilize phosphorous compounds in the soil organic matter and make it available to the crop. Endophytic symbiotic fungi called *Vesicular Arbuscular Micorrhizae* (VAM) exist in the root systems of almost 80 percent of the crop plants. Nematodes are frequent pests that are controlled by VAM. *Micorrhizae* act as deterrents to feeder root infection by pathogens like *Fusarium* and *Phytophthora;* these reduce the growth and mortality of seedlings in the host.

Microorganisms are known to release biologically active substances like B-vitamins that promote plant growth during their metabolism. *Azotobacter* inoculation has increased the yields of sorghum, maize, cotton etc. The BGA, apart from fixing atmospheric nitrogen, also release several vitamins for the fungal partner that enriches the host plant and the soil. Microorganisms are a source of genetic material for a variety of beneficial traits.

By far the most widespread application of genetic engineering in agriculture is in genetically modified crops. The traits most commonly introduced into crops are herbicide tolerance, insect tolerance and virus tolerance. Recent studies in crop improvements have focused on pest resistance through transfer of pest-specific endotoxin genes from bacteria. Genes from the bacterium *Bacillus thuringiensis* that direct the production of insect-specific toxins have been isolated and spliced into genomes of various crops like tomato and cotton. These have proved effective against a wide range of insects, especially lepidopterian and dipterian insects (caterpillars and moths). Varieties incorporated with this gene are prefixed 'Bt'. One of the crops attempted for large-scale commercialization in India is Bt Cotton, effective against the cotton bollworms. Genes that confer resistance to viral diseases have also been derived from viruses themselves, most notably with coat protein mediated resistance (CP-MR) (MSSRF 1999).

Lichens are symbiotic associations of fungi and algae that form a thallus. Lichen density and diversity in forests are ideal indicators of the health of forest ecosystems. Lichens are also excellent indicators of air pollution. Indian lichen flora comprises about 1,850 species, 234 genera and 80 families. The largest number of enumerations has come from South India, followed by the Himalayan region (Upreti 2002).

Significance of Genetic Diversity for Sustainability of Agriculture: Human food and nutritional security have long depended on the availability of different types of food grains, fruits and vegetables. Locally adapted landraces have been a source of food for local communities. Several wild species and natural habitats are managed and used on a daily basis by local households. These resources help improve diets, tide over famine, supplement income and serve as a source of medicines. They are aptly termed as the "hidden harvest". For the small and marginal farmers and landless labourers, almost three-fourths of the food (even up to 100 percent in lean seasons) is not cultivated but harvested from forests, streams or untilled fields.

The sustainability of agro-ecosystems depends largely on the diversity of crops cultivated, the trees that conserve water and litter the soil, the teeming flora and fauna, the earthworms that maintain soil fertility and the traditional practices that efficiently tap natural biodiversity. The genetic traits present in these landraces and their wild relatives have contributed substantially to crop improvements in plant breeding. The future availability of these genes is very important for further scientific advancements in plant breeding. It is vital to achieve higher yields, induce hybrid vigour, improve pest resistance and disease tolerance, combat biotic stress such as salinity and alkalinity, drought and floods. This is vital for reducing risks in rain-fed conditions. Crop improvements to adapt to newer agronomic conditions and soil-moisture regimes are critical for agricultural strategies involving land reclamation. Crop improvements are also critical to achieve vertical growth in agriculture resulting from optimized natural resource management.

Recombinant DNA technology and genetic engineering tap this genetic diversity to develop adaptive hybrids with specific features like enhanced nutrition. Several germplasms have been introduced for strengthening protein content and enriching fibre, flavour or aroma. Examples: germplasm have been introduced for high oil content and quality protein in maize; for high protein in mustard; for high Beta-Carotene in tomatoes; high Carotene-A in carrots; high lysine content in sorghum. Developing specific resistance to eye spot disease, *Fusarium* wilt, leaf minor etc, are examples of gene- mediated disease tolerance.

Wild genetic strains also lay the foundation for anticipatory research for future food security. For example, salt-tolerant genes from mangrove species have been effectively transferred to rice varieties to develop salt tolerance in these rice strains. This kind of research anticipates the problems that will be faced by agriculture due to saline intrusion caused by climate change and rise in sea level. Thus, genetic variations in wild relatives of crop plants help introduce essential qualities for the next generation's hybrid varieties.

As modern agriculture becomes more demanding and more globalized, it becomes necessary to seek desirable genetic traits that satisfy these specific demands. The importance of cultivars and wild species, even unrelated ones, becomes apparent. It is critical to collect, characterize and conserve them. The significance of assessing and conserving natural environments that house much of this genetic diversity is all the more relevant. This is what the next section attempts to do.

2.3.2 Diversity of Natural Environments

Natural habitats are a treasure house of biodiversity. The resilience and stability of an ecosystem that consists of many physical and biological components, including Man himself, depend to a large extent on its diversity. A study of the species diversity of dominant plants and animals reflects the complexity of these habitats. It is important to preserve biodiversity in its pristine purity for the functions that they play in shaping the ecosystem.

India's major ecosystems are forests, grasslands, agricultural lands, rivers, wetlands, mangroves, oceans, deserts and mountains. These habitats range from the moist forests to the deserts. The presence of diverse healthy habitats indicates a variety of biological resources that can be tapped and that need to be preserved. The resilience and stability of these ecosystems, which contain both physical and biological components, depend to a large extent on their diversity.

These ecosystems feed, support and sustain agriculture and thereby the livelihoods of local communities. Dense forests, mangroves and coral reefs are particularly significant in that they are highly complex ecosystems. Natural forest ecosystems are dealt with in the section on forests; the major forest types are outlined in Appendix 2.1. Coastal ecosystems and mangroves are described in the next section.

No studies are available on biodiversity in its entirety in the natural ecosystems. One pioneering study is the biodiversity characterization at the landscape level carried out for the forested landscapes of northeastern India, Western Himalayas and Western Ghats. These studies have shown how satellite imagery can be a powerful tool for useful information on various aspects of biodiversity in natural environments. Combining species studies and phytosociological analysis of the species (made possible through ground-level data) with landscape data (structural details relating to fragmentation, patchiness, porosity, etc.) has made possible the derivation of meaningful indicators such as ecological uniqueness and biological richness. While biodiversity is essentially considered at the species level, effective management of biodiversity requires organization at the landscape level (IIRS 2002)

This section outlines the diversity of flowering vascular plants that occupy the highest rung in the taxonomy of the plant kingdom. Next, it enumerates the diversity of natural environments present in different parts of India.

Diversity of flowering plants in natural habitats: Flowering plants or angiosperms are vascular plants positioned high up in the taxonomical ladder. Most of the plants that are an important source of food grains are flowering plants. They are widely represented and also widely studied. India is home to a large number of flowering plants. The Botanical Survey of India has enumerated the flowering plants found in the different states of India and is currently the most reliable source of information on the country's floristic wealth (Appendix 2.4). The description below of northeastern India and the Himalayas is evidence of the country's floristic wealth and diversity.

Arunachal Pradesh is called the "*cradle of flowering plants*". It has the largest number of primitive plants belonging to 23 species from ten families. The state accounts for about half of the 17,000 flowering plants recorded from India. The different forest types of Arunachal Pradesh harbour much of the diversity, with more than 4,500 species of flowering plants.

The Himalayan mountain systems extending about 2,500 km from northwest to southeast represent the richest natural heritage on the Indian subcontinent. The Himalayas are influenced by different floral cultures: Indo-Turanian, Euro-Siberian, Saharo-Sindhian, Mediterranean, Sino-Japanese and Indo-Malayan. Based on characteristic bio-geographic features, the Himalayas have been divided into two main zones. The West Himalayan belt harbours cold and drought-resistant vegetation dominated by conifers (chir, blue pines, deodar, fir, spruce, etc), legumes, grasses, etc. The East Himalayan belt is wet and humid and supports vegetation rich in magnolias, oaks, laurels, rhododendrons, epiphytes, orchids and ferns (Table 2.10). Sixty eight genera are monotypic and endemic to east Himalayas. There is greater endemism in East Himalayas than the West Himalayas. It is one of the two biodiversity hotspots in India recorded by the IUCN (Gujral and Sharma 1996).

The Andaman and Nicobar Islands host more than 2,000 indigenous and 500 non-indigenous angiosperm species. A characteristic feature is the significant population of Pteridophytic flora represented by the 'Tree Fern' (*Cyathea*) in the Great Nicobar (Mudgal and Hajra 1999).

Endemic diversity of natural habitats: While species richness reflects the biological richness of the habitat, "endemism" relates to the adaptation of the species to that particular habitat; or, even more specifically, to that ecological niche. India's heterogeneity in habitats has enabled the same species to express itself differently in different habitats. This adaptability of a species to different environments has been the basis of evolution.

Table 2.10

Plant Diversity in Himalayas with respect to India and World

	Total Number of Species Recorded *		
Taxon	Himalayas	India	World
Angiosperms	8,000(3,200)	17,000(5,400)	2,50,000
Gymnosperms	44(7)	54(8)	600
Pteridophytes	600(150)	1,022(200)	12,000
Bryophytes:			
Liverworts	500(115)	843(166)	8,500
Mosses	1,237(450)	2,000(820)	8,000
Lichens	1,159(130)	1,948(423)	20,000
Fungi	6,900(1,890)	13,000(3,000)	1,20,000

* Figures in parenthesis represent the number of endemic taxa.

Gujaral, G. S.and V. Sharma, 1996

Endemism can be a tool to identify the centres of speciation and the areas of extinction. It also serves to explain the centres of origin of various economically important crop and animal species. Regions of high risk such as mountain peaks, dense forests and islands that are geographically delineated show a high degree of endemism and are often centres of the origin of species.

The centres of biodiversity exhibiting a high degree of endemism are also termed *hotspots*. The North Eastern Himalayas and the Western Ghats are important hotspots in the IUCN (World Conservation Union) list of major biodiversity hotspots in the world, characterized by a high degree of species/niche specificity. There are several phytogeographical hotspots in the country, which are mega- and micro-centres of endemic flowering plants in India (Nayar 1996, Appendix 2.5). Roughly 8,000 species of flowering plants are estimated to occur in the Himalayas alone, and about half of them are endemic. The endemism of flowering plants is outlined in Appendix 2.3, Column 3. Almost 74 percent of the amphibians, 54 percent of the reptiles and 40 percent of the angiosperms have been recorded in the Western Ghats (Gopalakrishnan 2000). They display a remarkable degree of endemism.

The Andaman and Nicobar islands reveal a high level of endemism. About nine percent of the fauna is reported to be endemic. About 40 percent of the 268 species and subspecies of birds and about 60 percent of the 58 species are reported to be endemic. This endemism has resulted because of the isolation of these islands from mainland Asia.[6] As regards plants, about 14 percent of the angiosperm species are found to be endemic (Mudgal and Hajra 1999).

Coastal Diversity: India's coastline of over 8,041km and shelf area of over 0.5 million sq km harbours much of the country's marine biodiversity. Gujarat, Maharashtra, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Orissa, West Bengal, the union territory of Andaman and Nicobar Islands and Lakshadweep lie along the coastline. More than 24 families of marine species are presently exploited from these coasts. These include Indian mackerel, sardines, prawns, elasmobranches, catfishes, ribbonfishes and tunas among pelagic resources; prawns, shrimps, crabs and lobsters among crustaceans; squids and cuttlefishes among molluscs. They are exploited all along India's coasts. These states also have sizeable populations that depend on marine resources for food and livelihood. There are some six million traditional fishermen, either full time, part time or occasional.[7] Fisheries in India have always played a pivotal role in the people's food and nutritional security, especially in the rural areas. Fishes and seafood are an important source of protein for the population. However, species richness studies for these ecosystems have been grossly neglected. Only reports on the level of extraction of marine species offer any indication of the diversity of the oceans.

The coastal wetlands along the seacoasts are highly productive. They are considered important nursery grounds for fishes, crabs and prawns. They include tidal mudflats, estuaries, lagoons, marshes and coral reefs. Some 3,960 coastal wetlands sites have been mapped by ISRO, covering a total extent of 40,230 sq. km. These wetlands are distributed among nine states and four union territories. Wetlands in Gujarat occupy about 25,083 sq. km (62.3 percent)—more than any other state. Tamil Nadu, West Bengal, Orissa,

[6] http://sdnp.delhi.nic.in

[7] FAO, 2000. Fisheries country profile: The Republic of India. www.fao.org

Andhra Pradesh and Andaman and Nicobar also have large areas under coastal wetlands (Singh 2002, Table 2.11).

Indian reefs, together with their shelves, lagoons and submerged banks, have a potential yield of 10% of the total marine fish catch. A variety of marine resources such as fish, prawn, lobster, crab, pear oyster, shells, medicinal material and algae are associated with the coastal wetlands. Many human families draw their sustenance from the vegetation supported by coastal wetlands.

Table 2.11

Area of coastal wetlands in select states

S.No	State	Area, sq km
1	Gujarat	25,083
2	Tamil Nadu	3,987
3	West Bengal	3,604
4	Orissa	1,854
5	Andhra Pradesh	1,855
6	Andaman and Nicobar	1,078

Source: Singh, H. S, 2002.

Mangrove Diversity: Mangrove cover in India has been estimated at 4,482 sq. km., which is 0.14 percent of the country's total geographical area. Dense mangroves comprise 2,859 sq. km. (63.8 percent of mangrove cover) while open mangroves cover an area of 1,623 sq. km. (36.2 percent).

Some 380 km of the country's mainland coast, constituting about 6 percent of the entire coast of India, is covered by mangroves; 40 percent of the coasts (260 km) of Andaman and Nicobar islands are lined with mangroves. The mangrove forests in this group of islands are exceptional in quality, characterized by high floral diversity, with trees that sometimes exceed 25m in height. A study revealed that 38 species of mangroves belonging to 21 genera and 18 families are found in Andaman and Nicobar. The Sundarbans of West Bengal represent the largest stretch of mangroves in the country, with tree cover estimated at 2,123 sq. km. The Sundarbans is famous for its biodiversity. It harbours 50 of the 60 varieties (many of them rare) of the mangroves and mangrove associates found in India. Sundarbans has been named after the dominant mangrove species *Heritiera fomes*, locally known as *sundri*. The Sundarbans is a unique tiger habitat and is the only mangrove eco-region that harbours the Indo-Pacific region's largest predator, *Panthera tigris*.[8] Gujarat ranks second after West Bengal with respect to mangrove area, but it is considered to be inferior in the matter of floristic composition and height. Thirteen species of mangroves are found along the west coast of India.

Mangrove ecosystems are breeding grounds for several varieties of fishes and marine and freshwater species. The mangroves have an extensive tangled mass of roots known as pneumatophores that provide a critical habitat for numerous species of fishes and crustaceans that are adapted to live, reproduce and spend their juvenile lives in the mangroves. Maintaining these ecosystems is vital for sustaining the fisheries of the region. The mangrove ecosystem is an important staging and wintering area for migratory birds, which include several species of shore birds, gulls and terns. Many local communities spend a large part of their lives in the swamps in boats and earn their sustenance from the ecosystem. Mangrove tree species are an important source of timber and fuel wood.

Coral Reef Diversity: The coral reefs of the Indian Ocean include sea level atolls, fringing and barrier reefs, elevated reefs and submerged reef platforms. Fringing reefs are found in the Gulf of Mannar and Palk Bay. Platform reefs are seen along the Gulf of Kutch. Atoll reefs are recorded in the Lakshadweep archipelago. Fringing and barrier reefs

[8] World Wildlife Fund, 2001. www.worldwildlife.org

are found in the Andaman and Nicobar Islands (Naik 1997, Table 2.12). The islands' coral reef resources constitute the largest block of coral cover in South Asia[9] and are known for immense diversity. Approximately 200 coral species have been identified in the islands. Some of them are rare and need conservation; some others may have a genetic value with a potential to produce new medicines; yet others may be suitable for use in aquaculture. Coral reefs are a vital source of fish and other food for millions of people living in the coastal regions. Most recently, coral reefs have acquired enormous tourism value. The potential of coastal tourism justifies the protection of reefs within marine parks and reserves.[10,11] Corals are very fragile and easily susceptible to pollution. Sedimentation due to erosion, sewage pollution and industrial toxic waste disposal have threatened to destroy much of the diversity and density of coral reefs.

A healthy ecosystem maintained by biodiversity performs a variety of basic functions critical for human life, such as purification of air and water, detoxification and decomposition of wastes, pollination of crops, natural vegetation and dispersal of seeds, recycling and movement of nutrients in the ecosystem. The entire ecosystem is built upon fragile and intricate interactions between the physical and biological elements. Agriculture draws much of its strength from the inherent quality of the ecosystem. Inter-linkages are vital for the sustainability of agriculture. Moreover, as mentioned earlier, genetic resources of wild species have contributed substantially to crop improvements in agriculture. Exploration, enumeration and conservation of ecosystems and prevention of further degradation are essential to sustain the vast genetic resources of these ecosystems.

Table 2.12

Area and diversity of coral reefs in India

	Coral Reef Area, (Sq Km)			
Diversity	Gujarat	Tamil Nadu	Lakshadweep	A & N Islands
Reef Flat	148.40	64.90	136.50	795.70
Coraline Shelf	-	-	230.90	45.00
Algae	53.80	0.40	0.40	-
Sea grass and Sea weed	-	-	11.60	-
Reef vegetation	112.10	13.30	-	8.90
Lagoon	-	0.10	322.80	-

Shailesh Naik (1997)

2.3.3 Human cultural diversity and diversity of traditional agricultural ecosystems

India's sociocultural structure is highly diverse, with over 40,000 endogamous groups (2001). There are 550 tribal communities of 227 ethnic groups spread over 5,000 forest villages. Socioculture-specific biodiversity and traditional ecological knowledge have evolved along with this rich human cultural diversity. Countless different and genetically distinct plant and animal species owe their existence today to thousands of years of evolution and careful selection by farmers to suit their livelihood, cultural and social needs.

Traditional agro-ecosystems are diverse, complex and sustainable. A farmer in a traditional agro-ecosystem puts his farm to multiple uses. The paddy field also grows fishes and amphibians that enhance the stability of the agricultural ecosystem. Multiple crops and multiple strains of the same crop ensure

[9] Andaman Sea Ecoregion, http://www.panda.org/downloads/marine/andamancoral.pdf

[10] The Indian Ocean coral reef fish monitor, http:// dspace.dial.pipex.com/ town/avenue/aba60/ reefwatch.htm

[11] Singh, H.S. 2002. Marine Protected Areas of India, Status of Coastal Wetland Conservation. www.iucn.org/themes/wcpa/newsbulletins/ news/MPA_WCPAindia.pdf

sustained land quality. The farmer has at his disposal alternate crop varieties to fall back upon when the monsoon fails one crop. The main aim is to minimize risk and optimize overall productivity over a long period. Traditionally managed agro-ecosystems are rich in genetic diversity with the fewest external inputs. Legumes and ferns like *Azolla* are simultaneously grown. Crop residues that accumulate in canals are collected and thrown back into the field to maximize soil fertility. Thus, farming activities do not mine the land; rather they enrich the soil and enhance biodiversity. In fact, security of genetic diversity also means livelihood security.

The traditional knowledge possessed by traditional farmers has played an important role in ensuring sustained agriculture. A deep knowledge of various crops and medicinal plants growing in the wild has been the source of nutrition and health for tribal and rural populations. The conservational practices of these farmers, and the knowledge and practices of indigenous rural communities and tribal populations, constitute the cornerstone of global agriculture, food security and human health.

Women as caretakers and conservers of biodiversity: Women play a crucial role in the choice of crops and appropriate use of the plant and animal genetic diversity in their environment. (Jiggins 1994; Shiva and Dankelman 1992). Women perform a number of tasks that perpetuate an important relationship with biodiversity such as food production, seed preservation and storage and seed exchange. These are based on traditional knowledge of nutritional and medicinal values of the local plants. Women's deep concern for maintaining diversity in their surrounding environment is rooted in their daily reality: their experience as individuals responsible for a wide range of activities closely related to the survival of their communities, such as food production, processing, preparation and preservation, and their concern for future generations (Badri and Badri 1994; Norem, Yoder and Martin 1989; UN Economics and Social Council 1994). Home gardens maintained by women exemplify their role in *in situ* conservation of traditional varieties. They are considered as the custodians of biodiversity (RAFI 1997).

Caste and social divisions, levels of education and economic factors are of considerable significance in determining gender roles in relation to biodiversity conservation. Women's involvement with conservation practices such as preservation of high-quality seed was high in communities where they were the main food producers. Examples are the Apatanis of Arunachal Pradesh and the Garhwalis of the Western Himalayas. The same is true of areas where women shared joint responsibility, such as among the Mizos, Nagas and some hill tribes of the Western Ghats. In agriculturally developed areas where market forces have penetrated deeply, such as Tamil Nadu, women are less involved in conservation practices but continued to play a role in seed preservation (MSSRF 1997).

Women's perception of the environment tends to be comprehensive and multidimensional, whereas men's knowledge (males often are involved in profit-oriented agricultural production) tends to be one-dimensional, focusing on narrow areas such as the cultivation of a certain kind of high-yield, commercially profitable crop (Jiggins 1994; Shiva and Dankelman 1992). Yet, women's role in biodiversity conservation has been overlooked. Very often, no value is attached to the time and labour which women farmers and whole communities invest into creating and conserving diversity. Loss of habitats and biodiversity ultimately affects the underprivileged, the majority of whom are women.

2.4 Endangered Environments and Loss of Biodiversity

The previous section attempted to discuss the significance of biodiversity at all levels for human security. It stressed the critical need for accurate assessments and for conservation. This section is devoted to understanding the many factors behind loss of biodiversity and genetic erosion.

Economic growth and developmental paths have affected India's biological diversity in many ways. Unrestrained economic exploitation is the main reason for the loss of biodiversity. Habitat destruction has occurred in virtually all natural ecosystems. The arrogation of large areas of land for crop monoculture has impoverished the ecosystem and increased its vulnerability to pests and diseases and crop failures. Natural habitats have been cleared for development, forests have been converted to non-forest areas, wetlands and prime agricultural lands have been filled up to make space for urban cities.

There has been a considerable shift in farming systems toward a cropping system dominated by rice and wheat. The growth of monoculture in agriculture along with a handful of high-yielding varieties monopolizing the cropped area has substantially reduced the food basket in terms of the number of species cultivated and the genetic diversity of the strains cultivated. A few improved varieties are grown in 70 percent of the paddy fields and 90 percent of the wheat fields. Genetic uniformity has caused extensive genetic erosion. Unsustainable practices, such as uncontrolled application of pesticides and fertilizers for short-term gains in productivity, have aggravated damage to habitats. The soil has in fact suffered a slow death in major agricultural lands. The quantity of available water is going down drastically, while the quality is deteriorating alarmingly. Monoculture-based agriculture and shrinking cultural diversity are taking a heavy toll on nature and biodiversity.

The menace of Alien Invasive Species is another important reason for loss of biodiversity. New genetic stocks from one habitat when introduced into another can emerge as an indomitable competitor with native natural flora or fauna. They can cause irretrievable loss to native species and ecosystems (WTO 2000). They can alter or disturb ecological behaviour. The scope of invasions is global and the cost is enormous, both ecologically and economically. It can imperil national economies, hurt transnational trade, threaten human health, weaken crop agriculture, forestry and fisheries and bring about climate change (McNeely 2000 and MSSRF 2000). Alien Invasive Species are increasingly being recognized as the greatest biological threat after habitat destruction.[12]

Weeds such as lantana, Siam weed and water hyacinth were introduced into India as ornamental plants. But they escaped into the wild. *Prosopis* (Mesquite) in the Thar desert of India has displaced other flora of the area and has become an invasive species, seriously threatening the biodiversity of the only Ramsar-listed wetland of India. Aquatic weeds like hydrilla (*Hydrilla* sps), hyacinth, pondweeds (*Potamogeton* sps.), water fern (*Salvinia*), cattails (*Typha*), algal scum, etc. have clogged waterways, dams and reservoirs, destroyed fisheries and endangered the ecosystem as a whole.

Invasions by alien species can have far-reaching implications for agriculture. Crop loss and the resulting annual economic loss caused by the alien species that have become invasive are believed to be enormous. Infestations in paddy fields in the lowlands

[12] IUCN, 2000. IUCN guidelines for the prevention of biodiversity loss caused by alien invasive species, www.iucn.org

by weeds and algal scum have harmed irrigation and drainage, rendering several hectares of cultivable paddy land in northeastern India, Andhra Pradesh, Kerala and Maharashtra un-utilizable. However, there is no database at present to evaluate the spread of alien invasive species in India.

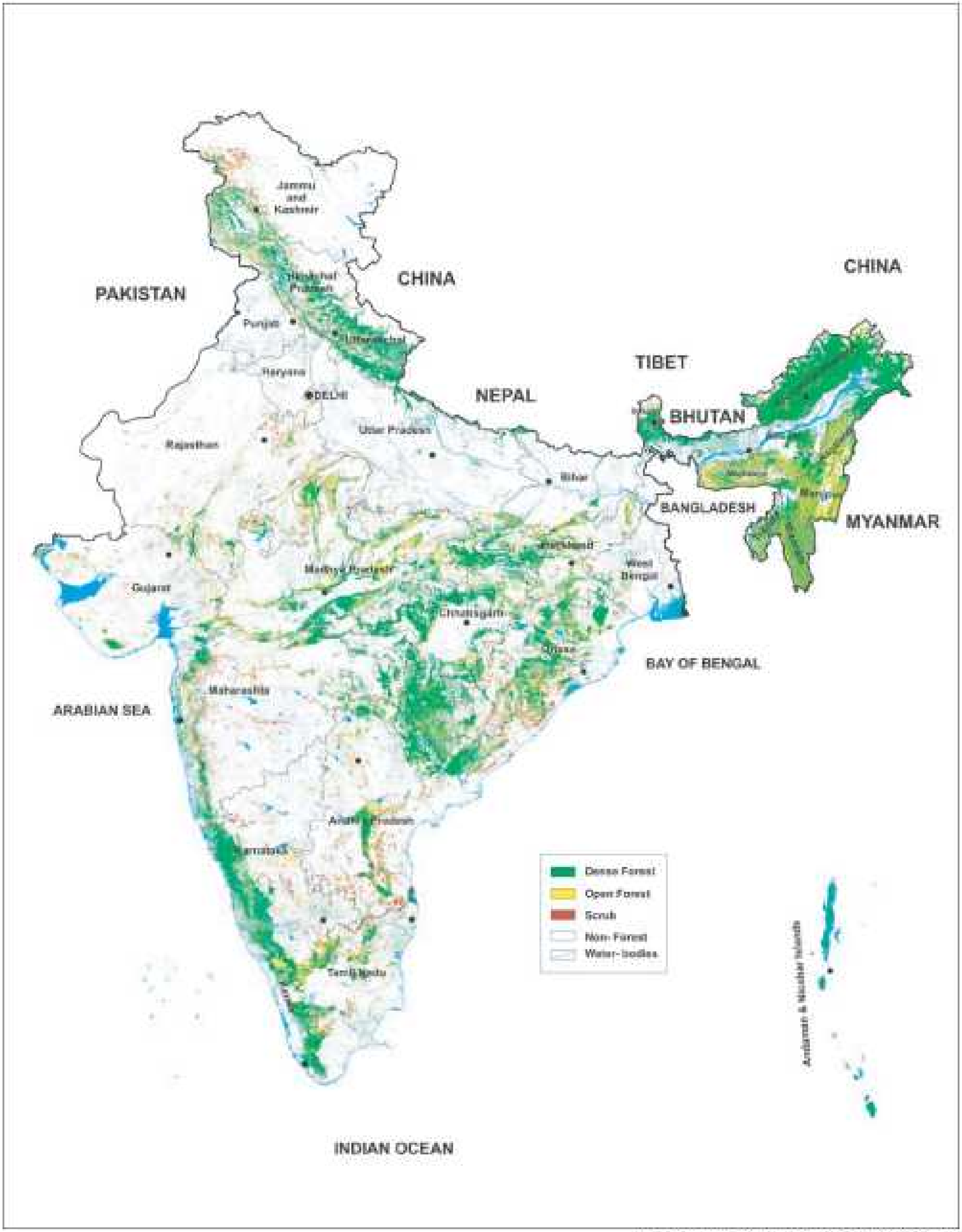
No accurate estimates have been made of the extent of loss of biodiversity or the annual rate of loss of biodiversity. The IUCN list of threatened animals and plants and the Red Data Book on animals and plants in India, compiled by the Zoological Survey of India and the Botanical Survey of India, is periodically updated to list the threatened and endangered flora and fauna. The Red Data Book has recorded some rare and threatened species of higher flora and fauna (Appendix 2.6). Whereas there isn't enough data to link biodiversity loss to actual causes of habitat destruction, the book conveys some ominous warning signals.

The factors mentioned earlier have threatened to break the intricate links that bind the various components of biodiversity with its physical environments. These interactions are very complex and fragile and often go unnoticed. Breaking a single link can have a cascading effect on the entire complex web. Erosion of agricultural biodiversity can have far-reaching consequences—such as narrowing of the food basket, widespread malnutrition arising from consumption of only a few crops that cannot provide the entire range of essential macro- and micro-nutrients. Loss of resources also spells danger to further genetic crop advancements necessary to bring about vertical growth in food production. It ultimately results in reduced access to food, nutrition, natural medicine and livelihood opportunities.

Loss of biodiversity affects normal ecosystem functioning as well. Loss of genetic variability within a population of species can reduce the flexibility of the ecosystem to adapt to environmental disturbances and narrow the options for adjustments to climate change. The addition or deletion of species can profoundly alter the balance of the ecosystem and drastically reduce the resilience and the stability of the ecosystem.

The ultimate impact of loss of biodiversity could be poverty by way of reduced access to natural resources; loss of livelihood and income opportunities arising directly from the appropriation and use of bio-resources; from crop failures due to pest attack and diseases; from loss of agricultural productivity due to declining soil microbial diversity, etc. (Appendix 2.7). It is important to realize that loss of genetic diversity is irreversible and irreplaceable. The loss affects not just India but the rest of the world. It is, therefore, of paramount importance to determine the exact nature and extent of biodiversity and take immediate measures to conserve and enhance it.

FOREST COVER



Geographical Representation 3

CHAPTER 3

Atmosphere and Climate Change

Atmospheric Pollution and Global Climate Change adversely impact the sustainability of food availability. Due to lacunae in data, it has not been possible to develop indicators and do a state-wise analysis of the impact of atmospheric pollution and global climate change on the sustainability of food security. However, any discussion on sustainable food security cannot but include these aspects. This chapter is divided into two parts. Atmospheric pollution and its linkages with food production are discussed in the first section. In the second section we study global climate change and its effects on agricultural production. Global warming is a phenomenon with worldwide impact as opposed to the more localized influence of air pollution.

3.1 Atmospheric Pollution and its Impact on Food Production

Clean air is a mixture of nitrogen (about 78 per cent), oxygen (21 per cent), carbon dioxide, argon and other gases (less than 1 per cent) and varying amounts of water vapour. Air pollution is the existence of particles or gases in the air that are not part of its normal composition. The level of air pollutants at a particular point of time depends on

- Quantity and type of pollutants introduced in the atmosphere
- The ability of the atmosphere to disperse or absorb the pollutants and
- The various chemical and physical dissipation processes which remove pollutants through a process of self-purification.

Air pollutants may be classified into two categories—primary and secondary pollutants. Primary pollutants are emitted directly into the atmosphere. They remain scattered in the atmosphere in the same chemical form as at the time of emission from the source. Secondary pollutants are formed by chemical reactions between primary pollutants. The sources of air pollutants may be point sources (emissions from domestic and industrial sources), line sources (vehicular emissions) and non-point sources (emissions from construction activities and refuse burning).

3.1.1 Levels of Air Pollution in India

Industrial emissions along with vehicular emissions are the biggest pollutants of air. The Suspended Particulate Matter (SPM) in the residential and industrial sites of Pune is at high to critical levels while the levels of sulphur dioxide and nitrogen dioxide are moderate to moderately high. Bangalore and Hyderabad have seen substantial increases in pollution levels since 1990. Kanpur and Chandigarh again have high to critical levels of SPM pollution levels. Chennai and Kolkata have shown only a marginal increase in the average levels of air pollution between 1990 and 1998. There has been a substantial fall in SPM levels in the industrial sites of Kolkata. However, the SPM levels in residential sites in Kolkata have reached critical levels. Jaipur has seen a significant fall in SPM levels in its residential areas. Mumbai has seen a fall in overall pollution levels, especially in residential areas. (Appendix 3.1)

Air pollution has a harmful effect on building materials, vegetation and human beings. Over 1.3 billion urban residents worldwide are exposed to air pollution levels above recommended limits (World

Bank 1993a). The health effects associated with air pollutants are discussed in detail in the chapter on food absorption. The impact of air pollution on vegetation, and more specifically on food production, is discussed in the following section.

Box 3.1 : Depletion of the ozone layer

Chlorofluorocarbons (CFCs) used as refrigerant solvents, foam blowing agents, etc, methyl chloroform (a solvent), carbon tetrachloride (an industrial chemical), halons (fire extinguishing agent) and methyl bromide are some ozone-depleting substances (ODS) that are transported by the winds to the stratosphere. The ODS, when they break down, release chlorine or bromine and damage the ozone layer. The ozone layer is destroyed faster than it is naturally created. The ozone hole has been occurring every Antarctic spring over Antarctica since the early 1980s. It is a large area over the stratosphere with very low concentrations of ozone. Ozone levels have fallen by over 60 per cent in the worst years. Ozone depletions occur over North America, Europe, Asia, much of Australia and Africa. With reductions in the ozone levels, higher levels of UVB reach the earth. UVB causes nonmelanoma skin cancer. It has been linked to cataracts and malignant melanoma development. Studies have shown that UVB also harms crops, plastics and other materials and some forms of marine life. The Montreal Protocol has sought to reverse past damage done to the ozone layer. As on September 2002, 183 countries have ratified the protocol, which sets out a time schedule to 'freeze' and reduce consumption of ozone-depleting substances (ODS). The new ODS regulation issued by the Ministry of Environment and Forests, Government of India, has banned the manufacture and sale of all ODS-based products with effect from January 1st 2003.

3.1.2 Impact of Air Pollution on Vegetation and Crop Yields

Vegetation acts as an absorbent of air pollutants by filtering out dust, smoke, soot and other fine particulate matter through the process of absorption, detoxification, accumulation and metabolization. The leaves of some evergreen trees like banyan, chatian, bargad and mango, deciduous trees like ber and peepul, shrubs like datura, aak and besharmi booti and shrubs like brinjal, tomato and kakrakanda have

Box 3.2: Effects of Air Pollutants on Vegetation

Air Pollutants	Effects on Vegetation
Sulphur dioxide	- Enters into leaf through stomata
	- Excessive exposure causes injury on blade with ivory colour, brown to reddish brown spots, depending on plant and environmental conditions
Ozone	- High concentration causes dark brown to black lesions on upper surface of leaves
Suspended	- Block the stomata through deposition on leaf surface
Particulate Matter	- Excessive dust deposition retards the growth of plant
	- Automobile exhaust smoke damages lower surface of leaves, bronzing and silvering, upper surface shows fleck like marking

Source: Central Pollution Control Board, "Air Quality Status and Trends in India"-2000 high dust-collection efficiency. However, when the concentration of air pollutants in the environment becomes excessive, vegetation may get affected. Qualitative and quantitative changes may occur to solar radiation input on the leaf surface; there may be alterations to the energy exchange process. Chlorophyll content may decrease; the leaf may suffer chloroplast injury, and dust-induced alterations in the physio-chemical parameters of the leaf may also occur.

Air pollutants may cause injury to the leaf tissue and make the crop look less appealing to consumers. Prolonged exposure to air pollutants may reduce the crop's growth and yield. Low levels of exposure to pollutants may cause subtle physiological, chemical or anatomical changes. These may not reduce yield under optimal growth conditions but may increase the crop's sensitivity to other stresses, thereby causing losses in yield. The effect of fluorine in reducing the yield of wheat, onions, potatoes and barley has been observed in several countries (Halbwachs 1984). Exposure to sulphur dioxide causes visible injuries to the leaf. It may also reduce the yield of barley and the growth of radish and tomato. Depositions of dust render fruits and vegetables un-saleable, thereby resulting in huge losses to farmers (Conway, and Pretty 1995)

Several global risk-assessment studies have been conducted to identify areas of high, moderate and low risk in the matter of reductions to crop yield on account of emissions of ozone and sulphur dioxide (Marshall *et al* 1997).[1] Ashmore and Marshall (1997) carried out a study of crop loss because of exposure to ozone. High-risk areas correspond to ozone exposure, which could reduce yield by over 15 per cent. The figures for intermediate and low-risk areas are 5 to 15 per cent and less than 5 per cent respectively. The authors found significant areas of high risk in northern India, China, Korea and Taiwan. Significant areas of moderate risk were found in Egypt, Malaysia, Thailand, Pakistan, Mexico, Venezuela, India and China. Field studies conducted individually in some of these countries have supported these findings (Lee and Kohler *et al* 1997). They discussed how yield losses are likely to increase if global nitrogen oxide emissions continue at the current rate, and made a projection for 2025. Large cultivated areas in India, China, South Africa, Egypt, Malaysia, Bangladesh, Indonesia and the Philippines fall in the high-risk category. Mexico, Nigeria and Zimbabwe have large areas entering the moderate risk category. The pattern of high, moderate and low-risk areas for sulphur emissions is similar to that of ozone. A prediction of sulphur emissions for 2025 made by the Stockholm Environment Institute in 1997 led to a similar change in pattern as observed for ozone.

Several local area studies have been carried out in developing countries to study the impact of air pollution on agriculture. High ozone concentrations have caused a 30 per cent yield loss to radish, a 17 per cent yield loss to turnip in the Nile Delta (Hassan *et al* 1997), and a 40 per cent loss of yield to rice and wheat in Pakistan Punjab (Wahid *et al* 1995). In Indian Punjab, visible leaf injury has been observed in the potato crop. A recent field study in Faridabad, Haryana brought to light the damage suffered by agriculture because of air pollution from industries in adjacent areas. In Malerna, a village in Faridabad, heavy damage is being caused to crops and livestock

[1] Ozone in high concentrations in the troposphere is a pollutant while the ozone layer in the stratosphere is life saving as it protects the earth from the harmful UVB radiation.

by smoke from a local thermocole factory. Deposits are formed on wheat plants in Khadoli because of pollution from factories in Ballavgarh. In Uncha Gaon, another village in the region, black deposits emanating from a local thermocole factory settle on cauliflower and spinach. They cause the cauliflower to turn creamish and the spinach to turn blackish and salty. Polluted air from Chandawali factories causes crop disease to spread at an unprecedented rate in Sahapur Kalan (Mukherjee*et al* 2002).

3.1.3 Pollution as a Harmful Externality

The market is often held up as the panacea for all economic ills. However, the market fails to perform in certain key areas. One example of market failure is when an economic activity generates an "externality"; that is, it does incidental good or harm to outsiders or to society as a whole, without the producer of the activity being rewarded for the incidental good or penalized for the incidental harm. Because firms are not charged for their use of clean air, they end up producing more than public interest warrants, and polluting more as well. Air pollution has become a serious problem because markets allow individuals, firms and government agencies to deplete resources like clean air without them having to pay anything for using these resources.

Controlling the damage caused by air pollution is a tough challenge. Taxes on emissions and emission permits are more effective than voluntary programmes and direct controls in controlling pollution, as they provide the firm with financial incentives to reduce pollution. In India, we largely follow the system of direct controls. These measures do not provide the polluters with incentives to choose the least-cost method of pollution control (Appendix 3.2).

3.2. Climate Change and its Impact on Food Production

Earth's temperature is maintained at a level that can sustain life through a balance between heat absorbed from the sun and cooling that results when some of the heat from Earth's surface and atmosphere is reflected back to space. Some atmospheric gases, such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_20), chlorofluorocarbons and two CFC substitutes (hydrofluorocarbon and perfluoromethane), collectively known as Greenhouse Gases (GHGs), absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by Earth's surface, the atmosphere and the clouds. Thus, acting as a blanket and preventing much of the heat reflected by Earth's surface and atmosphere from escaping directly to space, they warm Earth's surface. This warming is referred to as the natural greenhouse effect.

The problem starts when there is an increased concentration or accumulation of GHGs in the atmosphere. Human-induced changes in the composition of the atmosphere lead to this increased concentration and hence to the *enhanced greenhouse effect,* the process that is expected to cause *global warming.* Global warming is an increase in the pattern of average temperature of Earth at its surface. Other changes—cloudiness, rainfall—and changes in winds or ocean currents are likely to accompany global warming. These changes are referred to collectively as *climate change.*

Atmospheric concentrations of carbon dioxide (CO_2), methane and nitrous oxide have increased since 1750 by 31 per cent, 151 per cent and 17 per cent respectively. During the last two decades, CO_2 levels have increased at an unprecedented rate of about 1.5 parts per million (ppm) per year. During the 1990s, this rate varied from 0.9 to 2.8 ppm. About threequarters of anthropogenic emissions of CO_2 were a result of fossil-fuel burning (IPCC 2001)[2] (Appendix 3.3 for sources of global emissions of the main greenhouse gases).

The largest share of emissions is from the USA, followed by the Soviet Union and East Europe and Western Europe. Industrialized countries owe their current prosperity to years of 'historical emissions', which have accumulated in the atmosphere since the start of the industrial revolution, and also to a high level of current emissions (often referred to as 'luxury emissions') (Table 3.1). Developing countries, on the other hand, have only recently embarked on the path of industrialization and their per capita emissions are still comparatively low. The GHG emissions of one US citizen, for instance, were equal to that of 19 Indians, 19 Sri Lankans, 30 Pakistanis, or 107 Bangladeshis in 1996 (Agarwal, A., Narain, S. and Sharma, A., 1999).

Although India figures among the top 10 contributors to GHG emissions, its relative share is low in terms of per capita emissions. The current gross emissions per capita are only about one-sixth of the world average (Asian Development Bank., 1994). The total carbon dioxide equivalent of emissions (carbon dioxide + methane + nitrous oxide) from India was estimated to be 1,001,352 giga tonnes, which is about 3 per cent of the carbon dioxide equivalent of emissions from the entire globe. (Table 3.2) The per capita CO_2 equivalent emissions for 1990 were estimated at 325 kg of carbon. By comparison, the per capita emissions for Japan and the US for the same year were 2,400 and 5,400 kg of carbon respectively (ADB 1998).

Table 3.1

Percentage distribution of net emissions of GHGs by industrialized and developing nation

Country	CSE calculation
India and China	0.6
United States	27.4
Soviet Union and E.Europe	17.6
Western Europe	11.9
Japan	2.5
Other Industrialized countries	7.5
Brazil	18.2
Other Developing nations	14.3

Source: Agarwal. A and Narain. S, 1991,

"Global Warming in an unequal World A case of Environmental Colonialism", Centre for Science and Environment, (CSE), New Delhi,

Table 3.2

Green house gases and their sources (giga tonnes)

Greenhouse gas, sources and sinks	CO_2 equivalent (CO_2 + CH_4 + N_20)
Energy (fuel combustion + fugitive emissions from fuels)	565,245
Industrial Processes	24,510
Agriculture:	341,064
Enteric fermentation rumination	158,823
Manure management	19,005
Rice cultivation	85,470
Agricultural soils	74,400
Prescribed burning of savannas	
Prescribed burning of agricultural residues	3,366
Land use and Forestry Change	1,485
Waste	69,048
Total National Emissions and Removals	1,001,352

Source: ALGAS - Asia Least - Cost Greenhouse Gas Abatement Strategy, Asian Development Bank, 1998, Manila: Asian Development Bank.

3.2.1 Impact and Consequences of Climate Change and Predictions

It is clear that if the build-up of GHGs in the atmosphere continues without limit, it is bound, sooner or later, to warm Earth's surface. Such a trend will cause shifts in the zonation of vegetation and in the quantity and distribution of rainfall (and, hence, of river flow and groundwater recharge). It will also

[2] Intergovernmental Panel on Climate Change, 2001 "The Regional impacts of climate change".

induce melting of glaciers, expansion of ocean water, rise in sea levels, inundation of coastal areas—in short, a change in the entire thermal and biophysical regimes governing both natural and agricultural ecosystems.

The problem of anthropogenic climate change has in a few years moved to the forefront of global environmental concerns. The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 to assess the available scientific information on climate change and its environmental and socio-economic impact and to evaluate response strategies. The findings of the IPCC First Assessment Report were presented to the second World Climate Change Conference in Geneva in 1990. The Second Assessment Report was finalized in 1995, and the Third Assessment Report was released in January 2001. The main findings are given below[3]:

Temperature: The 20th century saw unusual warming as temperature increased by about 0.6°C. Globally, the 1990s were the warmest decade and 1998 the warmest year since 1961. Global surface temperatures are expected to rise by 1.4 to 5.8 °C by 2100, with the warming rate being significantly greater than that in the last century. Extreme low temperatures are less frequent than before, while extreme high temperatures have become more frequent since 1950.

Warming in northern and central Asia will be about 40 per cent more than the global average rate. As a result of the continued emissions of GHGs, the spatial average over the Asian region of the annual

Srivatsa, H.N., B.N. Dewan, S.K. Dikshit, G.S.P. Rao, S.S. Singh and K.R. Rao, 1992. "Decadal Trends in Climate Change Over India", Mausam 43: 7 – 20.

aerosols) will be about 2.5°C in the 2050s and about 4°C in the 2080s. In general, the warming is expected to be higher during the Northern Hemisphere winter than during summer. According to computer simulations of the General Circulation Model (GCM), more pronounced increases may be expected in the minimum temperature than in the maximum temperature during winter and, hence, decreases in the diurnal temperature range (DTR). However, in summer, the DTR is expected to increase, suggesting a more pronounced increase in the peak temperature rather than in the minimum temperature.

In a study covering the period 1901–1987 (Rupakumar *et al* 1994), it was shown that the countrywide mean maximum temperature has risen by 0.6°C, while the mean minimum temperature has fallen by 0.1°C. In a study on decadal trends, Srivatsa *et al*. (1992) have shown that the two most recent decades (that is, 1971–1980 and 1981–1990) have registered higher warming rates than earlier decades. Such studies have merely analyzed temperature trends in India and have not attributed any particular cause, such as increasing greenhouse gas concentrations, to the recorded increase in temperature. Estimates indicate that India's climate could become warmer under conditions of increased atmospheric carbon dioxide. The average temperature change is predicted to be in the range of 2.33°C to 4.78°C with a doubling in CO_2 concentrations.

Sea level: Global sea levels rose by 10 to 20 cms in the 20th century and are expected to rise between 9 and 88 cms in 2100. Thermal expansion and loss of ice from glaciers and ice caps are believed to be responsible for this rise (Srivatsa *et al* 1992). A series

locations (Mumbai, Cochin, Howrah, Haldia and Sagar Island) report an increase in sea level. Trends indicate higher levels on the east coast than on the

[3] The findings on the possible impact on Asia are taken from the Chapter on Asia in the Special Report of the IPCC, "The Regional Impacts of Climate Change: An assessment of Vulnerability", February 2001.

west coast. The average sea level rise since the 1950s has been reported to be 2.5 mm/year.

Precipitation: Precipitation over the middle and high latitudes in the Northern Hemisphere has increased by 0.5 to 1 per cent per decade during the 20th century. Heavy precipitation events became more frequent by 2 to 4 per cent during the latter half of the century. Over the 20th century, rainfall in tropical areas increased by 0.2 to 0.3 per cent per decade, and it decreased by about 0.3 per cent in subtropical regions of the Northern Hemisphere.

In Asia, warming because of GHGs (taking into account the effect of aerosols) is expected to result in an annual mean increase in rainfall of about 3 per cent in the 2050s and about 7 per cent in the 2080s. The projected increase is the highest for the Northern Hemisphere winter. Tropical cyclones could become more intense. Coupled with the phenomenon of sea-level rise, this could aggravate the risk of loss to life and property in low-lying coastal areas of cyclone-prone regions.

The confidence level in precipitation predictions is much lower than that in temperature predictions. Most of the GCMs, however, predict higher monsoon activity over the Indian subcontinent. The IPCC report also projects an increase in the river flow for a few decades, followed by a reduction in flow as the glaciers disappear. Almost 67 per cent of the glaciers in the Himalayan and Tienshan mountain ranges have retreated in the past decade.

3.2.2 Impact of Climate Change on Agriculture

Any significant change in climate on a global scale will obviously affect local agriculture and the world's food supply. Assessing the potential impact of climate change on agriculture is a complex, multidisciplinary challenge that calls for expertise in atmospheric science, hydrology, soil science, crop physiology and resource economics. In studying the impact of climate change, state-of-the-art models developed by researchers in disparate disciplines are being used to project future food supplies. Current General Circulation Models (GCMs) calculate the temporal and spatial transports and exchanges of heat and moisture throughout Earth's surface and atmosphere. These models can be deployed to predict changes in temperature, precipitation, radiation and other climate variables caused by increased GHGs. Crop models then predict the response of specific crops to alternative sets of climate and CO_2 conditions. Results in terms of changes to crop yields and water use are then subjected to an economic analysis based on a linked model system of international food trade (Rosenzweig and Hillel 1998). The results obtained from GCMs must not be accepted uncritically. There are several uncertainties:

- The degree of temperature increase and its geographic distribution.
- The concomitant changes likely to occur in precipitation patterns that determine the water supply to crops, and the evaporative demand imposed on crops by the warmer climate.
- The physiological response of crops to enriched carbon dioxide in the atmosphere.
- The fundamental complexity of natural agricultural systems and of the socio-economic systems governing food supply and demand.

Moreover, for any meaningful assessment of the impact of climate change, information on climate variables and resources is necessary at regional and local levels. The accuracy of climate predictions at the regional level is at present poor (IPCC 1990).

Much study has gone into how farming will be affected in different regions and by how much; whether the net result will be harmful or beneficial; and to whom. South and southeast Asia are thought to be particularly vulnerable[4] (Fankhauser 1995) Specifically, those countries where agriculture is responsible for a significant proportion of the Gross Domestic Product (GDP) are likely to be affected more (Qureshi and Richards 1997). Many of the world's poorest areas, dependant on isolated agricultural systems in semi-arid and arid regions, face the greatest risk. Many of these high-risk populations live in sub-Saharan Africa, South, East and Southeast Asia, tropical areas of Latin America and some Pacific island nations.

The following climate changes have been recognized as important for agriculture by Sinha and Swaminathan.

- Increase in temperature
- Changes in precipitation and storm activity
- Widespread run off
- Reduction in fresh-water availability
- Adverse impact on coastal agriculture on account of seawater intrusion.

Climate change can impact agricultural sustainability in two inter-related ways: first, by diminishing the long-term ability of agro-ecosystems to provide food and fibre for the world's population; and second, by inducing shifts in agricultural regions that may encroach upon natural habitats at the expense of floral and faunal diversity. Global warming may encourage the expansion of agricultural activities into regions now occupied by natural ecosystems such as forests, particularly at mid and high latitudes.

The major potential consequences of climate change for agriculture fall into three categories: direct effect on crop yields, effects on soil fertility and large-scale effects on agricultural zones.

Direct effect on crop yields: Increased soil fertilization is expected as a result of increased carbon dioxide levels. While the impact of elevated concentrations of CO_2 on crop growth and yield has been studied, the effects of other GHGs have yet to receive similar attention. If atmospheric CO_2 accumulation were occurring without concomitant changes in temperature and water regimes, it might indeed be a blessing for crop production. Greater atmospheric concentrations facilitate greater absorption of CO_2 and, hence, increased rates of photosynthesis. Crop species vary in their response to CO_2[5].

- **C3** plants (which make up the majority of species globally, especially in cooler and wetter habitats), such as wheat, rice, cassava, potato, barley, oats and soybeans respond readily to increased levels of CO_2. Most fruits and vegetables also belong to this class. Experiments based on a doubling of CO_2 concentrations (IPCC 2001) have confirmed that "CO_2 fertilization" can increase mean yields of C3 crops by 30 per cent.

[4] A team of scientists sponsored by the U.N has reported that in terms of a 'vulnerability index', developing countries are on an average twice as vulnerable and island states are three times more vulnerable. A 15–95 cm rise in sea level could turn people now living on islands and in coastal areas into environmental refugees. If many of the current scientific predictions come true, South Asia, which has over one-sixth of the world's population, will greatly suffer, may be more than any other region. The risks of negative impacts are particularly important for developing countries in semi-arid zones because they will be less able to adapt to change than industrial countries. Significantly, adverse effects on small island states and low-lying deltas such as Bangladesh, Egypt and China could render millions of people homeless. Climate change will have a direct impact on crop yields and soil fertility. It is also likely to force agricultural migration in many areas.

[5] Experiments conducted used 600 ppm or an even higher concentration of CO_2. Experiments were conducted in controlled environments, maintaining optimal temperatures for the growth of the experimental plants. Moreover, the plants were protected from pests and diseases. There were hardly any studies on the interaction of CO_2 effects with other environmental factors such as temperature, water stress and other GHGs.

- **C4** plants such as corn, sorghum, sugarcane, maize and millet tend to be less responsive to enriched concentrations. A smaller increase of up to 10 per cent is expected for this class of crops.

As CO_2 concentrations increase in the ambient atmosphere, plants also exhibit partial closure of their stomata, thereby reducing transpiration per unit of leaf area. Thus, under CO_2 enrichment, crops may use less water even as they produce more carbohydrates. This dual effect is likely to improve water efficiency, which is the ratio between crop biomass and the amount of water consumed. However, there is just too little quantitative information available to enable us to predict a precise response to CO_2 concentration (Cure 1985).

In high latitudes, global warming will extend the length of the potential growing season, allowing planting of crops in spring earlier than usual, earlier maturation and harvesting and, possibly, the completion two or more cropping cycles during the same season. In warmer, lower-latitude regions, increased temperatures may accelerate the rate at which plants release CO_2 in the process of respiration, resulting in less than optimal conditions for net growth. When temperatures exceed the optimal for biological processes, crops often respond negatively, with a steep drop in net growth and yield. Several experiments at the International Centre for Agricultural Research in Dryland Areas (ICARDA) and elsewhere have shown that the productivity of wheat, barley and chickpeas is lower during spring planting than during winter planting. Another effect likely, especially in temperate mid-latitudes, is reduced winter chilling. Many temperate crops such as barley and oats require a period of low temperature in winter to accelerate flowering periods. Reduced chilling results in low flower-bud initiation and ultimately in reduced yields. Increased temperature is also likely to affect the crop calendar in low-latitude regions, particularly where more than one crop is harvested during the year.

A broad generalization of the effects of increasing temperature on crop duration can then be drawn: the shorter the crop duration, the more accelerated is the physiological development of the plant and, hence, the lower the yield. Moreover, warmer climates and increased soil moisture increase the threat of pests and weeds.

Effect on soil fertility: There is a distinct possibility that as a result of high rates of evapotranspiration, some regions in the tropics and subtropics could be characterized by a higher frequency of drought, or a similar frequency of more intense drought, than at present. Lower-than-average rainfall in India in 1987 reduced food-grains production from 152 to 134 million tonnes. Changes in the risk and intensity of drought, heat stress and other extreme climatic occurrences represent potentially the most serious impact of climatic change on agriculture, both at the regional and global levels.

Higher air temperatures will also be felt in the soil, where warmer conditions are likely to speed up the natural decomposition of organic matter and increase the rates of other soil processes that affect fertility. Additional application of fertilizer may be needed to counteract these processes and take advantage of the potential for enhanced crop growth that can result from increased atmospheric CO_2. This may have to be at the cost of environmental risk, because additional use of chemicals impacts both air and water quality. The continuous cycling of plant nutrients carbon, nitrogen, phosphorous, potassium and sulphur in the soil-atmosphere-plant system is also likely to accelerate in warmer conditions, enhancing

CO_2 and N_2O emissions. Apart from this, the rise in sea levels that accompanies global warming can cause soil salinization and cropland erosion.

Effect on agricultural zones: Since average temperatures are expected to rise more near the North Pole and South Pole than near the equator, the shift in climate zones will be more pronounced at higher latitudes. In the mid-latitude regions, present temperature zones could shift by 150 to 550 kms. Since each of the latitudinal belts is optimal for particular crops, such shifts could strongly affect agricultural and livestock production. Efforts to shift crops poleward in response could be limited by the inability of soil types in the new climate zones to support intensive agriculture as practiced today in the main producer countries (Parry and Duinker 1990).

3.2.3 Impact of Climate Change on Agriculture in India

India is potentially vulnerable to several types of adverse impacts on account of climate change. These include impact on agriculture, animal husbandry and fisheries; on forests and biodiversity resources and potential impact on India's coastal resources and island territories. In this section we discuss the effects of climate change on Indian agriculture. Anticipated changes in water availability (surface, freshwater and groundwater), temperature rise, soil degradation and the suggested increase in unexpected events such as drought, floods and cyclones will affect agricultural productivity and threaten the country's food security.

The arrival and performance of the monsoon is no insignificant matter in India every year, and it is avidly tracked. This is because most states are largely dependant on rainfall for irrigation. Any change in rainfall patterns poses a serious threat to agriculture and, therefore, to the country's food availability. Scientists at the Centre for Science and Environment predict that the semi-arid regions of western India are expected to receive higher-than-normal rainfall as temperatures soar, while central India will experience a decrease of between 10 and 20 per cent in winter rainfall by the 2050s. Agriculture will be the worst affected in the coastal regions of Gujarat and Maharashtra, where agriculturally fertile areas are vulnerable to inundation and salinization. About 0.6 ton/hectare in low-yield agriculture will be adversely affected not only by an increase or decrease in the overall amounts of rainfall, but also by shifts in the timing of rainfall, as a lot depends on the moisture of the soil and the time of sowing of the crops.

There is also the added problem of evapotranspiration. Scientists at IIT Delhi predict that even an increase of 1°C could increase the rate of evapotranspiration by 5 to 15 per cent. A 2°C increase in mean air temperature will lead to a reduction in rice yield by 0.75 ton/hectare in high-yield areas and coastal regions. On the other hand, a 0.5°C increase in winter temperature will lead to a reduction in wheat crop duration by seven days, which will in turn reduce yield by 0.45 ton/hectare (Sinha and Swaminathan 1991). An increase in temperature will then translate into a 10 per cent reduction in wheat production in the high-yield states of Punjab, Haryana and Uttar Pradesh. In Rajasthan, a 2°C rise in temperature was estimated to reduce production of pearl millet by 10 to 15 per cent. Madhya Pradesh, where soybean is grown on 77 per cent of all agricultural land, might benefit from an increase in CO_2 in the atmosphere. According to some studies, soybean yield could go up by as much as 50 per cent, if concentration of CO_2 doubles. However, if the increase in concentration in CO_2 is accompanied by an increase in temperature, yields could decrease. If maximum and minimum temperatures go up by 1°C and 5°C respectively, the gain in yield comes down by 35 per cent. If the maximum and minimum temperatures rise by 3°C and 5°C respectively, then the yields will decrease by 5 per cent compared to 1998 levels.

However, the vulnerability of agricultural production to climate change depends not only on the physiological response of the affected plant, but also on the ability of the affected socio-economic systems of production to cope with changes in yield as well as with changes in the frequency of droughts and floods. Standing crops are more likely to be damaged due to cyclonic activity.

3.3 Mitigating the Effects of CO_2 Emissions

Carbon sequestration may be defined as the removal of CO_2 from the atmosphere into long-lived pools of carbon. A stock that is taking up carbon is called a carbon *sink*. Carbon sequestration and storage slow the rate at which carbon dioxide accumulates in the atmosphere. This effect helps mitigate global warming (Appendix 3.4).

The World Resources Institute has developed a spatial distribution system for global carbon stored in terrestrial ecosystems. Forests, soils and vegetation store about 40 per cent of all carbon in the terrestrial biosphere, more than any other ecosystem. About 34 per cent is stored in grasslands and 17 per cent in agricultural lands. The highest quantities of stored carbon are located in tropical and boreal forest regions. Grasslands generally store less carbon than forests on a carbon/unit area basis. However, because of their extensive area, grasslands are important carbon stores. Tropical (low-latitude) grasslands store significantly more carbon than temperate (mid-latitude) forests.

Re-growth of forests in the Northern Hemisphere may account in part for the increasing terrestrial sink that absorbs some of the carbon dioxide emissions released by fossil fuel burning. However, land use change, primarily tropical deforestation (probably 130,000 sq. km are lost every year), currently releases an estimated 1.6 billion tonnes of carbon per year, which is equal to 25 per cent of the emissions from fossil fuel combustion (Matthews, Pyne, Rohweder and Murray 2000). Globally, deforestation exceeds re-growth. Hence, forests are now a net source of carbon.

3.3.1 Forest Ecosystems as Carbon Sinks

The role of forests in carbon sequestration is probably best understood and appears to offer the greatest potential for human management as a sink. Every year, as forests grow and increase their biomass, they absorb carbon from the atmosphere and store it in plant tissue. Despite constant exchanges of carbon between forest biomass, soils and the atmosphere, a large amount is always present in leaves and woody tissues, roots and soil nutrients. This quantity of carbon is known as carbon store.

There are four components of carbon storage in a forest ecosystem: trees, understorey material (plants growing on the forest floor), detritus such as leaf litter and other decaying matter on the forest floor, and forest soils. As the forest biomass experiences growth, the carbon held captive in the forest stock increases. Simultaneously, plants grow on the forest floor and add to this carbon store. Over time, branches, leaves and other materials fall to the forest floor and may store carbon until they decompose. Additionally, forest soils may sequester some of the decomposing plant litter through root–soil interactions.

Unlike many plants and most crops, which have short lives or release much of the carbon at the end of the season, forest biomass accumulates carbon over decades and centuries. Current estimates of sequestration vary from 30 tons/hectare to 100 tons/hectare, depending on the maturity of the stand. Rapidly growing trees are more likely to gather carbon than either saplings or fully mature stands. However, forest carbon can also be released fairly quickly, as in forest burning. Fortuitously, forests managed for timber, wild life or recreation have carbon sequestration as a by-product. Forests may also be managed strictly to sequester carbon. The indirect effect of such a narrow focus could be reduced biodiversity. However, if forests managed for carbon sequestration are allowed to mature and remain unharvested, one of the long-term effects may be enhanced biodiversity.

As forests transit from one ecological condition to another, they produce substantial carbon flows—a forest can be a carbon source or a sink. Thus, it is important to carefully assess exactly what is happening to the carbon as the forest changes to determine the forest's source–sink contribution. Net forest carbon may be released because of biomass reductions from fire, tree decomposition or logging, thereby making carbon a source. In the case of fire or decomposition, forest carbon is released into the atmosphere. However, the forest may again become a carbon sink as it is recovered through forest regrowth. In much of the world, wood is used as source of energy and this burning will release carbon into the atmosphere. Where fuel wood is taken from a forest and regrowth occurs, no net carbon is emitted. If biofuels are produced sustainably and used as a substitute for fossil fuel energy, fossil fuel emissions are avoided and no new net carbon emissions are created. Natural disasters can impact forest stocks and often result in forests becoming a carbon source. In many forests, natural disturbance regimes create a cyclical pattern of growth (sequestration), disturbance (emission) and regrowth (sequestration) over a period of many hundred years.

The ongoing loss and degradation of forests and soils will not only contribute to future climate change, they will also impose tremendous environmental, economic and social costs, particularly on people and resources in developing countries. There are three broad categories of forestry-related interventions that will help stabilize GHG emissions: managing the existing forest cover better, expanding the area of forest cover and using wood fuels as a substitute for fossil fuels.

It has been estimated that in 1996 carbon sequestration in Indian forests, net of carbon emission, was 6.9 million tonnes (Ravindranath 1996). According to estimates, net annual carbon sequestration from 1972–1973 to 1999–2000 was positive, mainly because of the plantation of secondary forests during the past two decades (Chopra *et al* 2002). Thus there is a possibility for Indian forests to raise funds for forest regeneration through carbon trading with developed nations (Appendix 3.5).

3.3.2 Marine Ecosystems and Mangroves as Carbon Sinks

Oceans are the largest carbon reservoir on Earth. They take up a considerable portion of the carbon dioxide emitted by humans. The net carbon uptake by the oceans is 2 Gt/year. Various oceanic and coastal communities in the marine ecosystem use up carbon

[6] Primary production represents the net fixation of CO_2 into autotrophic biomass through photosynthesis. It thus corresponds to the excess of total CO_2 fixation over autotrophic respiration (that is, net primary production = gross primary production – autotrophic respiration).

during primary production.[6] These communities include phytoplankton, benthic (bottom-dwelling) micro algae, coral reef algae, sea-grass meadows, marshes and mangroves. Coral reefs, marshes, sea-grasses and mangroves and macrophytic communities have greater potential as organic carbon traps than other marine communities. Yet, microphytic oceanic phytoplanktons stand out as the greatest trap of organic carbon in the global marine budget because they cover the largest area.

Mangroves in coastal ecosystems play a very important role in mitigating the effects of climate change as well as carbon sequestration. Mangroves are complex and highly productive ecosystems with an average productivity of 2,500 milligrams of carbon per sq m (mg C m^{-2}) per day. Their significance lies in the fact that they support enormous sub-surface vegetation that is responsible for a substantial percentage of total biomass and primary production (Cebrian., 2002). This is particularly relevant in the river-dominated and tide-dominated mangrove areas where carbon accretion is very high. Measurements suggest that mangroves are able to sequester some 1.5 tonnes of carbon per hectare per year (Ong 2002). Mangroves also have high sedimentation rates and carbon accumulation rates. Large quantities of carbon accumulate in the sediments through litter fall. Half of this is exported to the coastal oceans while 25 per cent is recycled within mangroves. The remaining 25 per cent accumulates in the sediments (Jennerjahn and Venugopalan 2001).

Mangroves are a major mitigating agent of Co_2 rise; destruction of mangroves can cause irreversible damage to the process of arresting CO_2 rise. If a mere 2 per cent of mangroves are converted to aquaculture ponds, all the advantages of mangroves as a sink of atmospheric carbon would be lost. Mangrove forests which constitute a special coastal ecological system make up less than one per cent of India's geographical area.

Global climate change is a phenomenon that humanity cannot ignore. Efforts are being made worldwide to counter the phenomenon. Continuing action at all levels: local, national and international, to combat them should be regarded as one of the priorities of the human race.

CHAPTER 4

Sustainability of Food Production

Sustainability of food production has two components. The first one is the existing capacity of the state to produce food. The second consists of all the natural resources that can sustain food production in future. The first component is the present Food Production Security and the second component is Sustenance of Food Production.

It is important to have sufficient food to eat at present and in the future. Food availability is a function of food production and inflow of food into the state. Detailed information on the net flow of various food items into and out of states is difficult to get. Hence, food production has been used as a proxy for food availability. The variations in food grain production per capita indicate the security aspect very well.

4.1. Food Grain Production: State-level Variations

Given the natural resource endowments and the market demand for food, each of the states produces various food items. Food grain production is far more evenly spread across the states than the production of certain food items such as milk and fish. Food grains availability is basic to achieving security of food availability. Food grains consist of cereals and pulses.

Each state has to ensure that sufficient staple food is available for people to purchase at affordable prices. It is not necessary for the states to produce enough of the staple food for its people. The states can specialize in different commodities best suited to their agro-climatic conditions. However, the small size of the holdings and the lack of widespread access to the market lead many farmers to produce staple food for themselves, though they may produce other crops for the market.

It was also noticed that wherever local production is adequate to meet the local demand, the prices of food grains remain relatively low. Further, in states with a production deficit, the lowest deciles might consume lower calories. For example, the poor in Kerala, Tamil Nadu, Gujarat and Maharashtra seem to consume lower calories than the poor in Punjab, Haryana and Himachal Pradesh. For poor states with high levels of poverty and low purchasing power, local production is important (MSSRF 2001).

In the triennium ending in the year 2000, the monthly per capita food grain production was the highest in Punjab at 79.19 kg, followed by Haryana at 48.14 kg. Madhya Pradesh produced 26 kg, Uttar Pradesh about 21 kg and Himachal Pradesh about 19 kg. Kerala produced 2.05 kg per capita per month. Meghalaya, Gujarat and Goa produced less than 10 kg. Maharashtra produced just about 10 kg. Rajasthan's production was about 18 kg. All the other states produced between 11 and 15 kg per capita per month (Table 4.1 and Map 4.1).

States that have a higher food grain production are more secure than the ones with very low production. Food grain production per capita stands testimony to the food security of the state and its people from the standpoint of food availability and, hence, is included as an important indicator along with net sown area and change in the net sown area; these were elaborated in the chapter on land.

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Table 4.1

Indicators and Indices of Production Security

S.No	States	1 Weighted Net Sown Area* (NSA) ('000 hect.) (1998-99)	Index	2 Percentage Change in NSA (in 1988-89 over 1990-91)	Index	3 Foodgrain production Per Capita (Kgs/month) (1997-2000)	Index	4 Index of Production Security	**Rank**
1	Andhra Pradesh	5108.60	0.492	-0.57	0.055	14.36	0.160	0.236	**8**
2	Arunachal Pradesh	69.90	0.003	24.16	0.398	15.48	0.174	0.192	**12**
3	Assam	1039.10	0.097	-0.19	0.061	11.53	0.123	0.094	**18**
4	Bihar	3702.10	0.355	-3.68	0.012	14.17	0.157	0.175	**13**
5	Goa	51.40	0.002	7.58	0.168	9.79	0.100	0.090	**19**
6	Gujarat	4125.40	0.396	4.12	0.120	8.42	0.083	0.200	**10**
7	Haryana	2225.20	0.212	3.42	0.110	48.14	0.597	0.306	**6**
8	Himachal Pradesh	205.90	0.017	-4.36	0.003	19.53	0.227	0.082	**21**
9	Jammu and Kashmir	343.50	0.030	-0.14	0.061	11.62	0.124	0.072	**23**
10	Karnataka	4143.50	0.398	-2.05	0.035	14.71	0.164	0.199	**11**
11	Kerala	827.70	0.077	0.49	0.070	2.05	0.000	0.049	**25**
12	Madhya Pradesh	8575.70	0.828	2.46	0.097	26.62	0.319	0.415	**3**
13	Maharashtra	6498.00	0.626	-0.91	0.051	10.06	0.104	0.260	**7**
14	Manipur	68.00	0.003	0.00	0.063	13.17	0.144	0.070	**24**
15	Meghalaya	85.50	0.005	9.41	0.193	6.84	0.062	0.087	**20**
16	Mizoram	36.30	0.000	67.69	1.000	11.65	0.124	0.375	**4**
17	Nagaland	103.50	0.007	34.54	0.541	11.54	0.123	0.224	**9**
18	Orissa	2650.40	0.254	-4.56	0.000	13.65	0.150	0.135	**16**
19	Punjab	2873.00	0.275	0.55	0.071	79.19	1.000	0.449	**1**
20	Rajasthan	7021.50	0.677	3.76	0.115	18.54	0.214	0.335	**5**
21	Sikkim	34.90	0.000	0.00	0.063	15.43	0.173	0.079	**22**
22	Tamil Nadu	2898.10	0.278	-1.59	0.041	11.80	0.126	0.148	**15**
23	Tripura	97.10	0.006	5.32	0.137	13.08	0.143	0.095	**17**
24	Uttar Pradesh	10351.90	1.000	2.14	0.093	21.29	0.249	0.447	**2**
25	West Bengal	2396.40	0.229	-0.68	0.054	15.16	0.170	0.151	**14**

*Weighted Net Sown Area was obtained by assinging 0.7 for irrigated and0.3 for unirrigated area sown

4.2 Indicators of Sustainable Food Availability

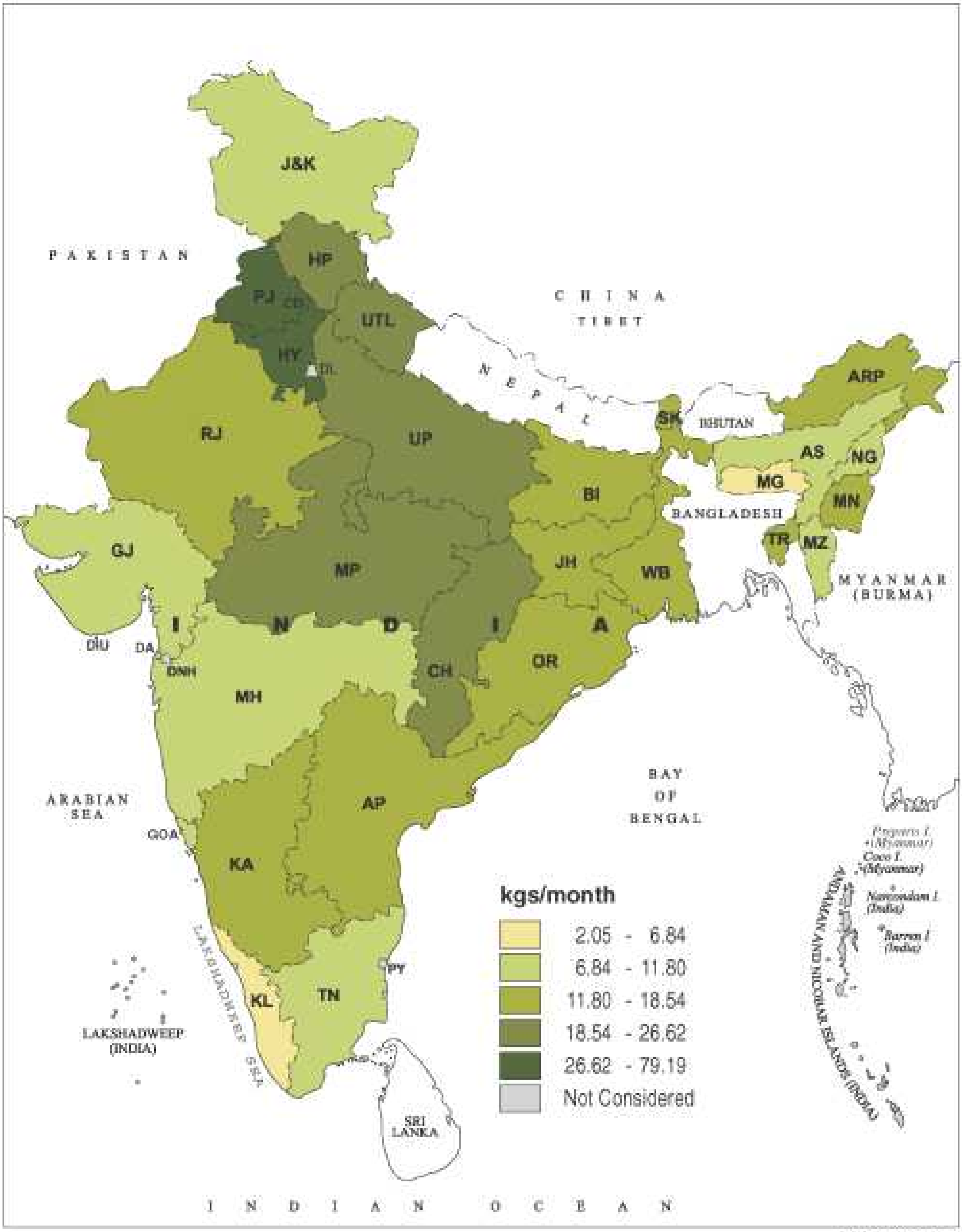
1. *The weighted net sown area* represents the comparable agricultural land-base for food production

2. *Percentage change in net sown area over the past five years* represents the limitation of land resources available for agriculture

3. *Food grain production per capita* represents the levels of current assured and demonstrated production

Food security can be achieved only when the

PER CAPITA FOODGRAIN PRODUCTION



Map No. 4.1

dependency on climate is minimized. Hence, irrigated land has been given a higher weight. This indicator has been discussed in detail in the first chapter on land and water. Net sown area represents food security in heavily land-based agriculture, where land cannot be freely be substituted by capital. Larger the weighted net sown area, higher the present security of food production. Even though all the net sown area is not used for the production of food, the weighted net sown area shows the availability of land that can be used for food production (Table 4.1).

A change in the net sown area in the recent past is considered a sign of Food Production Security. This is because the expansion of net sown area had been arrested in many states by the mid seventies. Since then, there has been a decline in the net sown area of some states as land-use shifted away from agriculture. In some cases, the total area has reduced because of degradation. Hence, a negative change in net sown area is considered a sign of declining food security.

Agricultural production sustainability depends upon levels of the health of natural resources such as land, water and forests. Natural resource health is very difficult to assess for the state as a whole. Data on the ecological functions of natural resources in the ecological sub regions are not available.

4.2.2 Indicators of Food Production Sustenance

5. *Per capita forest cover* represents the sustenance of watersheds.
6. *Unexploited surface water available for future use* represents unutilized potential of surface water available
7. *Unexploited groundwater available for future use* represents unutilized groundwater resources in relation to total groundwater resources
8. *Percentage of area degraded to total geographical area* represents eight varieties of lands that have been degraded; it excludes natural wastelands such as sandy beaches, deserts and mined areas
9. *Percentage of leguminous crops in the gross cropped area* represents the sustainability of soil fertility with the adoption of viable crop pattern

Forests: The per capita forest area measures human pressure on the forests. The forest cover for 2000 has been taken against the projected population for 2001. This indicator has been discussed in detail in the second chapter. Forests are important to agriculture for the ecological services they provide. They play an important role in sustaining watersheds. Per capita forest cover captures the bare minimum requirements of a healthy forested ecosystem. A higher per capita forest cover alone does not mean that the watersheds are protected. A state with a larger forest area is likely to protect the watershed better than a state with less forest cover. Some ecosystems do not have forests. They are considered naturally inferior to those with forested ecosystems. In some cases, a degraded forest on a hill slope is worse than no forest at all on plain land (Table 4.2).

It has not been possible to measure the health of an ecosystem. Despite the limitations of data, a higher per capita forest cover is a positive aspect of natural resource endowment, useful for future agricultural production, and hence has been included as an indicator of sustenance.

Land Degradation: It was not possible to capture the amount of prime agricultural land that exists in a state. This indicator could capture a very small part of the problem of land quality. Land quality differs from region to region within the states. A broad idea of land degradation has been arrived at from the eight varieties of wastelands that have been mostly caused by human negligence, and which can yet be restored

Table 4.2 Indicators and Indices of Production Sustenance

		1		2		3		4		5		6	
S.No	States	Per capita forest cover (Hect./person)	Index	Future availability Surface water (Percentage)	Index	Future availability Ground water (Percentage)	Index	Percentage of Degraded area to Total Geographical area	Index	Percentage of Leguminous crops to Gross Cropped Area	Index	Index of Production Sustenance	**Rank**
			(1998)			(1998-99)		(1997-98)		(1998-99)		(1998-99)	
1	Andhra Pradesh	0.06	0.008	38.36	0.395	73.90	0.739	16.58	0.752	25.89	0.689	0.517	**3**
2	Arunachal Pradesh	6.24	1.000	44.00	0.475	100.00	1.000	11.96	0.836	0.00	0.000	0.662	**1**
3	Assam	0.10	0.015	65.85	0.784	92.54	0.925	20.65	0.678	3.14	0.084	0.497	**5**
4	Bihar	0.03	0.003	50.16	0.562	66.84	0.668	11.39	0.846	8.94	0.238	0.463	**9**
5	Goa	0.16	0.024	63.56	0.751	91.70	0.892	11.90	0.837	0.00	0.000	0.501	**4**
6	Gujarat	0.03	0.003	51.82	0.585	50.73	0.508	19.90	0.692	26.25	0.698	0.497	**6**
7	Haryana	0.01	0.000	30.47	0.284	24.39	0.244	7.13	0.924	6.77	0.180	0.326	**21**
8	Himachal Pradesh	0.24	0.037	47.47	0.524	83.35	0.839	24.29	0.612	3.60	0.096	0.422	**14**
9	Jammu and Kashmir	0.21	0.033	16.57	0.087	98.93	0.989	8.05	0.907	2.92	0.078	0.419	**15**
10	Karnataka	0.07	0.010	27.45	0.241	66.94	0.669	9.41	0.882	25.21	0.670	0.494	**7**
11	Kerala	0.05	0.007	42.89	0.459	81.01	0.810	2.92	1.000	1.37	0.036	0.462	**10**
12	Madhya Pradesh	0.16	0.025	56.24	0.648	81.16	0.812	14.98	0.781	37.60	1.000	0.653	**2**
13	Maharashtra	0.05	0.007	34.74	0.344	65.30	0.653	16.03	0.762	18.15	0.483	0.450	**11**
14	Manipur	0.71	0.112	46.60	0.512	100.00	1.000	58.00	0.000	0.00	0.000	0.325	**22**
15	Meghalaya	0.68	0.107	59.24	0.690	96.03	0.956	44.16	0.251	0.00	0.000	0.401	**17**
16	Mizoram	1.96	0.314	81.14	1.000	0.00	0.000	19.31	0.702	0.00	0.000	0.403	**16**
17	Nagaland	0.67	0.106	20.71	0.146	0.00	0.000	50.69	0.133	0.00	0.000	0.077	**25**
18	Orissa	0.13	0.020	46.89	0.516	84.78	0.848	12.40	0.828	9.56	0.254	0.493	**8**
19	Punjab	0.01	0.000	15.69	0.075	1.66	0.017	3.14	0.996	1.03	0.027	0.223	**24**
20	Rajasthan	0.03	0.003	15.63	0.074	27.16	0.271	17.50	0.735	26.42	0.703	0.357	**20**
21	Sikkim	0.59	0.094	57.43	0.665	0.00	0.000	30.07	0.507	0.00	0.000	0.253	**23**
22	Tamil Nadu	0.03	0.004	10.41	0.000	37.45	0.375	16.03	0.762	26.01	0.692	0.367	**19**
23	Tripura	0.22	0.034	59.80	0.698	66.57	0.663	12.17	0.832	0.00	0.000	0.445	**12**
24	Uttara Pradesh	0.02	0.002	39.69	0.414	58.05	0.581	7.79	0.912	11.21	0.298	0.441	**13**
25	West Bengal	0.01	0.001	20.34	0.140	67.81	0.678	5.23	0.958	2.49	0.066	0.369	**18**

to health. All the same, its inclusion as an indicator of soil health is useful. The higher the percentage of degradation, the lower the chances of the state sustaining agricultural production for long. At least in the case of some northeastern states, this indicator could bring out the gravity of the situation.

Water: It was possible to get a broad estimate of available surface water. However, the efficiency of the use of rainwater and irrigation water for crop production is not known. Moreover, even if there exists unutilized surface water and groundwater, it may not be economical to tap the potential for several reasons, such as depth, availability of other cheaper sources and so on. Hence, the two indicators of availability of surface water potential and availability of groundwater potential capture only a part of the story. All the same, these indicators bring out the levels of over-exploitation in some states very well.

Legumes in the cropping system: Good cropping practices and eco-friendly technologies are useful. Beyond any doubt the inclusion of legumes in the crop pattern is a healthy practice. Now there are many short duration varieties available to fit between the rabi and kharif crops. It is true that leguminous crops, particularly pulses, have been grown on marginal lands and rain fed areas, despite their value in the multiple-cropping system followed in irrigated agriculture. They are valuable to any agriculture, rain-fed or irrigated. Hence, this indicator shows the sustainability of soil fertility. Given the fact that 60 per cent of the cropped area is rain-fed, it is important to recognize that legumes are invaluable for sustainability. The correlation matrix of the indicators shows the level of association and interdependencies (Appendix 4.1).

4.3 Methodology of Indexing

The individual indicators are converted into an index using the following formula similar to the human development index (Human Development Report, UNDP 2002). The number of observations of k^{th} indicator vary from 'i' to 'n', that is, 1–25 states.

$$I_k = (Value_{ik} - Value_{k\,min}) \div (Value_{k\,max} - Value_{k\,min})$$

where the value varies between 'i' to 'n' states (n = 25) for the k^{th} indicator.

The value of 'I_k' varies between one and zero. It means that the maximum value in the series for the indicator 'k' gets the index of one. The minimum value gets the index of zero.

Conceptually, the individual index measures the distance between a given state and the worst possible state for that indicator as a proportion of the distance between the best state and worst state. When the highest value in the series represents good situation and the lowest value represents the worst situation, the above formula applies for indexing. For example, this method applies to an indicator such as food production per capita where the higher the value, the better the situation. In some cases such as percentage of area under wastelands, higher the value the worse off the situation and the lower the value the better. In such cases, a small variation was introduced in the calculation of the formula to maintain the uni-directional approach to the index. The numerator of the formula has been changed to ($Value_{max} - Value_k$).

Two separate sub indices are calculated for Food Production Security and Food Production Sustenance. Indicators vary from 'k' to 'm' in the composite index. 'k' represents the k^{th} indicator chosen and it varies from one to 'm'. 'm' is 3 in the case of Food production Security Index and 'm' is 5 in the Food Production Sustenance Index.

The Index of Food Production Security is given by

$$I_{FPSE} = (\Sigma I_k) \div 3$$

where k is the indicator and it varies from 1 to 3. In other words, it is nothing but a summation and averaging of three indices of the chosen indicators into a composite sub index of Food Production Security.

Similarly, the Index of Food Production Sustenance is given by

$$I_{FPSU} = (\Sigma I_k) \div 5$$

where 'k' is the indicator and it varies between 1 and 5. The sub index of Food Production Sustenance is a simple average of five individual indices of the chosen indicators.

4.4 Composite Map of Sustainability of Food Production

The Composite Map of Sustainability of Food Availability is based on an index calculated for this purpose. This is a composite index of two components described earlier, the sub index of Food Production Security and the sub index of Food Production Sustenance. Finally, the weighted average of the two sub indices, have been combined with weights of 0.25 and 0.75 respectively to get the Composite Sustainability of Food Production (production is used as a proxy for availability).

The Index of Food Production Security is obtained as a simple average of the three indices of weighted net area sown, percentage change in NSA and per capita food grain production. The index shows that, in terms of production, Punjab is in the best position followed by Uttar Pradesh, Madhya Pradesh, Mizoram and Rajasthan and the worst states are Kerala, Manipur, Jammu and Kashmir, Sikkim and Himachal Pradesh (Table 4.1).

The Index of Food Production Sustenance has 5 indicators. The 5 indicators related to natural resources, namely, percentage of wasteland to total geographical area, per capita forest cover, the unutilized surface water, groundwater potential available for future use and the percentage of area under leguminous crops are converted into indices. Then an average of these five indices is obtained to get the Index of Food Production Sustenance. The index shows that Arunachal Pradesh, Madhya Pradesh, Andhra Pradesh and Goa as the top four states with a high level of production sustenance. The states with the lowest rank for production sustenance are Nagaland, Punjab, Sikkim, Manipur and Haryana. The others occupy the middle positions. It is interesting to note that Punjab, which occupies the highest position in the Security Index, gets a lower position in the Sustenance Index. Madhya Pradesh gets a high rank on both counts and hence is on the top in the final composite index.

Composite Sustainability of Food Availability Index is a weighted average of the two composite indices, that is, Food Production Security Index and Food Production Sustenance Index have been combined with weights of 0.25 and 0.75 respectively. The positions of the states are clear from the Sustainability of Food Availability Map (Table 4.3 and Map 4.1).

4.4.1 The Position of the States

States shown in shades of green: Madhya Pradesh and Arunachal Pradesh come out on top as the most sustainable states with respect to food availability. The most sustainable position of 0.594 goes to Madhya Pradesh followed by Arunachal Pradesh, which has an index value of 0.545. The position of the state in one of the five categories of sustainability is determined by the actual index and just not by the rank. Thus, Madhya Pradesh and Arunachal Pradesh are far ahead of many other states.

Table 4.3

Composite Index of Sustainable Food Availability

S.No	States	1 Index of Production Security (0.25)	2 Index of Production Sustenance (0.75)	3 Composite Index of Sustainable Food Availability (FPI*.25+FSI*.75)	**Rank**
1	Andhra Pradesh	0.236	0.517	0.446	**3**
2	Arunachal Pradesh	0.192	0.662	0.545	**2**
3	Assam	0.094	0.497	0.397	**10**
4	Bihar	0.175	0.463	0.391	**12**
5	Goa	0.090	0.501	0.398	**9**
6	Gujarat	0.200	0.497	0.423	**5**
7	Haryana	0.306	0.326	0.321	**19**
8	Himachal Pradesh	0.082	0.422	0.337	**16**
9	Jammu and Kashmir	0.072	0.419	0.332	**17**
10	Karnataka	0.199	0.494	0.421	**6**
11	Kerala	0.049	0.462	0.359	**13**
12	Madhya Pradesh	0.415	0.653	0.594	**1**
13	Maharashtra	0.260	0.450	0.402	**8**
14	Manipur	0.070	0.325	0.261	**23**
15	Meghalaya	0.087	0.401	0.322	**18**
16	Mizoram	0.375	0.403	0.396	**11**
17	Nagaland	0.224	0.077	0.114	**25**
18	Orissa	0.135	0.493	0.404	**7**
19	Punjab	0.449	0.223	0.279	**22**
20	Rajasthan	0.335	0.357	0.352	**15**
21	Sikkim	0.079	0.253	0.210	**24**
22	Tamil Nadu	0.148	0.367	0.312	**21**
23	Tripura	0.095	0.445	0.358	**14**
24	Uttar Pradesh	0.447	0.441	0.443	**4**
25	West Bengal	0.151	0.369	0.314	**20**

Madhya Pradesh has a fairly large net sown area, which has been increasing slowly over the past decade. Food grain production per capita is fairly high at 26.62 kg per month. Hence, Madhya Pradesh has achieved minimum food production security and a high level of security in staple food availability. Madhya Pradesh comes out sustainable since it has more unutilised water sources, large forest areas and more sustainable crop patterns that include leguminous crops.

Arunachal Pradesh has a fairly small net sown area as the state is small but the area has been increasing fast in the past decade. The state produces just about enough staple food for itself. Hence, the present level of food production security is reasonably good. More of forest and fewer people dependant on natural resources make food production sustainable.

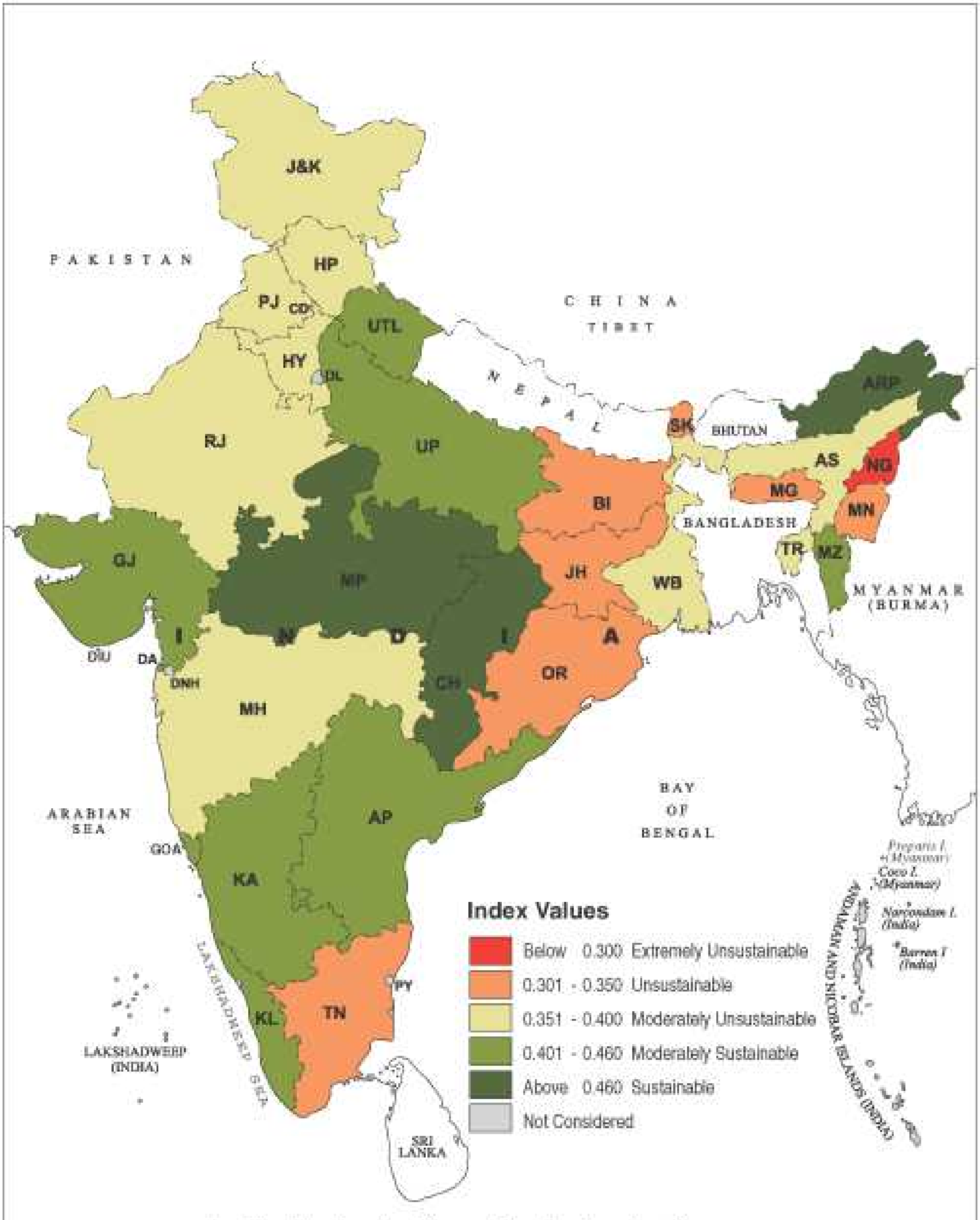
States shown in shades of light green: The states Kerala, Bihar, Mizoram, Assam, Goa, Maharashtra, Orissa, Karnataka, Gujarat, Uttar Pradesh and Andhra Pradesh are moderately sustainable. These eleven states are good in terms of both security and sustainability of food production. The natural resources of these states are good.

States shown in shades of yellow: The states in yellow are moderately unsustainable. Four states, Jammu and Kashmir, Himachal Pradesh, Rajasthan and Tripura fall in this category. The food production scenario is not so good in the states of Jammu and Kashmir and Himachal Pradesh. Rajasthan and Tripura are in a better position with respect to production of food. With regard to sustainability, all the four states are in a good position.

States shown in shades of orange: The category of unsustainable states has an index value lying between 0.201 and 0.323. The states that fall in this category are Sikkim, Manipur, Punjab, Tamil Nadu, West Bengal, Haryana and Meghalaya. Some of these states perform badly in terms of either production or sustainability. Hence, these states fall in the category of unsustainable food production.

States shown in shades of red: The value of the index varies from 0.114 to 0.201. The most unsustainable position goes to Nagaland, which has an index value of 0.114. The reason for Nagaland being in the worst position is that it has a very low net sown area and there have been no changes over the past decade. Food grain production per capita is also low at 11.54 kg per month. The state has very poor future availability of groundwater and has a very small area under leguminous crops. Surface water has been over-exploited. Though the per capita forest cover is relatively high, it is insufficient to protect the hill slopes. These reasons make Nagaland the least sustainable in terms of food production.

SUSTAINABILITY OF FOOD SECURITY



PART II

SUSTAINABILITY OF FOOD ACCESS

CHAPTER 5

Sustainable Livelihoods and Food Access

Sustainability of Food Access is the ability to have access to food at all times for all people in the country. Primarily, Food Access is a function of purchasing power. Purchasing power depends mainly on income earned. This chapter focuses attention on livelihoods and their sustainability. There is a vast literature on Sustainable Livelihoods (SL). A number of authors have written extensively on this topic. Sustainable food access may be defined as a situation where every one has access to sufficient food to sustain a healthy and productive life and where the food originates from efficient effective and low cost food systems that are compatible with sustainable use of natural resources (IFPRI 2002). Sustainable livelihoods consist of capabilities and assets. Assets could be material, human and social, all of which are required as a means of living.

In recent years, the development strategies suggested by economists (Stiglitz 2002, Sen 2002) [illegible] individuals have been given equal importance as stakeholders along with the private and the public sector. The strategy of poverty alleviation and economic development consists of developing each of these stakeholders and building formal and informal institutions that promote growth. These formal and informal institutions are the social capital. According to these theories, transformation of society rather than the rate of economic growth of the economy is the key to poverty alleviation. Instead of physical capital alone determining the rate of growth of the economy, as in the neo-classical growth models, sustainable development embedded in natural capital and social capital is deemed to determine growth. Five types of capital: physical, natural, human, social and financial (the asset pentagon) form the core requirements to achieve sustainable livelihoods (DFID 2001).

Sustainable livelihoods of the poor are a part of sustainable development. Here, the broader concern is about agriculture and rural development as a whole. Agriculture has to be sustainable to be able to provide for the food, fodder and fibre needs of people. It is not possible to sustain agriculture without protecting the health of natural resources. A growing agriculture that meets the needs of the people also provides land-based and natural resource based–livelihoods in a sustainable manner.

5.1 Development and Natural Resource Degradation

There are many reasons for the over exploitation of natural resources. It could be commercial exploitation and degradation, even though the minimum needs of the population are more than met and natural resources are abundant compared to the local population (commercial greed *versus* economic need). As the connection between decreasing natural resources and environmental degradation become clear, efforts are being made to use natural resources in a sustainable manner; and, in an effort to preserve their own environment, states buy their requirements from other places. This

Sen, Amartya K. and Jean Dreze, 2002. “India Development and Participation”, Oxford University Press: New Delhi.

is a situation typical of developing countries. Such behaviour gave raise to the hypothesis of Environmental Kuznet's Curve. The hypothesis says that in the initial stages of development, natural resources degradation will be high, but as development progresses the environment improves and natural resource degradation declines (Sengupta 2001).

The corollary of the hypothesis is that less developed regions and countries have higher levels of natural resource exploitation. In the initial stages of development, the country depends more on the primary sector and less on the secondary sector. The typical Kuznet's Curve has an inverted 'U' shape when we represent depletion of natural resources on the y-axis and the level of development on the x-axis. However, just as in the case of Kuznet's theory of income distribution, which says that in the initial stages of development inequalities are high, but they decline as development proceeds, Kuznet's Curve may not hold for all developing countries. The pattern of development of over-populated countries such as India and China is different.

In the initial stages of development, natural resources are depleted for commercial purposes, though the benefits reach only a few. Later, as the population increases, the scarcity of natural resources increases, and more and more poor people expect free natural resources to take care of their increasing needs. On the one hand, commercial exploitation continues unabated and, on the other, the poor continue to scramble for the meagre resources left over. Thus, the pressure on natural resources increases, both from exploitation by commercial interests and the sustenance and livelihood needs of the poor.

5.2 Security and Sustainability of Food Access

This section examines the present level of livelihood security enjoyed by people across the states of India. The population pressure exerted on natural resources determines the future sustenance of livelihoods. The focus is on rural people and their livelihoods. For the sake of simplicity, the entire population above the poverty line, both in urban and rural India, is assumed as having sufficient purchasing power to buy enough food. Hence, sustainable livelihoods are more the problem of the poor who suffer from natural resource depletion. Urban poverty is a spill over of rural poverty, and if the rural poor were to get access to adequate livelihoods, there would not be any distress migration to the urban slums. Hence, rural poverty is the basic problem. Another related assumption is that if the population pressure increases, natural resources such as land, forests, water resources and village common property resources would be depleted. Accordingly, the per capita endowments of natural resources are considered as a measure of population pressure creating a potential problem of natural resource degradation.

The future earning capacities and bounty of natural resources are meaningless when people do not have economic access to sufficient and nutritious food. The present state of food access is apparent from two indicators of livelihoods.

1. *Percentage of people below the poverty line in rural and urban areas*

2. *The percentage of non-agricultural workers to total workers*

The capacity of the economy to create non-agricultural employment is particularly important, as the labour absorption capacity of agriculture has been declining (Ahluwalia Committee 2000). It brings about structural transformation from rural low paid jobs to highly paid non-agricultural work (Table 5.1).

1. **Percentage of population below the poverty line:** The planning commission based its poverty calculations on the National Sample Survey (NSS) data for 1999-2000. The data shows that Jammu and Kashmir has the lowest poverty rate at just 3.48 per cent; one of the reasons being the availability of land to all rural people, who constitute a majority of the population. Another reason could be the government transfers to the poor, which take place in a number of ways including the public distribution system. The states of Goa and Punjab also experience very low levels of poverty at 4.4 per cent in Goa and 6.16 per cent in Punjab. Himachal Pradesh and Haryana are also close to the better off states, showing less than 10 per cent as poor. Six other states show a poverty ratio between 10 and 20 per cent: Kerala, Rajasthan, Gujarat, Andhra Pradesh, Mizoram and Karnataka. The states with high levels of poverty are Orissa, Bihar and Madhya Pradesh in that order (Map 5.1).

2. **The percentage of non-agricultural workers to total workers:** A high percentage of non-agricultural workers is a sign of prosperity, as non-agricultural work is normally more paying than agricultural work. Goa and Kerala have a large percentage of non-agricultural workers, at 72 per cent and 71 per cent respectively. All the other states rank far below these states. The state that ranks third is Punjab and it has about 47 per cent of the total work force in non-agricultural occupations. West Bengal, Assam and Tripura also seem to have diversified occupations, with more than 40 per cent of the workers engaged in non-agricultural work, and have done particularly well in the recent decade. The states of Karnataka, Haryana, Manipur, Tamil Nadu and Gujarat show about 30 per cent of workers in non-agricultural occupations. These states have not been able to improve their position substantially. The big states that remain poor and not able to diversify employment are Madhya Pradesh, Bihar, Mizoram, Maharashtra and Uttar Pradesh. These states need to make special efforts to create non-agricultural work (Map 5.2).

Five key indicators that describe the pressure of population on natural resources and rural livelihoods have been considered to study the sustainability of rural livelihoods. The poorer sections of the population depend excessively on the free goods of nature from community resources and the government lands. Their access to self-owned land is limited. The more the number of people who do not own land but depend upon common land for livelihoods, the more the pressure exerted on natural resources. The following list indicators adequately describe the sustainability of food access to the rural poor.

3. *Average size of the holding*
4. *Livestock per hectare of total geographical area*
5. *Instability in cereal production*
6. *Percentage of landless labour households*
7. *Dense forest area per lakh population*
8. *Rural workers in non-crop agricultural enterprises*

The sustainable food access situation is closely related to natural resources and the above six indicators together describe the population pressure and vulnerability of natural endowments. We shall now elaborate their importance and look at the sustainability of food access in various states (Table 5.1).

Table 5.1

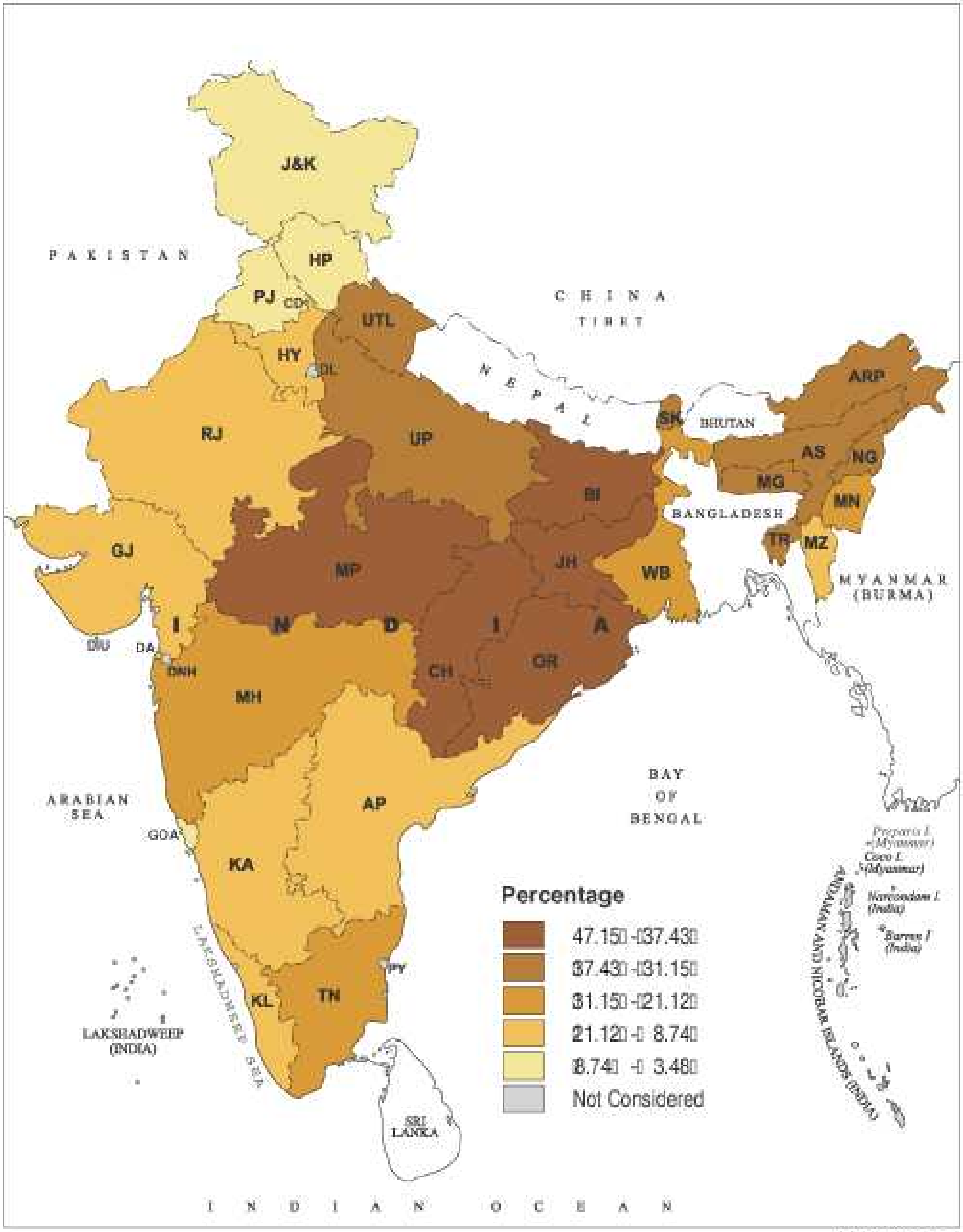
Sustainability of Food Access

S.No	State	1 Percentage of Population Below Poverty Line (Rural + Urban) (1999-2000)	2 Percentage of Non-agricultural workers to total workers (2001)	3 Average Size of the Holdings 1990-91	4 Livestock per hectare of TGA 1992	5 Landless housholds* to total rural households 1991	6 Instability in cereal production from 1990-91 to 1999-2000	7 Dense forest per lakh population (Sq.Km) 2001	8 Percentage of Workers in Non crop Ag. Enpr. To Total Workers (2001)
1	Andhra Pradesh	15.77	24.84	1.56	1.20	19.80	14.17	30.44	4.68
2	Arunachal Pradesh	33.47	27.47	3.71	0.10	2.40	12.13	4963.26	0.20
3	Assam	36.09	40.96	1.27	2.05	8.00	5.57	58.37	0.80
4	Bihar	42.60	17.56	0.83	2.76	19.00	14.25	12.11	0.40
5	Goa	4.40	72.06	0.93	0.66	10.10	6.60	74.03	3.36
6	Gujarat	14.07	28.13	2.93	0.95	17.90	30.27	12.52	9.96
7	Haryana	8.74	34.98	2.43	2.07	7.80	7.51	1.75	0.61
8	Himachal Pradesh	7.63	26.28	1.21	0.92	0.90	9.42	157.31	0.97
9	Jammu & Kashmir	3.48	37.56	0.83	0.39	1.00	8.67	109.43	0.19
10	Karnataka	20.04	26.47	2.13	1.54	14.70	12.38	47.13	5.13
11	Kerala	12.27	71.34	0.33	1.50	3.60	16.32	26.55	5.63
12	Madhya Pradesh	37.43	14.50	2.63	1.06	12.70	11.29	198.94	1.99
13	Maharashtra	25.02	20.28	2.21	1.18	20.20	28.79	24.41	3.97
14	Manipur	28.54	34.75	1.23	0.58	1.60	22.80	206.69	1.57
15	Meghalaya	33.87	25.37	1.77	0.53	11.40	8.33	175.36	0.60
16	Mizoram	19.47	18.29	1.38	0.10	0.00	11.96	487.96	0.79
17	Nagaland	32.67	22.60	6.82	0.65	0.20	10.02	175.35	0.18
18	Orissa	47.15	27.66	1.34	1.46	12.00	21.82	71.11	2.55
19	Punjab	6.16	46.49	3.61	2.03	20.10	5.39	2.10	0.42
20	Rajasthan	15.28	22.70	4.11	1.42	4.90	33.22	6.53	2.29
21	Sikkim	36.55	37.95	2.09	0.54	1.70	7.85	448.29	0.32
22	Tamil Nadu	21.12	30.05	0.93	1.92	26.60	15.90	13.97	3.33
23	Tripura	34.44	40.62	0.97	1.52	8.90	10.98	57.00	0.51
24	Uttar Pradesh	31.15	22.29	0.90	2.20	7.60	4.52	13.15	0.62
25	West Bengal	27.02	41.60	0.90	3.96	13.90	6.51	4.43	2.12

Source: Col.1, Sample survey data on Consumer expenditure, GOI,"Press Information Bureau" - (55th Round)-1999-2000, Col.2, Census of India - 2001

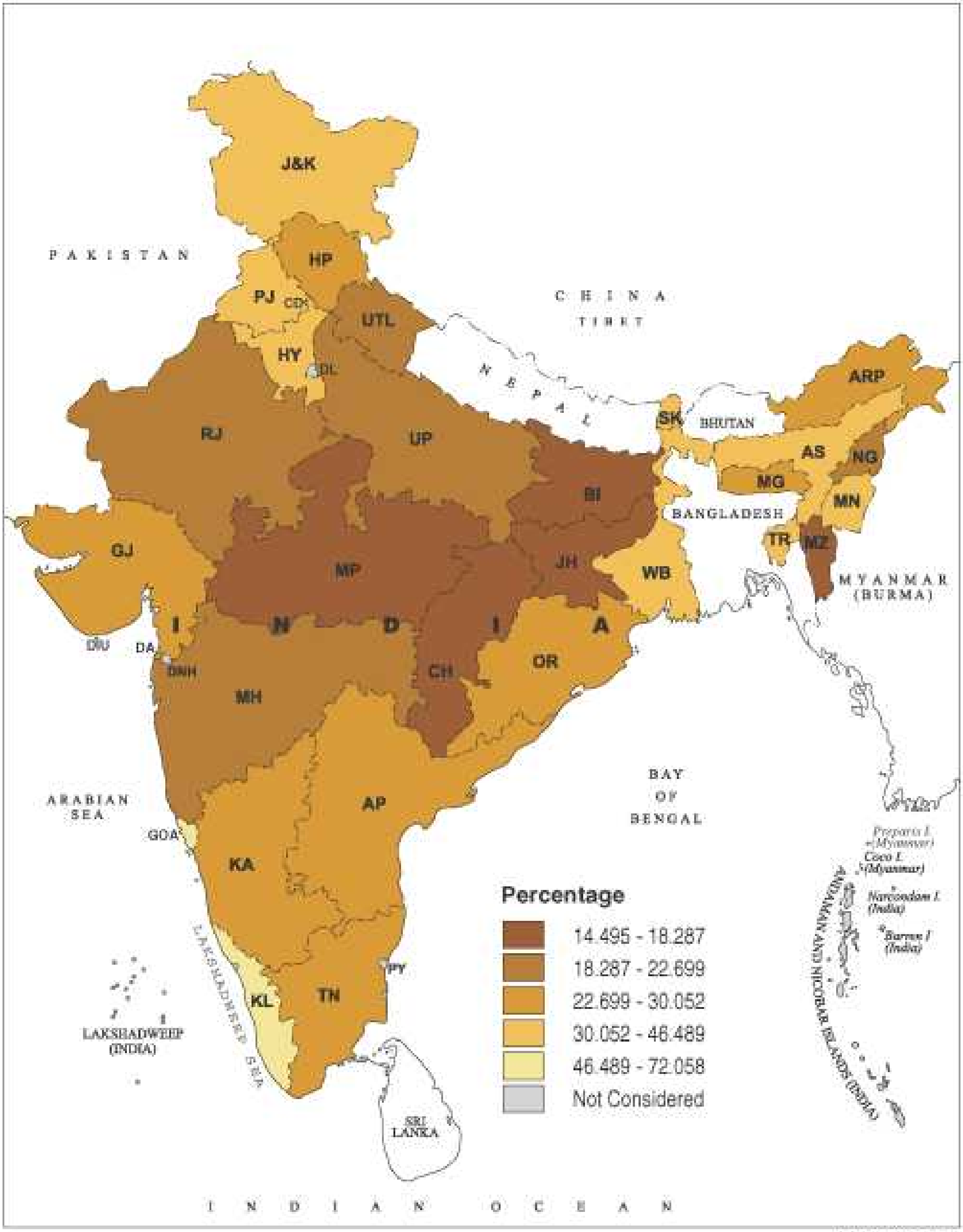
Col.3, Agricultural Census Division,Ministry of Agriculture, GOI," Agricultural Statistics at a Glance"-2000 pg-131 , Col.4, GOI-Ministry of Agriculture "Indian Agricultural in Brief" 27th Edition (Jan.2000) Pg-117, Forestry Statistics of India-2000, Col.5, NSS 48th Round Report No. 419 "Debt and Investment Survey" Household Assets and Liabilities as on 30.6.1991- Feb 1998., Col.6, GOI-Ministry of Finance Economic Division " Economic Survey" 2000-21 (Various issue), Col.7, Indian Council of Forestry Research & Education "Forstry Statistics India" - 2000, Col.8, GOI-Ministry of Statistics and Programme Implementation "Economic Census"-1998, Census of India "Provisional Population Total", Distribution of Workers and Non-WorkersPaper-3 of 2001, The percentage is worked out by taking the number of workers given in the Economic census as a percentage of 2001 worker population. *: Households Operating lessthan 0.002 Hectares

POPULATION BELOW POVERTY LINE



Map No. 5.1

NON-AGRICULTURAL WORKERS TO TOTAL WORKERS



Map No. 5.2

As per the 2001 census, we have about 72 per cent of the population living in the rural areas. Those who depend directly on land exert more pressure on it, as their increased use depletes the fertility of the soil and available water resources which, being used more intensively, may not sustain food production in perpetuity.

3. **The average size of the holding:** The more the number of people who depend on land, the lower the sustainability of food access for several reasons. The size of the holding typically represents the population pressure on cropland resources. It is also a fact that irrigated lands show smaller size of holdings than unirrigated lands. In canal-irrigated areas, smallholdings with higher cropping intensity and higher irrigation intensity are quite common. The excessive use of chemical fertilizers and groundwater resources are leading to higher levels of depletion of natural resources. No doubt the livelihood situation of the people is better in these areas. However, for sustainability, higher depletion of natural resources should be avoided. In any case, as the population increases, if the present occupational distribution continues, the small size of the holding cannot provide livelihoods, without further depletion of the land fertility. Hence, we have considered it as a key indicator of sustainable livelihoods. Larger the size of the holding and fewer the people dependant on this land, higher the sustainability of food access as well as livelihood access.

The size of the holding is the smallest in Kerala at one third of a hectare. It is less than a hectare in many states such as Bihar, Jammu and Kashmir, Uttar Pradesh, West Bengal, Tripura, Goa and Tamil Nadu. In eight of the 25 states it is less than a hectare. In seven states the land holding size is more than one hectare and less than two hectares. The average size for the country itself is 1.55 hectares. Other states such as Karnataka, Madhya Pradesh, Maharashtra, Gujarat and Haryana have a holding size of more than two but less than three hectares. Very few states have large average size of land holding. The size of the land holding is the largest in the case of Nagaland at 6.82 hectares per capita followed by Rajasthan at 4.11 hectares per capita, 3.71 in Arunachal Pradesh and 3.61 hectares per capita in Punjab (Table 5.1 and Map 5.3).

4. **Livestock population per hectare:** Next to human population, India has the highest cattle population. Though India produces the largest quantity of milk in the world, the productivity of the cattle is very low. Cattle are also extensively used for ploughing and for transportation of goods. Other livestock such as goats, sheep, etc. also give livelihood opportunities to the rural people. The livestock population, like human population, puts pressure on land for feed, fodder and grazing.

In India, the pressure on land from livestock is more from the requirements of free grazing lands in respect of low yielding cattle and draught animals rather than larger areas for fodder production. Mostly, high yielding milch animals are fed crop residue and oilcakes. Over-grazing on common lands and particularly in forest areas results in depletion of vegetative cover and soil erosion and desertification. As the demand for milk increases, there will be more pressure on land for more grain and fodder crops to feed high yielding animals. In addition, the buffalo needs more feed than the cow. The buffalo is a preferred milch animal in India, though the world over, cows are preferred as they are cost effective, and the beef is also used. In India, however, the demand is only for milk and not so much for meat, and so the buffalo is preferred. The pressure of livestock becomes critical in times of drought, since animals also put pressure on the water resources of the state. Though beyond doubt, it is advisable to have more diversification of rural livelihoods to non-crop based activities; to sustain the livestock, its population should be kept low; productivity should be increased rather than increasing the total livestock population. The best indicator to measure the pressure of livestock on land is the number of livestock per hectare of total geographical area of the state. There is greater equity in livestock ownership compared to arable land. Livestock and livelihoods are intimately intertwined among the poor. (Table 5.2)

The pressure of livestock on land appears to be the highest in the case of West Bengal, with about four animals per hectare. States such as Bihar, Assam, Haryana, Punjab and Uttar Pradesh have about two to three animals per hectare of geographical area of the state. Most of the other states have less than two animals per hectare. Almost all the northeastern states have very few animals and much less pressure (Table 5.1 and Map 5. 4).

5**. Instability in Cereal Production:** The food and livelihood access of the rural people depends upon the land productivity and stability in production. We have observed in our previous study of rural food insecurity that one of the causes of inadequate access to food is conditions of drought. Water shortage can occur even in the areas of sufficient rainfall such as Orissa. Natural resource degradation could increase the severity of disasters such as floods, droughts and cyclones. The fluctuations in monsoon lead to larger fluctuations in the production of crops. Fluctuation in food production results in shortages in food production and increase in food prices. There will also be a loss of livelihoods for those dependant upon crop production and livestock production during the affected periods. In addition to the deviations in rainfall, droughts, floods and cyclones also lead to loss of crop and food shortages. Thus, food access gets affected, wherever year-to-year fluctuations occur. Instability in cereal production has been taken as an important indicator of sustainability of food access, because unstable cereal production leads to frequent loss of livelihoods during periods of crop failure, particularly to landless labour. Recurring problems make poor farmers lose their productive assets, as they are unable to invest in soil and water conservation measures; livelihood access may therefore become unsustainable.

Instability in food production can be measured in several ways. Normally, the time series are detrended and then measures of deviations around the trend

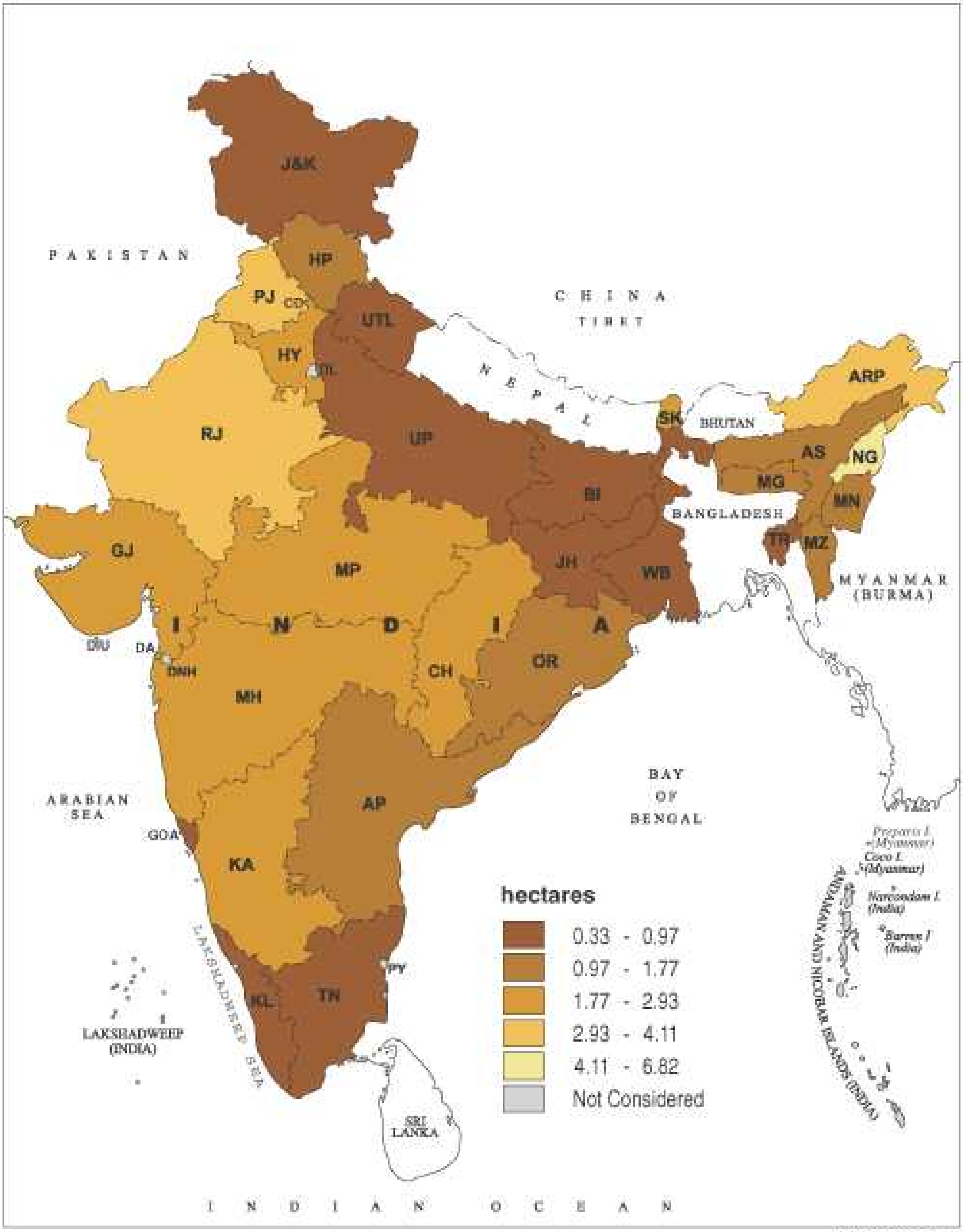
Table 5.2

Distribution of Livestock according to the size of holdings, 1991-92 (Pect.)

Size of Holdings	No. of Holdings	Area per holding (ha)	Area operated	Livestock per holding		Bovine	Ovine
Marginal	62110	0.40	14.87	1.74	0.80	34.88	41.61
Small	19970	1.44	17.34	3.66	1.38	23.62	22.93
Semi-medium	13910	2.76	23.16	4.71	1.54	21.21	17.80
Medium	7630	5.90	27.20	6.36	1.95	15.70	12.40
Large	1670	17.30	17.45	8.48	3.79	4.58	5.27
All size classes	105290	1.57	100.00	2.94	1.14	100.00	100.00

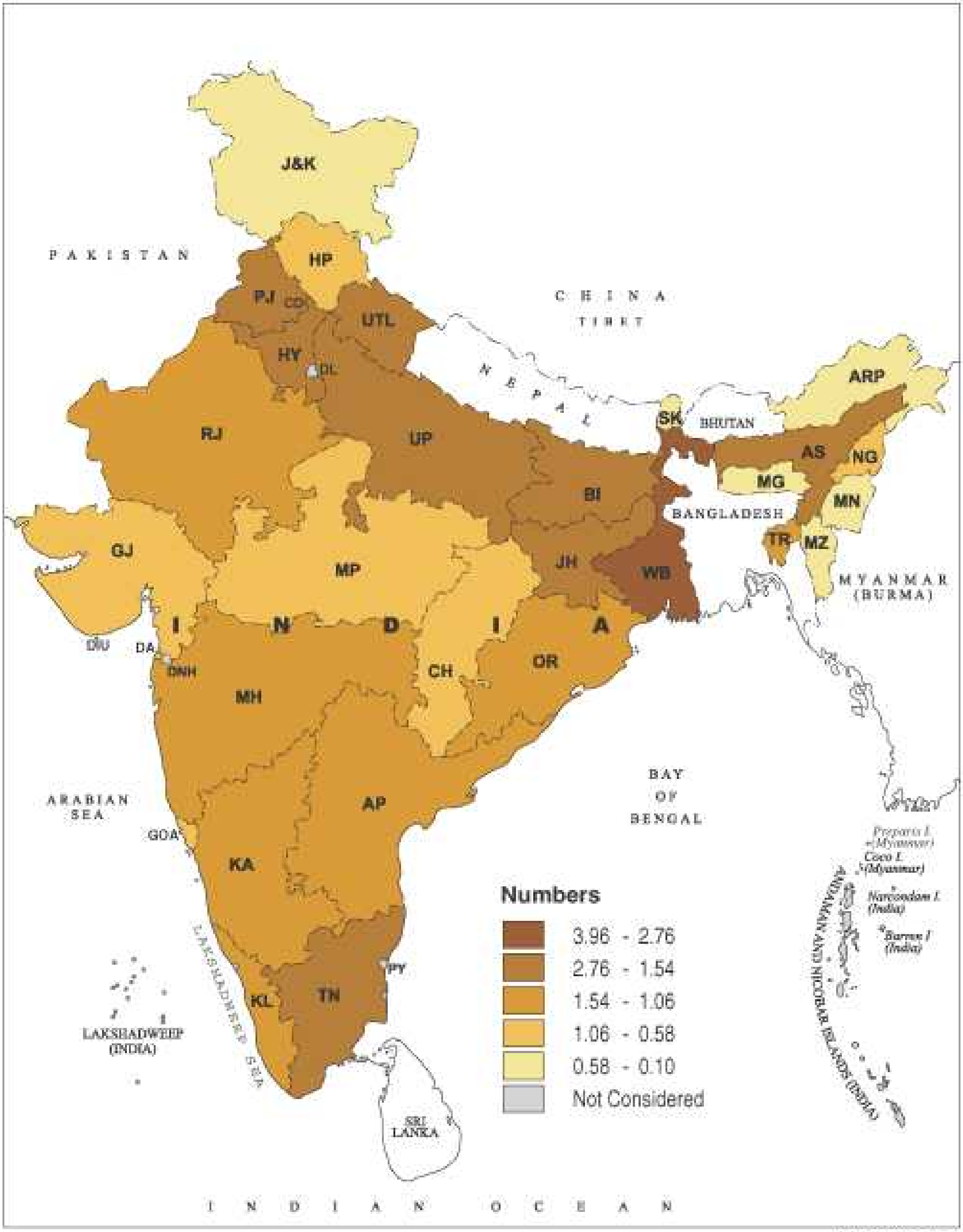
Source: Directorate of Economics and Statistics, 1997

AVERAGE SIZE OF THE LAND HOLDINGS



Map No. 5.3

LIVESTOCK POPULATION PER HECTARE



Map No. 5.4

are taken to measure the instability (Hazel 1994). The methodology used here is the standard deviation of the year-to-year growth rates for a period of ten years from 1990–1991 to 1999-2000. Such a measure will clearly show the fluctuations around the trend. For example, if the production is steady at about 2 per cent, then there will not be any fluctuations. If the growth rate changes drastically over and above this level or far below the levels, or becomes negative, then the fluctuations are recorded.

The data show that instability in the production of cereals is the highest in the state of Rajasthan at 33.2 per cent followed by Gujarat at about 30.2 per cent. Instability in cereal production was also high in the states of Maharashtra at about 28 per cent. Despite high rainfall, the instability in Orissa is high at about 22 per cent. Other states with moderate instability are Kerala, Tamil Nadu, Andhra Pradesh and Bihar: between 14 to 16 per cent. States with low production instability are Punjab, Uttar Pradesh, West Bengal, Haryana and Himachal Pradesh, where the cereal production is under assured canal irrigation (Table 5.1 and Map 5.5).

It may be noted that in many states where the instability is high to moderate, the calorie consumption of the lowest 10 per cent of the population is less than 1890 kilocalories per consumer unit per day, according to the 55^{th} Round NSS data. These are the states of Tamil Nadu, Kerala, Maharashtra and Gujarat. Some of them are also deficit states in food grain production. Thus, unstable production of staple food appears to be the main problem of the low-income groups rather than the overall production of the state. Year-to-year fluctuations are even more important, since transitory food insecurity and water insecurity of the rural poor is closely related to the phenomenon of drought that may occur even with a good rainfall in the non-monsoon season. Hence, we have examined land degradation and its relationship to unstable food grain production (MSSRF 2001).

6. **Landless households to total rural households:** The size of the land itself does not show how sustainable livelihoods are, because productivity per hectare differs. However, it is one of the indicators of sustainability of access to livelihoods. This becomes a more meaningful indicator of population pressure on land when we also take the landless households to total households as an indicator.

In general, the larger the land holding size and the fewer the landless depending on land, the better the sustainability, as it is likely to prevent over-exploitation by a dependant population. It has been found that livestock enterprises provide better livelihood access to the landless population at present,[1] but this will prove to be a limiting factor, given the scarcity of resources such as water and fodder for animals, food and water for self consumption and surplus crop-generation for sale.

In some of these states, where there had been a more equitable distribution of land, very few people are landless and so the size of the landholding is small. This is the case of Kerala and Jammu and Kashmir and even Uttar Pradesh. However, in other states, for instance, Tamil Nadu, in addition to the small size of the existing land holdings, a number of other factors, including the migration of labour into more prosperous areas from drought-prone areas, results in more landless

[1] See Appendix I on correlation Matrix that shows a very close relationship between the percentage of the landless and the per hectare number of livestock.

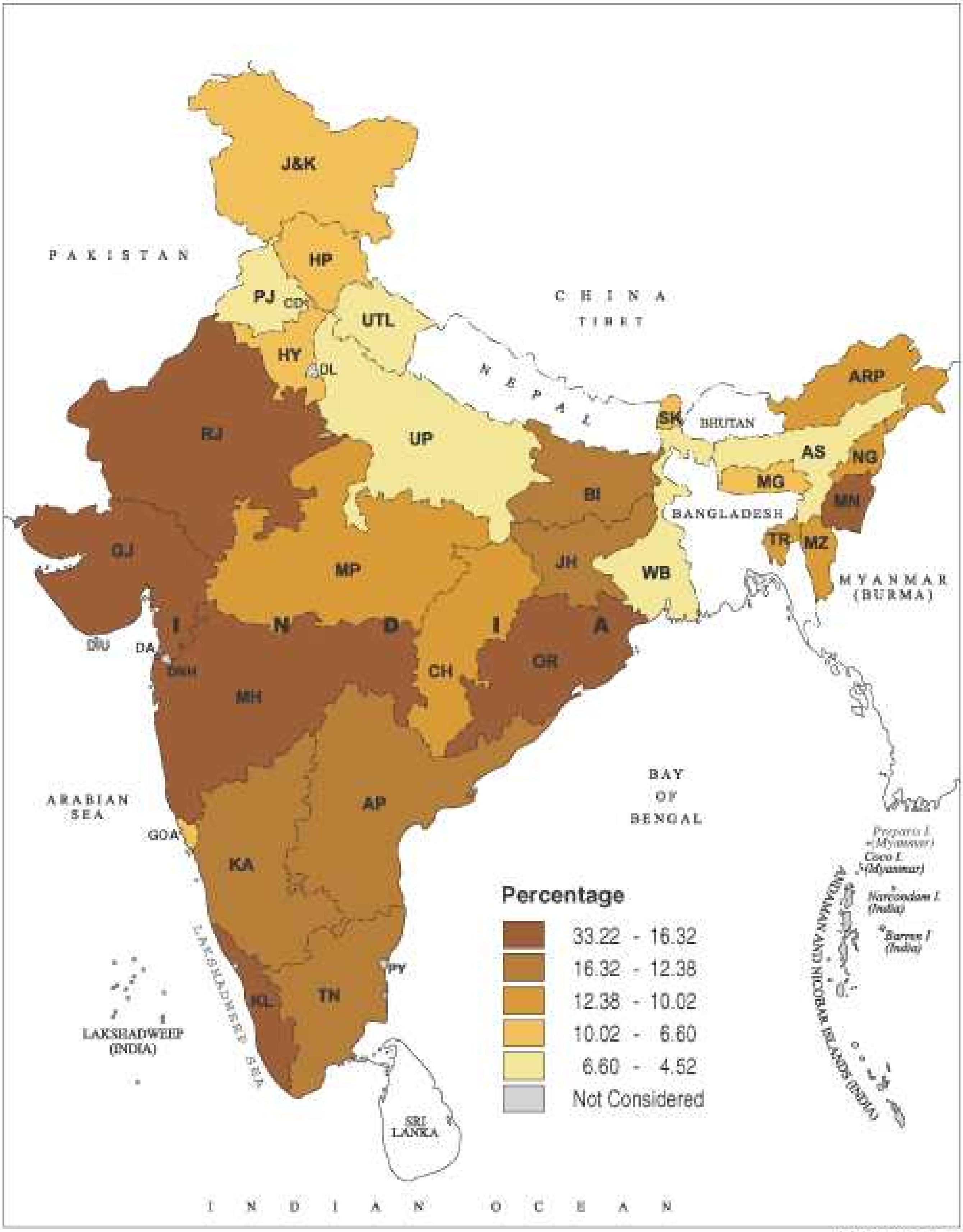
agricultural labour depending upon croplands. In these areas of high population pressure and small land size but low poverty, there is also a possibility of higher cropping and irrigation intensity leading to diversification within agriculture, and larger numbers of livestock in relation to the extent of geographical area.

Sustainable livelihoods for the landless depend upon the health of natural resources and "the percentage of landless households to the total rural households". However, we need to keep these two separate, as it is the landless who suffer first when the land gets degraded, productivity is reduced and labour absorption declines. Thus, the higher the number of landless households, the lesser is the sustainability of food access. This holds good both in the agriculturally prosperous as well as backward regions. The higher pressure of landless labour in agriculturally prosperous areas, more intensive use of land for crop and livestock production and the possibility of providing higher incomes to landless labour from the very same land resources invariably puts more pressure on land. If productivity does not go up, the increasing population cannot be absorbed on land, leading to migration to urban and other areas and making livelihoods unsustainable. Hence, at any point of time, the lesser the number of landless labour, more sustainable the livelihood access in future, both for the existing population and the growing millions of the future.

The percentage of landless labour households has been taken from the NSS 48th Round survey. In this survey, the landless have been defined as those having less than 0.002 hectares of land. They might own a house and the land with it, but the land owned is not enough to support any viable cultivation. We find the largest such numbers in Tamil Nadu at about 27 per cent followed by 20 per cent in Maharashtra and 20 per cent in Punjab. States such as Andhra Pradesh, Bihar and Gujarat also have a fairly high percentage of landless labour, such households constituting 17 to 20 per cent of the total rural households. West Bengal, Karnataka, Madhya Pradesh and Orissa have 12 to 14 per cent rural households in the category of landless labour. The states with very few landless are Nagaland, Himachal Pradesh and Jammu and Kashmir with less than one per cent. Mizoram has no landless labour. In states such as Kerala and Rajasthan the landless labour constitutes less than 5 per cent of the total rural households. In Assam, Haryana, Uttar Pradesh and some northeastern states the landless are less than 10 per cent (Map 5.6).

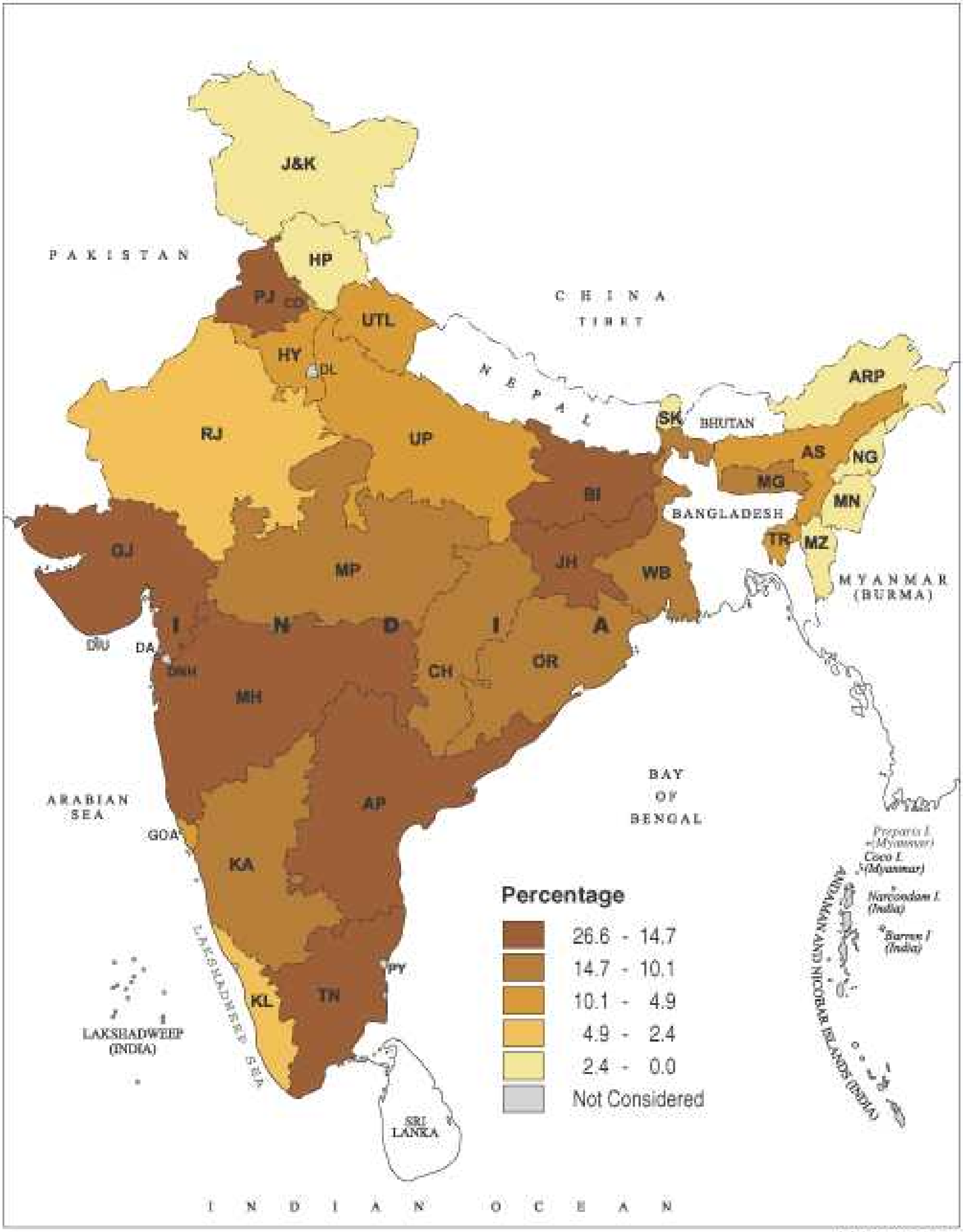
7. **Dense Forest Area Per Lakh Population:** Forest areas are useful for water conservation and watershed management for sustainable agriculture; they also sustain livelihoods. For the country as a whole, about 30 per cent of the villages include forest areas. Other forest areas do not belong to the villages, but the people in the village have access to the forests. About 11 per cent of the rural population belongs to scheduled tribes and many of them live in the forest areas. In times of water shortage, the tribal population depend upon the streams in remote areas of the forests. A large percentage of rural households, directly or indirectly, depend upon forests for their daily needs of fuel wood, building material such as bamboo, non-timber forest produce for sale and for food. In lean crop seasons, tribal population depend upon forest foods. Degradation of forests occurs mostly due to excess felling for commercial purposes or clearing for agriculture, mining or other industrial uses.

INSTABILITY IN CEREAL PRODUCTION



Map No. 5.5

LANDLESS LABOUR HOUSEHOLDS



Map No. 5.6

The percentage of population having access to forests varies across states. In Himachal Pradesh and the northeastern states of Arunachal Pradesh, Mizoram, Meghalaya, Sikkim, Nagaland and Tripura 65 to 100 per cent of the rural population has access to forests. In Assam and Manipur 42 per cent of the rural population has access to forests. In Karnataka, Madhya Pradesh and Jammu and Kashmir about 55 per cent of the people seem to have access to forests. In Punjab only 5.7 per cent of households has access to forests. In Kerala, about 19 per cent of the rural population has access to forests (Table 5.3)

Not only forests, even the other common village lands and water resources are the mainstay of rural livelihoods. The richness of vegetation and water resources in turn depends upon the health of the forest and its ability to meet the needs of the rural people. In recent years, the availability of common lands has been declining. Common village lands available per household is less than 0.2 hectares for about 56 per cent of the rural households. The households with access to more than one hectare of common village lands are only 11.4 per cent of the total rural households. This clearly shows the pressure of population on land. The livelihood access of the poor in villages is sustainable only when natural resources such as dense forest areas are adequate. Degraded forests are of less use than the dense forests. Hence we have considered **dense forest area per one lakh population** as the sustainability indicator.

Dense forest cover per lakh population is highest in Arunachal Pradesh at about 4963 hectares per person. Obviously, the state is a very sparsely populated one. The people of Mizoram and Sikkim have about 487 and 448 square kilometres of forest cover to access ecological services. Manipur and Meghalaya still enjoy about 206 and 175 square kilometres of dense forest per person. Other states with more than 100 square kilometres per lakh population are Nagaland, Himachal Pradesh, Madhya Pradesh and Jammu and Kashmir. Notable among the others are Orissa and Goa. Tripura and Assam show about 57 to 58 square kilometres per lakh population. Other states show very little dense forest cover (Table 5.1 and Map 5.7).

8. **Percentage of rural workers in non-crop agricultural enterprises:** Non-crop rural enterprises are important for sustainable livelihoods, because they offer opportunities to the landless as well. The data on employment in rural non-crop enterprises has been taken state-wise from the economic census. Wherever the rural economy has diversified to provide more remunerative jobs through livestock and agriculture-related enterprises other than crop production, poverty is lower. Both rural and urban poor benefited from non-crop agricultural enterprises. A worker is considered as engaged in non-agricultural enterprises, if he is either a hired worker or is self-employed, and if the enterprise sold the produce for economic gain. Both self-employed workers and hired workers engaged in the production for market are considered as households engaged in non-crop enterprises.

The percentage of such workers is small compared to the total rural worker population, but it helps to ease the pressure on crop production and land to some extent. Even in the states such as Gujarat, they are no more than 10 per cent of the population. Barring Orissa, in states such as Maharashtra, Goa, Karnataka, Kerala, Rajasthan, Tamil Nadu and West Bengal, extreme poverty was avoided by diversification. Only when we get the industrial classification of the workers from the 2001 Census, can we assess the situation better.

Table 5.3

Access to Forest and Common village lands

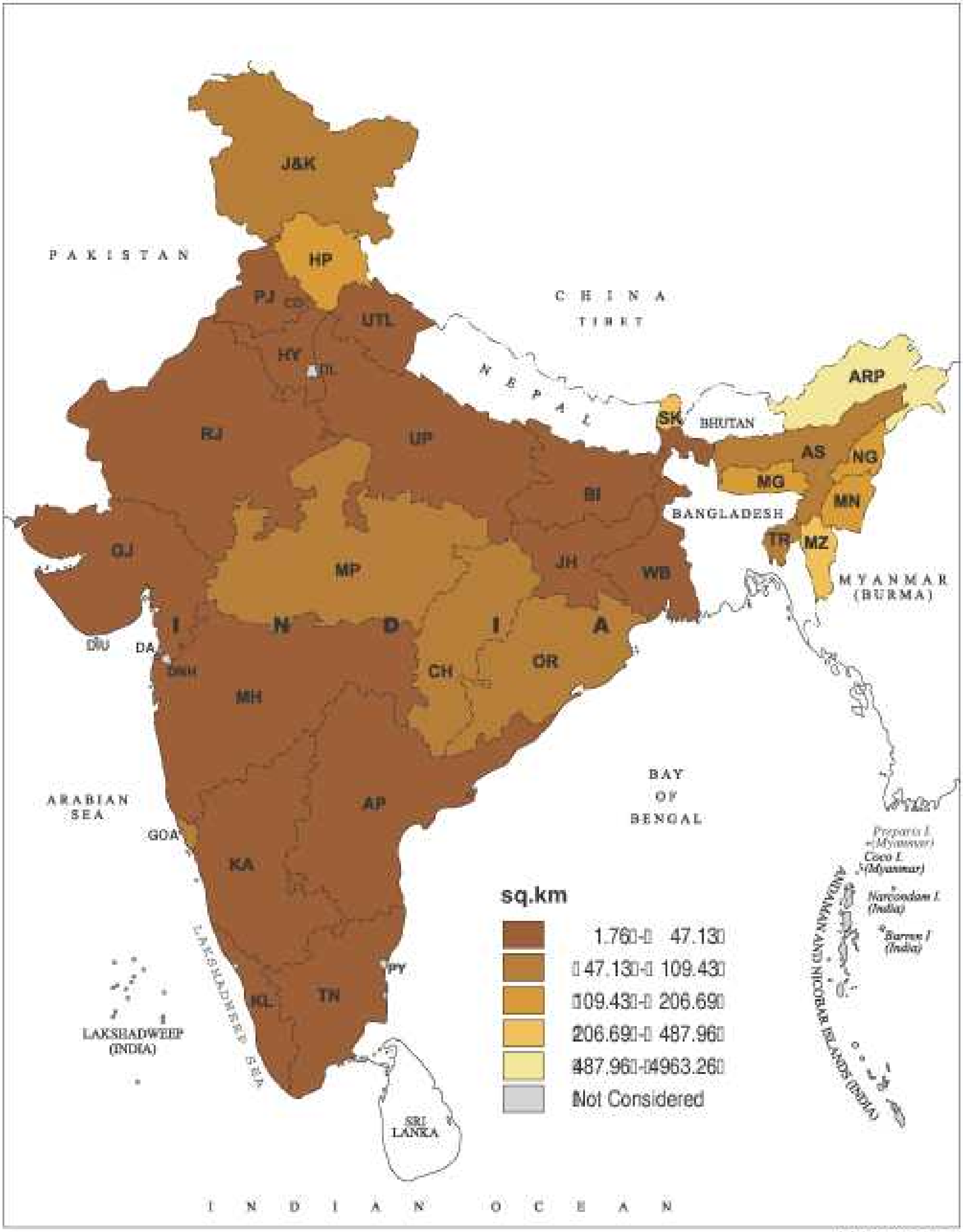
		1	2	3	4
S.No	State	Percentage of Households with access to forests	Percentage of villages with forest area	Percentage of Households with an access of less than 0.2 hectares of Common land	Percentage of Households with an access of more than 1 hectares of Common land
1	Andhra Pradesh	37.70	19.11	54.10	8.90
2	Arunachal Pradesh	83.90	36.20	31.80	36.50
3	Assam	41.20	8.67	79.50	1.70
4	Bihar	26.60	25.25	81.60	5.00
5	Goa	_	38.33	_	_
6	Gujarat	30.80	26.25	15.20	27.80
7	Haryana	29.50	1.33	67.50	_
8	Himachal Pradesh	79.60	35.27	65.10	12.80
9	Jammu & Kashmir	54.70	41.22	47.00	5.20
10	Karnataka	41.00	26.34	38.30	12.70
11	Kerala	19.10	22.90	97.20	1.80
12	Madhya Pradesh	56.60	40.96	28.60	27.50
13	Maharashtra	53.90	38.83	37.90	12.10
14	Manipur	42.40	84.78	61.30	11.00
15	Meghalaya	92.30	71.61	7.90	43.00
16	Mizoram	100.00	97.85	6.50	71.30
17	Nagaland	65.20	55.02	25.60	35.00
18	Orissa	69.80	62.36	33.10	11.70
19	Punjab	5.70	1.07	90.80	_
20	Rajasthan	35.30	18.78	13.80	41.50
21	Sikkim	86.00	68.23	38.30	17.10
22	Tamil Nadu	42.70	8.88	53.80	8.10
23	Tripura	68.90	75.32	94.90	0.70
24	Uttar Pradesh	28.10	21.19	56.80	8.00
25	West Bengal	22.30	22.61	94.00	1.80
	All India	37.5	29.01	55.60	11.40

Source: Col.1,3,4 NSS 54th Round Report No 452, "Common Property Resources in India" 1998, Col. 2 Forest Survey of India, "State of Forest Report 1999.

In the case of Orissa such diversification probably has meant only a move to dependence on forest products and not on livestock products. Though a high percentage of population is not dependent on crop production, the poverty levels are high (Table 5.1 and Map 5.8).

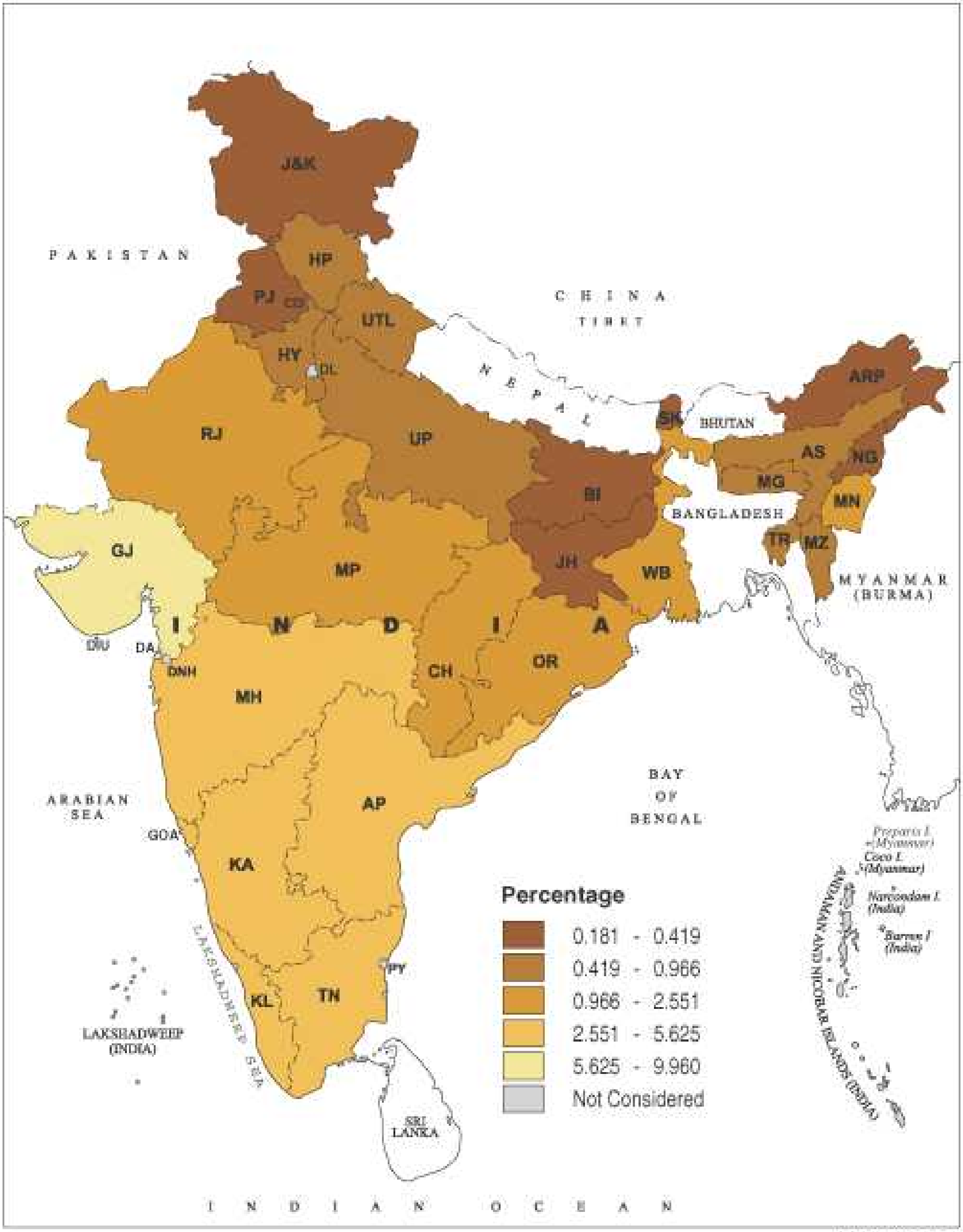
The number of households engaged in non-crop agricultural enterprises does not constitute a high percentage of the total rural population. All the same, they are crucial for the generation of higher incomes and better livelihoods. The data are taken from the economic census 1998. Statistics reveal the

DENSE FOREST AREA PER LAKH PERSONS



Map No. 5.7

RURAL WORKERS DEPENDENT ON NON-CROP AGRICULTURE ENTERPRISES



Map No. 5.8

importance of such enterprises in reducing poverty and promoting livelihoods. Hence, more importance is attached to this aspect in our Livelihood Index. It is the future path for sustainable rural development.

In this context, the success story of white revolution in India needs to be emphasised. Today, India is a global leader in milk production. About 70 million farmers maintain a milch herd of 100 million cattle. The share of the livestock sector output value in India's gross domestic product (GDP) is about 9 per cent, which is 25 per cent of the total output value from the agriculture sector. The dairy sector alone contributes 60 per cent of the 9 per cent GDP. The current milk production is growing at the rate of 4.51 per cent annually. The projected output for 2000 AD was 86 million tonnes, while the World Bank forecast was still higher at 94 million tonnes. About 85 per cent of Indian cows give less than 1 kg milk per day and cows giving more than 2 kg of milk per day are only about 5 per cent. Indian dairy, therefore, becomes a unique case where its marginal farmers contribute their share of milk resources through cooperative unions, notwithstanding a situation of several handicaps. Nearly seven million rural milk producers are direct beneficiaries of the biggest economic development programme anywhere in the world.

During the post-Independence period, milk production registered a persistent increase from 17.4 million tonnes between the years 1948 and 1952 to an estimated 74 million tonnes in 1998 with per capita consumption of milk of 204 gm per day. This level of milk production is characterized by the presence of poor breeds of milch animals maintained on inadequate feeding, management and health care.

About 85 per cent of Indian cows give milk ranging from 200 to 500 kg per lactation of 300 days compared to 4,154 kg in the USA, 3,950 kg in the UK and 3,902 kg in Denmark. A major proportion of indigenous stock is also plagued with longer ages of first calving, that is, 36 to 50 months and an inter-calving period of 14 to 22 months.

The situation with buffaloes is little brighter as 10 per cent of the buffalo population yields little less than 1 kg milk per day and about 25 per cent yield more than 2 kg of milk per day. On an average, an Indian buffalo gives about 650 kg milk per lactation. In a nutshell, poor yields are a direct reflection of poor breed, feed and management. Upgrading and selective breeding of indigenous breeds will not be effective in bridging the gap between requirement and availability within a reasonable period of time.

Diversification with dairying requires an appraisal by the farmer of his own resources. The choice of breed has to be made depending on available feed resources. An exotic cross requires more available feed, while the indigenous could subsist even with deficit feed. It is the small farmers who can entirely change the picture of milk production in the 21st century, as 85 per cent of Indian cows yield less than 1 kg milk per day. Even a marginal increase from such low yields can bring about a big revolution. Therefore, dairying has vast scope and technology dissemination aimed at the small farmers is necessary.

5.3 Women in agriculture

The long-term sustainability of food production and security in India is, therefore, essential for elimination of endemic hunger, for strengthening livelihoods in both the on-farm and off-farm sectors and for national sovereignty. Sustainability was considered for too long only from an economic perspective. Later, the social and equity aspects, particularly in terms of gender, were added. Both women and men play critical roles in agriculture throughout the world although rural women in particular are responsible for half the world's food production, and produce between 60 per cent to 80 per cent of the food in most developing countries (FAO 2001). Contributions of women to global food security are frequently underestimated and overlooked in development strategies. The significance of the role played by women in agriculture and allied activities is revealed not only by high female participation rates in farm and non-farm activities, but also by their intimate connection to rural customs, values and traditions. They participate in all operations pertaining to livestock management, crop production (weeding, transplanting, sowing, harvesting, etc.) as well as post-harvest operations (threshing, winnowing, drying, grinding, husking, storage, etc). Their contribution to secondary crop production of legumes and vegetables is even greater. These crops provide essential nutrients and are often the only food available in the lean season. Women's specialized knowledge of genetic resources for food and agriculture makes them essential custodians of agro-biodiversity.

Although rural women are assuming an increasingly prominent role in agriculture, they remain among the most disadvantaged sections of the population. FAO studies demonstrate that whereas women in developing countries are the mainstay of agricultural sectors, they have been the last to benefit from, and in some cases are even negatively affected by, development processes. Rural to urban migration of men in search of paid employment, smaller land holdings necessitating hiring of female family members as against additional workers and, in certain cases, technological trends, have contributed to the increasing *feminization of labour*.

5.3.1 Wage Differentials

A desirable wage is one that not only meets survival and social needs, but also enables investment for further contingencies, sickness and old age and acquisition of income-generating assets and livestock. Female work participation rates and wage differentials indicate the access to work and income. The average work participation rates (usual and subsidiary status) for women at the all-India level between the age group 15 to 59 years is 40.7 per cent, whereas for men its 83.2 per cent. The lowest female work participation rates are seen in Assam at 12 per cent, Haryana at 26 per cent and Bihar at 30 per cent. The highest female work participation rates are seen in Himachal Pradesh at 74.6 per cent followed by Maharashtra at 59.4 per cent (India Human Development Report 1999).

Wage differentials exist in both agricultural and non-agricultural work. Legally, the existing Minimum Wage Regulations should be enough to ensure that employers do not exploit workers or discriminate between men and women in the payment of wages. Women's wages are, on the average, 30 per cent lower than men's wages. There is not a single state in India where men and women are paid the same wage for the same work. The justification usually given is that women and men perform different tasks. The work done by women is invariably categorized as light work or unskilled work. For example, in agriculture, the back-breaking work of weeding, which is usually reserved for women, has the lowest wage rate. Transplanting of paddy, a highly skilled job reserved for women, has not been put in the highest wage bracket in any state. The all-India average agricultural wage rate per day for females is Rs 16.4 whereas for males it is Rs 23.4 (Shariff 1999).

The states in which wage differentials are low are also states in which the number of female labourers is low. To indicate the wage inequality among the states, female wages as a proportion of male wages is taken. Ideally, it should be one, indicating no wage differentials. The wage taken in the study is the average wage of non-public works. In Tamil Nadu, the female wage as a proportion to male wage is 0.51, in Kerala and Goa female wage is 0.53 of the male wage, as compared to the all India average of 0.64. In Kerala the absolute female wage is high compared to other states but the differential is also high. In states like Punjab where the wage differential is relatively low, that is, the proportion of female wage to male wage is 0.75, but it is also a state where the participation of female agricultural labourers is only 25 per cent and the percentage of female cultivators is 13 per cent. The absolute wages are the lowest for women in Madhya Pradesh and Orissa but are still marked with high percentage of agricultural labourers. About 58 per cent of the women are agricultural labourers in Madhya Pradesh (Table 5.4).

Women's work is often under-reported or not reported at all. Female work, especially female domestic work, is invisible, as women's household work culturally and subjectively is not considered to be contributive to the household income. Women spend large portions of time and effort in fuel, fodder and water collection. These tasks are unrecognized and unpaid. The opportunity cost of time is also sufficiently large as they could invest the same amount of time in remunerative work. If unpaid tasks are valued and women contribution to work in the households is included, the female participation rate would definitely increase. Six states—Tamil Nadu, Gujarat, Orissa, Meghalaya, Madhya Pradesh and Haryana representing north, south, east, west and central India have been taken to show that rural labourers depend on water, fodder and fuel from common property resources and the time spent by women in collection of fuel, water and fodder is greater than men. In Haryana 24.6 per cent of the households have their main sources of drinking water further than 200 metres from their dwelling (Table 5.5). The time spent by women on such work on an average per week is 2.31 hours for women compared to 0.08 hours for men in Haryana (Table 5.6). About 41.7 per cent and 49.1 per cent of the households in the state depend on common property resources for fuel and fodder collection respectively (Table 5.7 and 5.8). Women spend 3.39 hours per week

Table 5.4

Equal work and remuneration of Men and Women

S.No.	State	Female wages Rs.	Male wages Rs.	Index of wage equality
1	Delhi	N.A	80.99	(-)
2	Haryana	51.01	62.65	0.8142
3	Himachal Pradesh	50.36	67.06	0.7510
4	Jammu and Kashmir	66.07	77.04	0.8576
5	Punjab	49.48	65.86	0.7513
6	Rajasthan	37.02	55.19	0.6708
7	Madhya Pradesh	24.91	30.15	0.8262
8	Uttar Pradesh	30.08	43.50	0.6915
9	Bihar	31.57	36.53	0.8642
10	Orissa	23.34	31.14	0.7495
11	West Bengal	35.59	44.60	0.7980
12	Arunachal Pradesh	42.73	67.09	0.6369
13	Assam	35.55	48.82	0.7282
14	Manipur	47.40	59.46	0.7972
15	Meghalaya	43.06	57.37	0.7506
16	Mizoram	66.24	97.77	0.6775
17	Nagaland	46.67	71.93	0.6488
18	Sikkim	40.60	50.71	0.8006
19	Tripura	38.66	49.14	0.7867
20	Goa	46.99	83.20	0.5648
21	Gujarat	34.43	43.91	0.7841
22	Maharashtra	25.28	41.32	0.6118
23	Andhra Pradesh	26.48	40.67	0.6511
24	Karnataka	27.14	42.51	0.6384
25	Kerala	56.65	100.78	0.5621
26	Tamil Nadu	30.78	60.20	0.5113
	India	29.01	44.84	0.6470

Source: NSS 55th Round, Employment and unemployment situation in India, July 1999-2000, NSSO, GOI, Ministry of Statistics and Programme implementation for fodder collection as compared to 1.09 hours by men, and women spend .47 hours for fuel collection compared to .03 by men in Haryana. A similar pattern is seen in all states. In Tamil Nadu about 72 per cent and 6.9 per cent of the households depend on common property for fuel wood and fodder respectively. The time spent by women is .41, 1.21

Table 5.5

Percentage of Households having Principal Source and Drinking Water at a Distance greater than 200 meters from Dwelling (Rural)

S.No.	States	Total
1	Andhra Pradesh	8.70
2	Assam	5.00
3	Bihar	3.90
4	Gujarat	7.20
5	Haryana	24.60
6	Karnataka	5.60
7	Kerala	5.40
8	Madhya Pradesh	12.00
9	Maharashtra	9.30
10	Orissa	9.50
11	Punjab	0.90
12	Rajasthan	21.20
13	Tamil Nadu	7.00
14	Utta Pradesh	7.40
15	West Bengal	8.90
	All India	8.40

Source : GOI, Department of Statistics, National Sample Survey Organisation,NSS 54th Round, Drinking Water, Sanitation and Hygiene in India, Report No: 449

and .05 hours per week in fodder, water and fuel collection respectively in the state as compared .10, .11 and .03 hours per week spent on the same by men. This shows that women, compared to men, spend more time in unpaid and unrecognized work in spite of the fact that the entire household is dependant on these common property resources for their livelihood.

5.3.2 Land rights

In India, agriculture dominates all other forms of occupation. Ownership of land, including home sites and forestland, are socially, politically and economically significant. Women's access to, control and management of land are crucial aspects of sustainable development. Land as a resource has dimensions of ecological diversity, productivity for human sustenance and is a source of wealth creation in the economy. Command over land is, arguably, the most severe form of inequality between men and women today. Even small plots provide access to natural resources that contribute to survival, security and economic status. Rural women claim that secure land rights increase their social and political status and improve their sense of self-esteem, confidence, security and dignity. By diminishing the threat of eviction or economic destitution, direct and secure rights to land can increase women's bargaining power in their families and participation in public dialogue and local political institutions. Efforts to diversify livelihoods of asset-poor rural women from the task of agriculture in rural areas to small-scale allied activities like livestock production and sericulture require some land base, however small.

Women play an important role in sustaining and improving food security at global, national, community and household levels in various ways: Women are the majority of the world's agricultural producers and in many places in the world they are responsible for providing food for their families, if not by producing it, then by earning the income for its purchase (FAO 1998). Finally, women are nearly universally responsible for food preparation for their families. However, these contributions many times go unnoticed, as they are not counted in surveys and statistics, since most of the work that women

Table 5.6

Time Spent on Fetching of Water, Collection of Fuelwood, Collection of Fodder by Sex and Place of Residence (Weekly Average - in Hours)

S.No.	States	Fetching of Water		Collection of Fuel/ Fuelwood/ twigs		Collection of Fodder	
		Male	Female	Male	Female	Male	Female
1	**Haryana**						
	Rural	0.08	2.31	0.03	0.47	1.09	3.39
	Urban	0.02	0.69	0.01	0.03	0.07	0.28
2	**Madhya Pradesh**						
	Rural	0.02	0.21	0.14	0.48	0.29	0.18
	Urban	0.00	0.04	0.02	0.07	0.04	0.03
3	**Gujarat**						
	Rural	0.00	0.00	0.02	0.02	0.00	0.00
	Urban	0.00	0.00	0.00	0.00	0.00	0.00
4	**Orissa**						
	Rural	0.00	0.05	0.16	0.40	0.00	0.00
	Urban	0.00	0.00	0.00	0.00	0.00	0.00
5	**Tamil Nadu**						
	Rural	0.11	1.21	0.10	0.41	0.03	0.05
	Urban	0.08	0.71	0.00	0.03	0.00	0.00
6	**Meghalaya**						
	Rural	1.33	2.82	0.25	0.52	0.00	0.00
	Urban	1.94	1.26	0.00	0.00	0.00	0.00
7	**Combined States**						
	Rural	0.05	0.58	0.10	0.35	0.19	0.33
	Urban	0.04	0.31	0.00	0.02	0.01	0.02

Source: GOI, Central Satatistical Organisation, Ministry of Statistics and Programme Implementation, Report of the Time Use Survey, Appendix: A

perform in agriculture and the processing of food is unpaid. Given their crucial role in and contribution to food security, any factor that constrains women's ability to carry out their roles must be taken into consideration while measuring sustainability of food access.

It is important for women to have independent legal rights on land on three grounds: welfare, efficiency and equality or empowerment (Agarwal 1994).

On **welfare** grounds, women's lack of control over independent sources of income such as income from land has implications not just for her own well-being, but also for her children's well-being, as it is known that child nutritional status is more closely related to women's than men's income (Mearns 1999). It may even threaten the well-being of many household members who are dependent on her. But even women who are economically better off in higher-caste households are disadvantaged in this respect by their lack of access to and control over land. Direct access to land minimizes women's risks of impoverishment and improves the physical well-being and prospects for her children (Agarwal 1994).

Table 5.7

Percentage of Households Reporting Collection of Fodder from CPR by Household Type

S.No	State/UT	Rural Labours	All Households PossessingLand	All Households
1	Andhra Pradesh	9.80	13.50	11.50
2	Arunachal Pradesh	2.40	5.70	5.50
3	Assam	11.90	16.90	15.20
4	Bihar	16.50	10.60	13.20
5	Gujarat	10.10	7.30	8.40
6	Haryana	41.70	17.90	25.90
7	Himachal Pradesh	36.80	36.10	36.20
8	Jammu & Kashmir	2.60	3.10	3.00
9	Karnataka	18.10	14.00	15.80
10	Kerala	5.70	3.50	4.60
11	Madhya Pradesh	7.80	9.40	8.70
12	Maharashtra	10.80	11.50	11.10
13	Manipur	11.70	5.40	6.30
14	Meghalaya	0.70	2.40	2.20
15	Mizoram	15.40	20.90	20.60
16	Nagaland	18.50	22.40	22.10
17	Orissa	6.20	8.30	7.30
18	Punjab	33.60	7.50	18.00
19	Rajasthan	4.90	2.20	2.90
20	Sikkim	29.90	33.30	32.50
21	Tamil Nadu	6.90	6.20	6.60
22	Tripura	0.90	1.80	1.40
23	Uttar Pradesh	29.20	20.50	23.20
24	West Bengal	8.30	10.10	9.30
25	A. & N. Islands	5.80	3.10	4.50
	India	13.40	12.20	12.70

Source: GOI, National Sample Survey Organisation, Ministry of Statistics and Programme Implementation Common Property Resources in India, NSS 54th Round, Report No: 452, Jan 1998-June 1998

Table 5.8

Pecentage of Households Reporting Collection of Fuelwood from CPR by Household

S.No	State/UT	Rural Labours	Land Possessing Households	All Households
1	Andhra Pradesh	66.90	48.50	58.50
2	Arunachal Pradesh	64.00	83.90	82.40
3	Assam	54.10	38.80	43.80
4	Bihar	55.50	29.00	40.70
5	Gujarat	75.40	41.30	54.80
6	Haryana	49.10	15.90	27.10
7	Himachal Pradesh	70.40	52.00	55.60
8	Jammu & Kashmir	26.40	34.80	32.90
9	Karnataka	69.90	38.90	52.60
10	Kerala	18.80	6.90	12.70
11	Madhya Pradesh	66.60	48.30	56.10
12	Maharashtra	74.30	42.10	58.80
13	Manipur	34.30	40.50	39.50
14	Meghalaya	94.00	84.10	85.60
15	Mizoram	97.80	97.40	97.40
16	Nagaland	76.90	65.90	66.70
17	Orissa	76.30	48.60	61.70
18	Punjab	44.80	9.30	23.60
19	Rajasthan	31.10	16.90	20.60
20	Sikkim	60.40	50.10	52.60
21	Tamil Nadu	72.50	43.60	60.50
22	Tripura	45.50	21.10	31.30
23	Uttar Pradesh	47.00	26.90	33.00
24	West Bengal	51.10	27.30	38.40
25	A. & N. Islands	72.80	57.90	65.60
	India	59.70	33.70	44.80

Source : GOI, National Sample Survey Organisation, Ministry of Statistics and Programme Implementation Common Property Resources in India, NSS 54th Round, Report No: 452, Jan 1998-June 1998

On **efficiency** grounds, women are often the sole heads of households and, on the assumption that greater tenure and title security provides production incentives, granting them independent title to land is likely to lead to higher agricultural output. Without secure land rights, women have little or no access to credit, no incentive to invest in technology or modern farm inputs, will not be able to exercise their knowledge about traditional plants and will not get the benefits of membership in rural organizations which are often important for obtaining inputs and services.

The **equality and empowerment** arguments concern women's access to land relative to that of men, rather than their access to land in absolute terms. Strengthening women's relative access to land will help increase their bargaining power and ability to challenge male dominance both within the household and within the wider community. Some of the most persuasive arguments relate to women's ability to escape situations of marital abuse and physical violence. A common complaint from women against joint land titles is that they will remain bound to their husband even in the case of marital break-up. Women are often disadvantaged through illiteracy, seclusion, social stigma and lack of political voice. Local government officials are also major impediments; for instance, the village record keepers may refuse to register land holdings in the sole name of widows, registering it only jointly with their sons.

Rural women often spend a number of hours every day in tasks related to agriculture in addition to fulfilling their responsibilities as homemakers. According to the Economic Census in 1998, the percentage of female agricultural workers to total workers was 34.3 per cent in rural areas and 23.8 per cent in urban areas. In general, the contribution of farmwomen in agriculture is around 50 per cent to 60 per cent (Economic Census 1998). The extent of their participation varies depending on the socio-economic and cultural background of the area. Considerable variations occur from state to state in the involvement and division of labour between men and women.

The study looks at the percentage of female cultivators who work on land in different parts of the country. Quantifying the number of female cultivators against the number of male cultivators is a rough measure to indicate the participation of women on land. It is used instead of property rights as an indicator of women's economic status in India with respect to land, as there is a lack of data on the latter. One of the main reasons women become cultivators is because the male in the household migrates to take up non-farm livelihoods, leaving the land to be taken care of by them. In less realistic situations women may actually purchase the land, inherit the land, or even acquire it from state transfers.

Low participation in female cultivators in agriculturally prosperous states: In states such as Punjab, Assam, Bihar and Uttar Pradesh, agriculture is the most profitable occupation for men and there is often no need to seek other options. States marked with increased agricultural technology and know-how such as Punjab, Uttar Pradesh and Gujarat have a higher number of male cultivators. The contribution of agriculture to the state domestic product in 2000–2001 was the highest for Punjab at 38.2 per cent, followed by Bihar at 36.5 per cent, Uttar Pradesh at 32.7 per cent and Assam at 31.4 per cent. The number of female cultivators as a percentage of male cultivators was low for Punjab, Bihar, Assam and Uttar Pradesh, which are also the states in which agriculture contributes a large share to the states economic wealth. The participation of female cultivators was as low as 13.13 per cent in Punjab, 19.81 per cent in Uttar Pradesh, 20.48 per cent in Bihar and 28.87 per cent in Assam (Table 5.9). Bihar and Orissa are economically poor states; yet they have a low percentage of female cultivators, as agriculture remains the only viable occupation for the men to rely on. But the number of women working as agricultural labourers as a percentage of the total work force was high in Orissa at 48.4 per cent and in Bihar at 34.9 per cent in 2001. Society places a very high regard to abstention from manual work, which explains why in a rural society, a non-cultivating owner is placed in higher esteem as compared to a cultivating owner. It has been noticed that women in more developed and economically endowed places tend to confine themselves to the household or to their family farm. Ploughing in Indian society is viewed as a male task; the task of transplanting and weeding are more gender-neutral. The social stigma attached to physical labour appears to be responsible for general low level of female participation. Prestige gain is also sought by lower castes through the withdrawal of women from manual domestic work in order to raise their status in society.

High participation of female cultivators in economically prosperous states: Tamil Nadu (35.37 per cent), Maharashtra (43.67 per cent), Andhra Pradesh (33.10 per cent), Karnataka (26.22) have a high percentage of female cultivators as well as a relatively high per capita national state domestic product (NSDP). These states contribute significantly also to the states GDP. The share of agriculture to the states GDP for Andhra Pradesh is 24.9 per cent, for Karnataka 26.9 per cent, fro Tamil Nadu 16 per cent and for Maharashtra 11.5 per cent. A large number of men in these states move to the urban cities in search of more profitable jobs both in the formal and informal sector leaving their land to be cultivated by the women in the household.

High level of participation of women in the hilly regions: There seem to be a high percentage of women cultivators in areas around the northeastern and western Himalayas as compared to the Gangetic plains. The percentage of female cultivators as a total of male cultivators is the highest in the western Himalayan state of Himachal Pradesh at 57.39 per cent, where the land is basically hilly. It is then followed by Arunachal Pradesh at 51.28 per cent, Nagaland at 50.11 per cent, Mizoram at 49.11 per cent, Sikkim at 46.62 per cent, Meghalaya at 45.24 per cent and Manipur at 43.66 per cent, which are all the states along the eastern Himalayas. Rajasthan, located in the central plateau where the land is dry and hilly, also shows a high percentage of female cultivators at 46.18 per cent (Table 5.9). The northeastern regions are rain-fed regions, but are largely difficult to cultivate; because of the nature of the land considerable amount of effort is required to perform the task of bunding and terracing. In the hilly regions, women carry out most of the agricultural operations (Dutta 1993) whereas the men engage in other sources of employment. Kala Bisht clearly summed the plight of hill women "men having enthusiasm to work, migrate for petty employment and those left behind accomplish their audaciously ordained work of ploughing and do nothing except this." (Kala Bisht 1987) Women engage in the preparation of land, involving the breaking of clods and weeding operations in the stony surfaces at different altitudes and gradients.

Northeastern India is also the home of three matrilineal tribal communities: the Garos, Khasis and Lalungs (Agarwal 1994), which may be one of the other reasons for large number of female cultivators. The Garos and Khasis belong to a matrilineal tribe in Meghalaya and the Lalungs belong to the hills and plains of Assam. In these states no man can inherit property under any circumstance. Among the Garos, the self-acquired property of an unmarried man belongs to his mother and her female descendents. Women play a major role in crop production and the gathering of forest produce. Their labour input is greater than that of men and they possess extensive knowledge of indigenous crop varieties. Among the Khasis, the family's ancestral land, house and movables are passed from the mother to the youngest daughter who is the heiress. However, the mother can also, in consultation with her brothers,

Table 5.9

Total Male and Female Cultivators & Agriculture (2001)

S. No	State/UT	Cultivators Males	Cultivators Females	Cultivators Total	Cultivators % of Female to total	Agricultural labourers Female	Agricultural labourers Total	Agricultural labourers % of Female to total	Different Climatic Zone
1	Andaman & Nicobar Islands	14795	6341	21136	30.00	1113	5092	21.86	Isl
2	Andhra Pradesh	5287272	2616363	7903635	33.10	7386920	13818754	53.46	DP, EG
3	Arunachal Pradesh	137292	144530	281822	51.28	8472	18569	45.62	Ehm
4	Assam	2661619	1080293	3741912	28.87	440468	1289902	34.15	Ehm
5	Bihar	8945034	3155309	12100343	26.08	6099463	16389823	37.21	MG, Ehg
6	Chandigarh	1472	113	1585	7.13	54	387	13.95	_
7	Dadra & Nagar Haveli	18129	21394	39523	54.13	9369	14743	63.55	_
8	Daman & Diu	1936	1960	3896	50.31	966	1287	75.06	_
9	Delhi	26584	10004	36588	27.34	3946	13559	29.10	_
10	Goa	26008	24655	50663	48.66	19939	36150	55.16	_
11	Gujarat	3804880	1808305	5613185	32.22	2583477	4987657	51.80	GC
12	Haryana	1873479	1172612	3046091	38.50	563739	1276143	44.18	UG
13	Himachal Pradesh	835574	1125266	1960840	57.39	37645	92761	40.58	WHm
14	Jammu & Kashmir	1023149	576507	1599656	36.04	53690	248577	21.60	WHm
15	Karnataka	4909653	2026468	6936121	29.22	3613282	6209153	58.19	WHg, DP, WC
16	Kerala	622724	117679	740403	15.89	550284	1653601	33.28	WC
17	Lakshadweep	0	0	0	_	0	0	_	_
18	Madhya Pradesh	9417344	5958137	15375481	38.75	5733475	10469094	54.77	Ehg, CHg, WHg
19	Maharashtra	6765759	5244144	12009903	43.67	6362152	11290945	56.35	CHg, EHg & WHg, WC
20	Manipur	277583	215113	492696	43.66	67764	120991	56.01	EHm
21	Meghalaya	250376	206819	457195	45.24	82351	172975	47.61	EHm
22	Mizoram	128836	124331	253167	49.11	14484	27494	52.68	EHm
23	Nagaland	271608	272825	544433	50.11	15711	33852	46.41	EHm
24	Orissa	3371717	866630	4238347	20.45	2420553	5001075	48.40	Ehg, EG
25	Pondicherry	10186	1098	11284	9.73	30105	72095	41.76	_
26	Punjab	1823594	275736	2099330	13.13	379418	1498976	25.31	UG
27	Rajasthan	7086876	6079901	13166777	46.18	1490938	2529225	58.95	CHg, TD
28	Sikkim	70154	61268	131422	46.62	8325	16939	49.15	Ehg
29	Tamil Nadu	3305413	1808971	5114384	35.37	4387880	8665020	50.64	DP, EG, WC
30	Tripura	221211	90167	311378	28.96	114408	278334	41.10	EHm
31	Uttar Pradesh	18465906	5266072	23731978	22.19	5343605	13863564	38.54	WHm, MG, TG, CHg
32	West Bengal	4672284	940829	5613113	16.76	2269448	7350988	30.87	Ehm, LG, Ehg
	India	86328447	41299840	1.28E+08	32.36	50093444	107447725	46.62	

Source: Census of India -2001,Provisional Population Totals divide the property among all her ancestral daughters usually when they married. The largest share was given to the youngest daughter, the custodian. In the case of insufficient land, the youngest inherited all the land. Women play an active role in cultivation and were often primary traders. Among the Lalungs, women play a significant role in agricultural production. Inheritance is passed on from the mother to whichever daughter she resides with. Cultivation resides with the woman's husband but he had no right of disposal over land or its produce.

The Nayars, Mappilas and the Tiyyars are matrilineal communities in Kerala where land is held traditionally in joint family estates; it was not individually inheritable but the inheritance was through the female line. Most women have little control over the management of property, but may have an equal say in decisions regarding partition of land. Kerala, which records a high per capita NSDP and where agriculture contributes 20 per cent of the GSDP, had a strikingly low level of participation of women as cultivators at 15.89 per cent in 2001. Women may be legal owners of the land but may not have adequate freedom on how to manage, use and allocate the produce, whereas the men are formally designated as managers. Management would involve decisions on the production, allocation of farm output and property management and hence shows that ultimately women might not reap their due benefits even though they own the land.

According the NSS 55th Round data, 8.3 per cent of the females in households where the head of the family is a woman had no land compared to 7 per cent of the males in the households headed by a male. This indicates that households headed by women are largely worse off and fail to have any security by way of land. A large percentage of the female headed households own marginal pieces of land compared to the male headed households. Often the men seek other sources of employment in urban areas or seek other means of self-employment when the lands are too small. In such situations, they leave it to the women of the household to take care of the land. About 66.8 per cent of the land possessed by women is between 0.01–0.40 hectares and only 1.6 per cent of women possess land more than 4 hectares. (Table 5.10)

Table 5.10

Distribution of households by sizeclass of land owned for each household type - rural only

Size class of land possessed (0.00 hectares)	Male % of male headed Households	Female % of female headed Households
0.00	7.00	8.30
0.01 - 0.40	49.20	66.80
0.41 - 1.00	19.70	13.70
1.01 - 2.00	12.10	6.20
2.01 - 4.00	7.70	3.40
4.01 & above	4.20	1.60
Total	100.00	100.00
Estimated Households (00)	1227336	143461
Sample Households	64202	7215

Source : GOI, Ministry of Statistics and Programmed Implementation National Sample Survey Organisation, NSS 55th Round, Report No: 458

CHAPTER 6

Index of Sustainable Food Access

6.1 Relevance of Sustainability to Livelihoods

Sustainability of food access of any state refers to the capacity of that state to provide livelihoods that give sufficient earnings and purchasing power to rural people, so that they can have access to nutritious food. Sustainability of food access would also mean conditions of sufficient natural resource base that help traditional livelihoods as well as modern livelihoods for a long time to come. All livelihoods, both modern and traditional, require natural resources such as land, reliable monsoon or irrigation water to reduce fluctuations in production. Finally, to sustain livelihoods, the state should have the capacity to provide non-crop agricultural enterprises. The states that have shown the capacity for such diversification are better off than the states where such efforts are not undertaken or have not become successful. Those that could not provide more assured livelihoods are normally left with a high percentage of casual agricultural labour that sometimes need to migrate to other places to earn a living. To sustain agriculture and the livelihoods associated with it, forests and the ability of villagers to access them is vital. Dense forest cover ensures watershed protection as well as forest produce. Some of the natural resources help livelihoods directly. Others may help indirectly. Thus, all the indicators chosen help the survival of the rural population with minimum comfort. Without these natural resource and livelihood opportunities, hardships would increase. Hence, there is sufficient justification to consider the chosen indicators to represent sustainable livelihoods in the very limited context of this Atlas. A detailed study of these indicators has already been undertaken in the previous chapter.

This chapter briefly describes the nexus between the natural resource endowments and the population pressure on the livelihoods of the rural poor to justify the inclusion of the above indicators in the Sustainability of Livelihood Access Index. Some of the limitations of the indicators have also been brought out during the discussion. There are many more indicators with sharper focus, but which have not been included for paucity of data.

Dense forest areas play an important role as watersheds and thus help livelihoods in more ways than one. They help agriculture indirectly. They are especially useful to tribal people and to nearby villages in enhancing their livelihoods. Both the economic and ecological functions of the forests help people sustain their livelihoods. Free grazing lands, for example, may mean free fodder for the cattle and sheep and other livestock on which villagers depend. Free fuel wood and free non-timber forest produce for housing, food, medicines and so on also come under this category. The free consumption items reduce the need for purchases and cash earnings. If non-agricultural growth brings development and eases pressure of population on natural resources and agriculture, it would be a welcome step, particularly if it happens with a lower level of pollution and without compromising on natural resources.

Higher levels of development and fewer poor can sometimes lead to greater degradation of natural resources: for instance, prime agricultural land can be shifted to non-agricultural uses; forests are often cleared for crop production; trees and forests are destroyed for the sale of timber, mining of minerals and construction of irrigation dams; biodiversity in forestry, agriculture and fisheries is often ignored by shifting to monocultures of commercially profitable species; over-exploitation of surface water and groundwater makes the water tables recede and there is extensive pollution of water bodies and of living surroundings. All this could happen in the name of economic development. However, such development is not sustainable; very soon agricultural production and the livelihood access of rural people begin to get affected. Eventually, there will be more poor people than before. Removing rural poverty in the long run will lead to the removal of urban poverty as well. The rural poor normally migrate to the slums of urban areas for lack of livelihoods. We are interested in preventing only distress migration and not migration into better-paid jobs that make them non-poor. Distress migration occurs when natural resource degradation forces the rural poor to leave their land. They are environmental refugees.

Decline in production or increase in the cost of production leads to an increase in the price of output. An increase in the price of food decreases purchasing power. The damage to natural resources and non-availability of free and cheap resources for food, water and daily needs increases the dependence of the rural people on purchased items and depletes their incomes. The capacity of land-based enterprises such as crop production, dairying, livestock enterprises, forestry and aquaculture to absorb labour and create livelihoods gets reduced, as the number of people per unit of natural resource declines. This happens with an increase in population and with the depletion of natural resources.

When natural resources are abundant compared to the population dependant on them, the situation is sustainable. Pressure can build up on natural resources in two ways: first, the increasing consumption demand of people may result in the over-exploitation of surface water and groundwater, decline in soil fertility and decline in forest cover through over-use of timber and non-timber forest products. Second, if the number of people directly dependant on natural resources, such as fuel, grazing pastures their animals, fodder for sale, wood for their houses and so on, for their daily requirements are high, there is more degradation in the long run. Resource degradation takes place on both counts. In other words, typically, in a developing country such as India, two types of pressures build up on natural resources from the economic use by commercial interest and from excess dependence of the poor on free resources. Both have a direct bearing on the sustainability of food access.

Primarily, the pressure can come from the requirements for food and water, forest-related products, land for crops and for non-agricultural and industrial purposes. This leads to over-exploitation in the short run without any concern for long-term sustainability. More and more forests are cut down for timber and for conversion into croplands. Also, more and more of fertile croplands are put to non-agricultural uses near cities and towns.

The practices of shifting cultivation, cutting of vegetation for fuel wood, fodder, grazing on forestlands, excess fishing and so on cause the degradation of natural resources. When no more of these free natural resources are available, poverty deepens and life becomes even harder for the poor. The indicators attempt to capture the natural endowments that have an impact on long-term livelihood access on the one hand and the pressure of human population and livestock on land, which also reduces the access to livelihoods, on the other. Unsustainable levels of consumption, beyond the carrying capacity of the natural resources, will lead to future poverty, even though, at present there is prosperity.

6.2 Indicators of Sustainable Food Access

This index has two components: sub Index of Food Access/Livelihood Access Security and the sub Index of Food Access/Livelihood Access Sustenance. The first sub index shows the present level of livelihood security and the second sub index shows the livelihood sustenance for future. These two sub indices are combined together with a weight of 0.25 for the Index of Food Access Security and 0.75 for Index of Food Access Sustenance.

The following indicators have been selected for the Composite Index of Sustainable Food Access (Tables 6.1 and Table 6.2)

There are two indicators of present Food Access and Livelihood Access Security

1. **Percentage of population below poverty in the entire state, both rural and urban:** This population is likely to face problems of food access. All those above the poverty line are considered as having sufficient food access at present. Problems of food access are obvious from this indicator
2. **Percentage of non-agricultural workers to total workers in the state both in rural and urban areas:** This is an indicator of relative prosperity. While all non-agricultural employment by itself may not mean prosperity, it definitely means reduction in dependence on the primary sector and shift to the higher- income secondary sector.

There are five Indicators of Food Access and Livelihood Access Sustenance

3. **Instability in cereal production in the past ten years:** This is more an indicator of food access than availability, because whereas trade-flows augment shortages in local cereal production, loss in incomes and purchasing power and indebtedness that depletes the future purchasing capacity as a result of crop loss becomes the more important issues. Instability includes many situations other than weather factors. The major weather factors that routinely bring about fluctuation every few years are rainfall deficiencies and other natural factors such as pests and diseases and floods. Fluctuations may also arise because of a crash in prices and change in the market situations, which may affect the livelihoods. As cereals are a staple food, production shortfall will result in serious food access problems for people. The transient and seasonal food-access problems arising out of natural and man-made situations are captured here.
4. **Average size of the holding:** This represents the direct pressure of population on cultivated land. Greater the pressure, more likely the exploitation of natural resources, particularly when the rates of exploitation are high.
5. **Percentage of landless labour households to total household:** This represents the indirect pressure of population on land and water resources, including both private land and common property resources .

Table 6.1

Indicators and Indicies of Food and Livelihood Security

		1		2		3	
S.No	States	Percentage of Population Below Poverty Line (Rural + Urban) (1999-2000)	Index	Percentage of non-agricultural workers to total workers (2001)	Index	Index of Food Access security (FASI)	**Rank**
1	Andhra Pradesh	15.77	0.720	24.84	0.180	0.450	**9**
2	Arunachal Pradesh	33.47	0.310	27.47	0.225	0.268	**19**
3	Assam	36.09	0.250	40.96	0.460	0.355	**15**
4	Bihar	42.60	0.100	17.56	0.053	0.077	**25**
5	Goa	4.40	0.980	72.06	1.000	0.990	**1**
6	Gujarat	14.07	0.760	28.13	0.237	0.498	**7**
7	Haryana	8.74	0.880	34.98	0.356	0.618	**5**
8	Himachal Pradesh	7.63	0.900	26.28	0.205	0.552	**6**
9	Jammu and Kashmir	3.48	1.000	37.56	0.401	0.700	**4**
10	Karnataka	20.04	0.620	26.47	0.208	0.414	**12**
11	Kerala	12.27	0.800	71.34	0.988	0.894	**2**
12	Madhya Pradesh	37.43	0.220	14.50	0.000	0.110	**24**
13	Maharashtra	25.02	0.510	20.28	0.100	0.305	**18**
14	Manipur	28.54	0.430	34.75	0.352	0.391	**13**
15	Meghalaya	33.87	0.300	25.37	0.189	0.244	**21**
16	Mizoram	19.47	0.630	18.29	0.066	0.348	**16**
17	Nagaland	32.67	0.330	22.60	0.141	0.235	**22**
18	Orissa	47.15	0.000	27.66	0.229	0.114	**23**
19	Punjab	6.16	0.940	46.49	0.556	0.748	**3**
20	Rajasthan	15.28	0.730	22.70	0.143	0.436	**10**
21	Sikkim	36.55	0.240	37.95	0.407	0.324	**17**
22	Tamil Nadu	21.12	0.600	30.05	0.270	0.435	**11**
23	Tripura	34.44	0.290	40.62	0.454	0.372	**14**
24	Uttar Pradesh	31.15	0.370	22.29	0.135	0.253	**20**
25	West Bengal	27.02	0.460	41.60	0.471	0.465	**8**

6. **Percentage of population in non-crop agricultural enterprises** represents diversification of agriculture and better livelihood access to the people who depend upon natural resources.
7. **Dense forest cover per lakh population:** This represents the ecological sustainability of water resources and the source of forest products. It includes the availability of biodiversity for a variety of uses not only to the population with access to forests, but also to those who depend on these water resources and products indirectly (Table 6.2)

Table 6.2

Indicators and Indicies of Food and Livelihood Sustenance

		1		2		3		4		5		6	
S.No	States	Instability of cereal prod. (Percentage) (1990-91 to 1999-2000)	Index	Average size of holding hectare per (Household) (1990-91)	Index	Percentage of landless labour (Household) (1991)	Index	Percentage of Workers in non-crop Ag. Enpr. To Total Workers (2001)	Index	Dense forest cover per lakh popln. (Hectare per persons) (2001)	Index	Index of food Access Sustenance (0.75) (FASUI)	**Rank**
1	Andhra Pradesh	14.17	0.66	1.56	0.19	19.80	0.26	4.68	0.46	30.44	0.006	0.315	**21**
2	Arunachal Pradesh	12.13	0.73	3.71	0.52	2.40	0.93	0.20	0.00	4963.26	1.000	0.637	**1**
3	Assam	5.57	0.96	1.27	0.14	8.00	0.72	0.80	0.06	58.37	0.011	0.378	**11**
4	Bihar	14.25	0.66	0.83	0.08	19.00	0.29	0.40	0.02	12.11	0.002	0.211	**24**
5	Goa	6.60	0.93	0.93	0.09	10.10	0.63	3.36	0.33	74.03	0.015	0.399	**7**
6	Gujarat	30.27	0.10	2.93	0.40	17.90	0.33	9.96	1.00	12.52	0.002	0.367	**14**
7	Haryana	7.51	0.90	2.43	0.32	7.80	0.72	0.61	0.04	1.75	0.000	0.397	**8**
8	Himachal Pradesh	9.42	0.83	1.21	0.14	0.90	0.99	0.97	0.08	157.31	0.031	0.414	**5**
9	Jammu and Kashmir	8.67	0.86	0.83	0.08	1.00	0.98	0.19	0.00	109.43	0.022	0.390	**10**
10	Karnataka	12.38	0.73	2.13	0.28	14.70	0.46	5.13	0.51	47.13	0.009	0.397	**9**
11	Kerala	16.32	0.59	0.33	0.00	3.60	0.88	5.63	0.56	26.55	0.005	0.407	**6**
12	Madhya Pradesh	11.29	0.76	2.63	0.35	12.70	0.53	1.99	0.18	101.93	0.020	0.370	**13**
13	Maharashtra	28.79	0.15	2.21	0.29	20.20	0.25	3.97	0.39	24.41	0.005	0.216	**23**
14	Manipur	22.80	0.36	1.23	0.14	1.60	0.96	1.57	0.14	206.69	0.041	0.329	**18**
15	Meghalaya	8.33	0.87	1.77	0.22	11.40	0.58	0.60	0.04	175.36	0.035	0.351	**16**
16	Mizoram	11.96	0.74	1.38	0.16	0.00	1.02	0.79	0.06	487.96	0.098	0.417	**4**
17	Nagaland	10.02	0.81	6.82	1.00	0.20	1.02	0.18	0.00	175.35	0.035	0.572	**2**
18	Orissa	21.82	0.40	1.34	0.16	12.00	0.56	2.55	0.24	71.11	0.014	0.276	**22**
19	Punjab	5.39	0.97	3.61	0.51	20.10	0.25	0.42	0.02	2.10	0.000	0.351	**15**
20	Rajasthan	33.22	0.00	4.11	0.58	4.90	0.83	2.29	0.22	6.53	0.001	0.326	**19**
21	Sikkim	7.85	0.88	2.09	0.27	1.70	0.96	0.32	0.01	448.29	0.090	0.442	**3**
22	Tamil Nadu	15.90	0.60	0.93	0.09	26.60	0.00	3.33	0.32	13.97	0.003	0.203	**25**
23	Tripura	10.98	0.77	0.97	0.10	8.90	0.68	0.51	0.03	57.00	0.011	0.319	**20**
24	Uttar Pradesh	4.52	1.00	0.90	0.09	7.60	0.73	0.62	0.05	13.15	0.002	0.374	**12**
25	West Bengal	6.51	0.93	0.90	0.09	13.90	0.49	2.12	0.20	4.43	0.001	0.341	**17**

6.3 Composite Index of Sustainable Food Access

The first 2 indicators—the percentage of population below the poverty line and the percentage of non-agricultural workers to total workers—together give us the indicators for Food Access and Livelihood Access Security. These two indicators are converted into indices first and then averaged together to get the Food Access Security Index. The remaining 5 indicators are the indicators of Food Access and Livelihood Access Sustenance. All these have been converted into individual indices and averaged together to get the Index of Food Access Sustenance.

The Composite Index of Sustainable Food Access is a weighted average of these two sub indices of present Food Access Security and future Food Access Sustenance. The former was given a weight of 0.25 and the latter a weight of 0.75 respectively (Table 6.3 and Map 6.1). The final Index has been divided into five categories using the natural break in the series. The natural break classifies the Composite Index into five classes taking the cut off points where variation is very high. If the variation between the states is not much, they will be bunched together. If some states have extreme values far removed from others, they will be kept in a separate category. The relative position of the states is explained in Map 6.1; these five categories have shades differently (Map 6.1).

6.3.1 Position of the States

States coloured dark green: There are three states in the sustainable category. They are Kerala, Arunachal Pradesh and Goa. The livelihood security is very good in these states. The poverty levels are very low compared to other states.

States coloured light green: Himachal Pradesh, Punjab, Haryana, Jammu and Kashmir and Nagaland are the five states in this moderately sustainable category with the index value ranging from 0.413 to 0.488. The livelihood security is good and the poverty levels are low in these states.

States coloured yellow: The six states in this moderately unsustainable category are Assam, West Bengal, Mizoram, Gujarat, Karnataka and Sikkim. The index value ranges from 0.354 to 0.413. The livelihood security is better in these states.

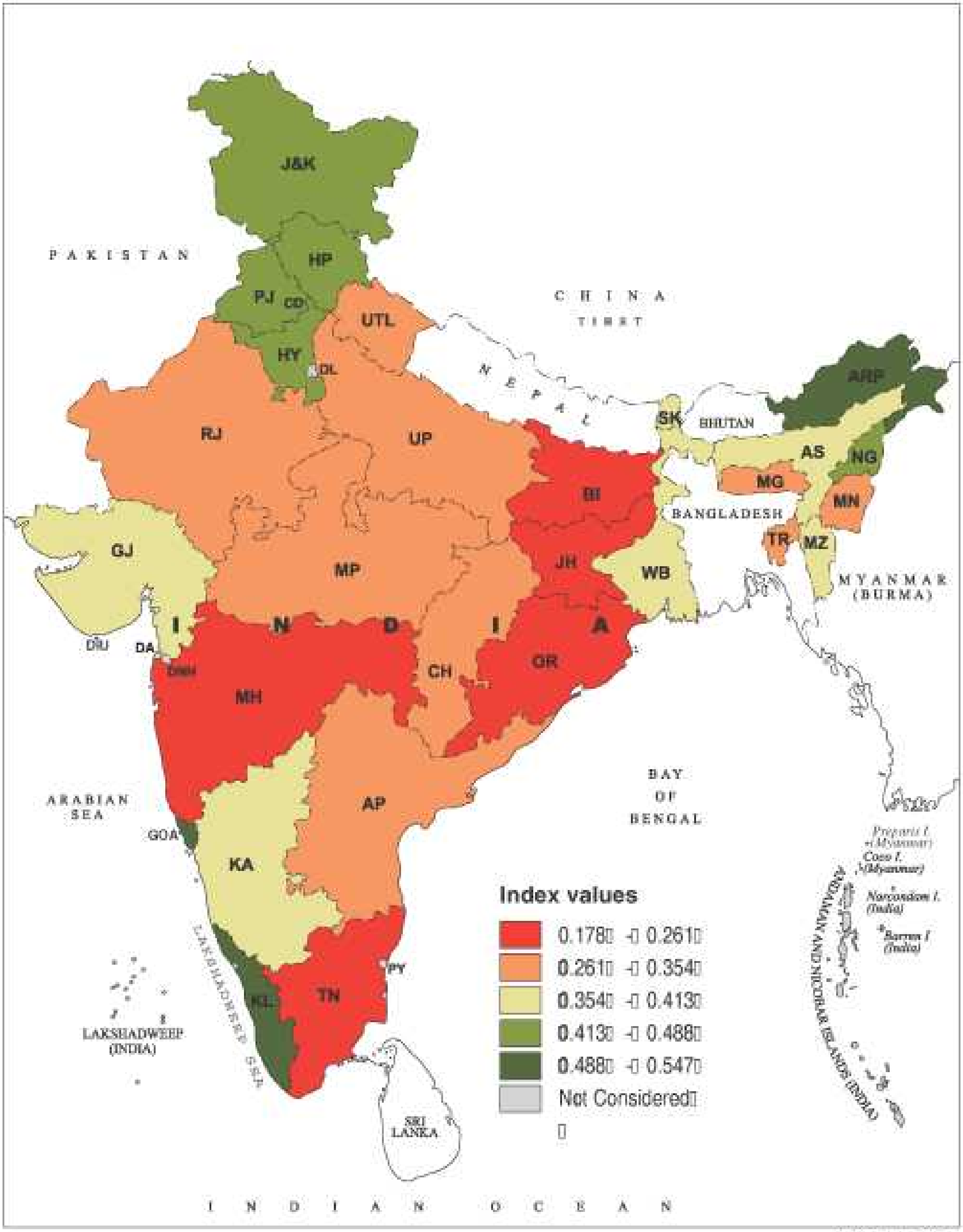
States coloured orange: Madhya Pradesh, Meghalaya, Tripura, Uttar Pradesh, Manipur, Andhra Pradesh and Rajasthan are the eight states in this unsustainable category. The index value ranges from 0.261 to 0.354. These states have very poor livelihood security and also have a large percentage of their population below poverty line.

States coloured red: Despite low instability of production, Maharashtra and Orissa fall in this category. The other states that fall in this category are Bihar and Tamil Nadu. All these states have large percentage of landless labour households, high poverty levels and very poor livelihood access.

6.3.1 Present Security *versus* Future Sustenance of Livelihoods

Orissa and Bihar are the two states where the present food access and livelihood access security as well as the future sustenance is low. Madhya Pradesh, Uttar Pradesh and Meghalaya are the states where the present security is low but the future sustenance is moderately high. Arunachal

SUSTAINABILITY OF FOOD ACCESS



Map No. 6.1

Table 6.3

Composite Index of Sustainable Food Access

S.No	States	1 Index of Food Access Security (FASI) (0.25)	Rank	2 Index of Food Access Sustenance (FASUI) (0.75)	Rank	3 Composite Index of Sustainable Food Access WACI (FASI*.25+FASUI*.75)	Rank
1	Andhra Pradesh	0.450	**9**	0.315	**21**	0.349	**16**
2	Arunachal Pradesh	0.268	**19**	0.637	**1**	0.544	**2**
3	Assam	0.355	**15**	0.378	**11**	0.372	**14**
4	Bihar	0.077	**25**	0.211	**24**	0.178	**25**
5	Goa	0.990	**1**	0.399	**7**	0.547	**1**
6	Gujarat	0.498	**7**	0.367	**14**	0.400	**11**
7	Haryana	0.618	**5**	0.397	**8**	0.453	**6**
8	Himachal Pradesh	0.552	**6**	0.414	**5**	0.449	**8**
9	Jammu and Kashmir	0.700	**4**	0.390	**10**	0.467	**5**
10	Karnataka	0.414	**12**	0.397	**9**	0.401	**10**
11	Kerala	0.894	**2**	0.407	**6**	0.529	**3**
12	Madhya Pradesh	0.110	**24**	0.370	**13**	0.305	**21**
13	Maharashtra	0.305	**18**	0.216	**23**	0.238	**23**
14	Manipur	0.391	**13**	0.329	**18**	0.344	**17**
15	Meghalaya	0.244	**21**	0.351	**16**	0.324	**20**
16	Mizoram	0.348	**16**	0.417	**4**	0.399	**12**
17	Nagaland	0.235	**22**	0.572	**2**	0.488	**4**
18	Orissa	0.114	**23**	0.276	**22**	0.235	**24**
19	Punjab	0.748	**3**	0.351	**15**	0.450	**7**
20	Rajasthan	0.436	**10**	0.326	**19**	0.354	**15**
21	Sikkim	0.324	**17**	0.442	**3**	0.413	**9**
22	Tamil Nadu	0.435	**11**	0.203	**25**	0.261	**22**
23	Tripura	0.372	**14**	0.319	**20**	0.332	**19**
24	Uttar Pradesh	0.253	**20**	0.374	**12**	0.343	**18**
25	West Bengal	0.465	**8**	0.341	**17**	0.372	**13**

Pradesh and Nagaland are the two states where the present security is low, whereas the future sustenance is high. Maharashtra and Tamil Nadu are the states where the present security is moderate whereas the future sustenance is very low. Jammu and Kashmir, Haryana, Punjab, Kerala and Goa are the states where the present security is high whereas the future sustenance is moderate. Gujarat, Rajasthan, Himachal Pradesh, Karnataka, Andhra Pradesh, West Bengal, Assam, Tripura, Manipur, Mizoram and Sikkim are the states where both the present security and future sustenance are moderate.

PART III

FOOD ABSORPTION

CHAPTER 7

Food Absorption and Environmental Hygiene

Food absorption is the biological utilization of food in the body. The food we eat is digested and assimilated in the body and used for growth and development. Nutrition is, thus, a function of the quality of the food consumed. The manner in which nutrients become an integral part of the body and contribute to its proper functioning depends on the physiological and biochemical processes taking place within the body. The health of an individual is a function of the quality of the environment in which she/he lives, such as clean air, clear water and clean food, and the type of lifestyle maintained. This is facilitated through adequate sanitation, primary health care and education.

Rapid industrialization, urbanization and agricultural modernization have occurred with the least regard to the quality of the environment. Industries have pumped in a lot of chemicals into the air, rivers and, increasingly, into groundwater sources. Cities have contributed to excessive accumulation of solid waste and sewage. Urbanization brings with it motorized transport and high levels of chemical pollution in the air. Modern agriculture relies on external inputs, pumps in a lot of chemicals into soils and water sources and depletes the soil of its natural micronutrients like zinc, manganese, copper and molybdenum that are essential for human nutrition.

As the quality of the environment deteriorates, the quality of the food and water consumed and the air we breathe goes down, and the susceptibility to disease increases. Malnutrition is an important cause worldwide for the death of children under five, every year, from preventable diseases and infections, such as measles, diarrhoea, malaria and pneumonia, or from some combination of these. Several socio-economic and environmental factors contribute to malnutrition, such as low income and lack of housing, water, sanitation, assets and access to health services. Inadequacy of safe drinking water is an important determinant of environmental pollution. A high rate of infant mortality is the major outcome of malnutrition and inadequate environmental hygiene.

The following discussion first looks at how micronutrient deficiency in the soil affects the micronutrient quality of food produced and the possible impact of malnutrition on human health. The second part addresses the various pollution factors that affect the quality and productivity of the environment. This part details water pollution, air pollution and toxins in the environment and addresses their impact on human health. These issues have been related to infant mortality and lowered life expectancy. It has been possible only to bring out the interrelationships between environmental deterioration, micronutrient deficiency in the soil and in the food produced and the associated health problems. Paucity of data at the state level has made it difficult to analyze in-depth the cause and effect relationship between the above factors.

7.1 Micronutrient Deficiency in Soil, Malnutrition and Health

A steady decline in micronutrient content in the soil has been reported in the intensively cultivated agricultural areas in the country. Repeated monocropping by fertility-depleting crops have resulted in soils with reduced micronutrient content: refill and replacement of locally adapted, more nutritious crops such as millets and legumes with superior cereals such as rice and wheat and non-food grains such as sugarcane is inadequate. As early as the 1980s, deficiencies in zinc (in 47 per cent of the soils analyzed), manganese (in 5 per cent), iron (in 11 per cent) and sulphur have been detected. This has been observed particularly in the highly irrigated and intensively cropped agricultural lands of Punjab and Haryana, which give very high crop yields (CSE 1982; Kanwar 1998).

Micronutrient deficiency in soil affects the quality of food produced. This in turn affects the micronutrient intake in humans and animals. Each one of these micronutrients in the right quantities is necessary for the body. Malnutrition arising out of micronutrient deficiency affects the health of the person and in turn affects the capacity of the body to absorb and assimilate food.

India alone has 204 million undernourished people and the South Asian sub-region accounts for more than one-third (284 million) of the world total.[1] More than half of all children under the age of four in India are malnourished; 30 per cent of newborns are significantly underweight and 60 per cent of women are anaemic (World Bank 1999). Malnutrition is one of the prime causes of Low Birth-Weight (LBW) in newborn babies. LBW survivors are likely to suffer growth retardation and illness throughout their life. Growth-retarded adult women are likely to carry on the vicious cycle of malnutrition by giving birth to LBW babies. Malnutrition can result in blindness or death among children; it contributes to decreased physical growth and impaired resistance to infections, with consequent increased mortality in young children[2]. Malnutrition in early life, including the period of foetal growth, is thought to result in chronic health disorders such as coronary heart diseases, diabetes and high blood pressure later in life.[3]

Some of the micronutrient deficiencies in the body arising from nutrient deficiency in the food consumed and the health impacts of these deficiencies, commonly reported in India, have been highlighted. Some are deficiencies in minerals such as zinc, manganese and sulphur along with the more commonly reported deficiencies of iron and iodine. Apart from mineral deficiency, one of the most common forms of nutritional deficiency is vitamin deficiency.[4]

Epidemiological studies have revealed that low plasma levels of zinc may be related to abnormal pregnancy outcomes. Zinc is a critical nutrient for central nervous system and immunological development of the infant. Its deficiency adversely affects neurological and behavioural development in the foetus and infant, and the ability to resist respiratory and diarrheal diseases, which goes a long way in improving the life expectancy of the newborn baby. Another indirect indicator of zinc deficiency is

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[1] "Hunger and Malnutrition in the World", cited in www.feedingminds.org/info/background.html.

[2] Opportunities for Micronutrient Interventions (OMNI) Micronutrient Fact Sheets: India, http://www.jsi.com/intl/omni/indi_pub.htm

[3] Feeding Minds Fighting Hunger, www4.gu.edu.au/ext/unesco/theme_c/mod14/uncom14t01s01.htm

[4] Opportunities for Micronutrient Interventions (OMNI) Micronutrient Fact Sheets: India, http://www.jsi.com/intl/omni/indi_pub.htm

the high percentage of stunting in children.[5] Zinc deficiency has been shown to be associated with iron deficiency, a common phenomenon in women. Iron deficiency can result in growth retardation, low resistance to disease, long-term impairment in mental and motor development and impaired reproductive functions; it contributes to approximately 20 per cent of pregnancy-related deaths.[6]

Iodine deficiency tends to occur in regions where the soil is poor in iodine, as the foods grown in the soil will also be low in iodine.[7] Iodine deficiency may cause permanent brain damage, mental retardation, reproductive failure, decreased child survival and goitre.[8] The incidence of goitre is dominant throughout the sub-Himalayan states from Jammu and Kashmir to the northeast. There are some 170 million people who are exposed to iodine deficiency disorders. In an expectant mother, iodine deficiency can produce varying degrees of mental retardation in her infant.[9]

The consequences of poor nutrition and health are a reduction in overall well-being and quality of life and in the levels of development of human potential. Malnutrition can result in productivity and economic losses, as adults afflicted by nutritional and related disorders are unable to work. There are also education losses, as children are too weakened or sickly to attend school or to learn properly. Health care costs arise out of caring for those suffering from nutrition-related illnesses. There is also significant cost to society for caring for those who are disabled.

Restoring micronutrients to the soil often requires an integrated use of micronutrients with organic manure and legumes in a multiple farming system. Another important aspect of improving nutrition is through food fortification. Putting an end to hunger necessarily starts with ensuring that enough food of adequate quality is produced and made available to everyone. However, increasing food grain production alone does not guarantee the elimination of hunger. Access by all people at all times to sufficient nutritionally adequate and safe food for an active and healthy life must be guaranteed.

7.2 Environmental Pollution and Health

The following section addresses the impact of different types of environmental pollution on health. Of all the pollutants, heavy metals, pesticides and organic compounds are of concern on account of their toxic nature. Many of the heavy metals and organic compounds are not broken down easily and tend to accumulate in the environment. Some enter the food chain. As they move up the trophic level in the food chain, they magnify in concentration, a process known as bioaccumulation or biomagnification, to levels that are toxic to the individual. Human beings at the top of the food chain stand to be affected the most. Pesticides, phenols, polychlorinated bi-phenyls and surfactants are some of the priority organic compounds of concern based on their prevalence and toxicity. For example, studies have reported that in Mumbai the fishes and prawns

[5] Dr. Nelly Zavaleta, 1998. Instituto de Investigacion Nutricional, Lima Peru, "Nutritional status in Peru: is zinc a common nutritional deficiency?" cited in http://www.iza.com/zhe_org/Articles/Art-01.htm

[6] op.cit., Feeding Minds Fighting Hunger

[7] Mineral Deficiency, http://www.genesishealth.com/micromedex/detaileddisease/00056740.aspx

[8] Feeding Minds Fighting Hunger, www4.gu.edu.au/ext/unesco/theme_c/mod14/uncom14t01s01.htm

[9] "Life Expectancy and Mortality India", cited in www.indianchild.com/ life_expectany_mortality_india.htm

consumed by people contain 100–200 times of excess bacteria and 8–10 times excess of heavy metals: lead is 30–50 times excess, mercury 7–25 times and cadmium 1.5–2 times excess.[10] Many of these are carcinogenic and mutagenic in nature. Their effects are felt not just by that generation exposed to the pollutants, but by future generations as well.

7.2.1 Water Pollution

In India, 14 major rivers provide about 85 per cent of the water that is used for agricultural, industrial and domestic purposes. Normally, water is free from contamination and is potable. The concentration of salts varies and hence the hardness of water is different at different places. Human sewage, industrial wastes, hospital waste and pesticides and fertilisers from agricultural farms have led to pollution of rivers and groundwater (Appendix 7.1; Appendix 7.2). Pollution alters the physical, chemical and biological properties of water (Appendix 7.3).

In India, it is estimated that only about 10–20 per cent wastewater generated from major towns and cities is being collected through sewerage (Central Pollution Control Board 2002a). Rural areas have very poor sewerage systems. Water-borne sewage systems are overburdened. Moreover, only around 30 per cent of urban populations have adequate sewage disposal, but scarcely any populations outside cities do. The uncollected wastewater gets washed-off into streams and other nearby water bodies or percolates and pollutes groundwater. As a result, almost all the rivers of India have high levels of fecal colliforms. The primary source of these bacteria are sewage and open defeacation.

Sugar mills, paper and pulp mills and tanneries are the major polluting industries. The three million small industrial units neither have nor can afford appropriate pollutant- disposal systems. They adopt cheap and polluting production technologies. Most of the solid waste and sludge gets scattered around or dumped in unlined pits. The effluents flow to nearby water bodies or stagnate in depressions to percolate or get washed off during the next rainy season.

Drainage waters from irrigated land are high in dissolved salts. For example, in Haryana, 40 kilometer-long drains pour 250,000 kilograms/day of chlorides into river Yamuna. This raises the chloride concentration from 32 milligrams/litre just upstream of the drain confluence to 150 milligrams/litre just downstream of it. Intensive use of fertilizers, pesticides, weedicides and other chemicals is adding a new facet to such pollution.

Significant other sources are leakage of toxic chemicals from storage areas or accidental spillage during transportation and handling; run off from city streets, from horticultural, gardening and commercial activities in the urban areas and from industrial sites and storage areas. Effluents, leachate and wash-over from cattle-farms and animal husbandry; drainage from wetlands and pollutants from aquaculture; deposition of air pollutants on to surface water and vegetation; disposal of highly mineralized mine drainage are other significant sources of pollution. Religious practices such as cremation on riverbanks, mass bathing and immersion of puja offerings in rivers add to the long list.

Of all the receptor systems exposed to the contaminants, groundwater has received little attention in the past because of the common belief that groundwater was pristine. Groundwater pollution is usually traced back to four main origins: industrial, domestic, agricultural overexploitation and geologic.

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[10] Cited in Centre for Science and Environment website, http://www.cseindia.org/ programme/ health/ healthfacts.htm

Overexploitation of groundwater has resulted in seawater intrusion in the coastal aquifers. Groundwater in certain geological formations may not be of desired quality for specific uses. Naturally occurring fluorides, arsenic and salinity are known to adversely affect the quality of drinking water supplies (CPCB 1996). Thirteen states in India have been identified as endemic to fluorosis because of the abundance in natural-occurring fluoride-bearing minerals. Fluorosis as a result of increased fluoride content in the water is endemic to 16 states of India (CSE 1998).

7.2.2 Air Pollution

Air pollution has become a major concern in India in recent years as some cities are exposed to some of the highest pollutant levels in the world. Vehicular emissions and industrial emissions are by far the largest contributors of air pollution in urban centres (Appendix 7.4). The number of vehicles in Gujarat has grown from 0.45 million in 1981 to 6.6 million in 2003. Correspondingly, the air pollution level in the city is 300 per cent higher than the accepted standard.[11] Rural population is exposed to indoor and outdoor pollution arising from biomass and coal burning, sometimes in even greater quantities than some of the urban centres, often 10 times more (Smith 2000). In the rural areas, about 97 per cent of households rely principally on biomass fuels such as dung, crop residues and wood (National Family Health Survey 1995). Several studies focusing on air pollution have brought have brought to light the lack of accurate information on air pollution levels and their impact on human health. This is particularly true of indoor pollution. The health hazards of air pollution have been briefly dealt in the next section.

7.2.3 Health Effects of Environmental Pollution

Slow and steady poisoning of the body's biophysical conditions as a result of constant exposure to unhygienic surroundings leads to recurrence of communicable diseases and more frequent abnormalities like cancer, severe respiratory diseases, hormonal disorders and physiological and genetic changes. We have considered the health-related impact of pollution from the standpoint of its impact on infants rather than adults because at this vulnerable stage of life, pollution may have substantial effects on life expectancy. Studies conducted worldwide have brought out the link between environmental pollution and infant mortality. By far, children younger than five bear the largest overall burden of environmental pollution.

Air pollution can result in considerable levels of morbidity and mortality. More than one lakh people die every year because of particulate pollution in India (Dietrich 1999). Studies conducted by the World Bank in 36 Indian cities have revealed that premature deaths on account of air pollution have gone up from about 40,000 in 1991–1992 to about 52,000 in 1995—an increase of 30 per cent (Carter *et.al* 1995). New Delhi, considered to be one of the most polluted cities in the world, had reported approximately 10,000 deaths in 1995, and another 25 million people were treated for various respiratory ailments such as asthma, bronchitis and allergic reactions. Data of asthma in children reported from Bangalore city reveal a steady increase from 1979 to 1999. This has been correlated with the almost exponential increase in the number of vehicles and industrial units (Table 7.1; Paramesh 2001). Similarly, 43 per cent of the children in Calcutta

[11] Report of the Central Pollution Control Board in *The Times of India*, Ahmedabad, 09/11/2003, cited in Centre for Science and Environment website, http://www.cseindia.org/ campaign/apc/ nov_dec2003.htm

city are suffering from respiratory disorders, such as allergic rhinitis, compared to 14 per cent among the rural children (Lahiri *et. al.* 2000). This has steadily increased. Studies have revealed that infants in cities with very high levels of particulate matter in the air are more likely to die from sudden infant death syndrome (SIDS) than those that live in areas with cleaner air (Chay and Greenstone, 2003). Studies reveal that for every one million children, 23 to 46 children may eventually develop cancer from the excess diesel exhaust they inhale (Solomon *et. al.* 2001).

Although, we have highlighted the frequent respiratory ailments, some of the pollutants, especially industrial pollutants, are carcinogenic and mutagenic.

Table 7.1

Increase in asthma in children in Bangalore city

Year	Incidence of asthma (in percent of children)	Number of vehicles (in lakh)	Numberof industrial units (in thousands)
1979	9.0	1.5	4.7
1984	10.5	2.4	7.9
1989	18.5	4.6	14.4
1994	24.5	7.2	25.8
1999	29.5	12.2	40.2

Source: Paramesh, H., 2001.

The Bhopal Tragedy of 2–3 December 1984, caused by massive leakage of methyl-iso-cyanate (MIC) from the Union Carbide pesticide plant, which killed between 2000 and 10,000 people and has affected the growth and development of subsequent generations, is testimony to the long-term impact of air pollution on health.

Studies conducted on the impact of air pollution on blindness revealed that 18 per cent of blindness in the total population in India might be attributable to the use of wood and dung for cooking. Women who have cooked on biomass stoves for many years exhibit a higher prevalence of chronic lung diseases than women who have not cooked on biomass stoves. A 50 per cent increase in stillbirths in women exposed to indoor smoke during pregnancy in Western India have been reported (World Bank 2000).

Water pollution also has a significant impact on human health. Humans may be exposed to toxic chemicals in water and consequently suffer various diseases. Animals also suffer from various chemical and pathogenic insults on consumption of water. Where proper sanitation facilities are lacking, water-borne diseases can spread rapidly. Untreated excreta carrying disease organisms wash or leach into freshwater sources, contaminating drinking water and food (Bowman 1994). Diseases directly influenced by hygiene, sanitation and water include, for example, *salmonella*, *shigella*, infectious diarrhoea, typhoid, cholera, hepatitis, malaria, trachoma (a cause of irreversible sight impairment) and fluorosis (which has both crippling skeletal and dental effects). In India, 60–80 per cent of water-borne diseases such as diarrhoea, dysentery, typhoid, jaundice and cholera are spread due to contamination of drinking water.

Diarrhoeal diseases may be considered to be the primary cause of early childhood mortality. They are linked to inadequate sewage disposal and lack of safe drinking water. Approximately 50 per cent of all illness is attributed to poor sanitation; in rural areas, about 80 per cent of all children are infected by parasitic worms. It is estimated that prevalence of anemia among young children may be as high as 90 per cent when hookworm infections are present.[12]

[12] "Life Expectancy & Mortality India", cited in www.indianchild.com/life_expectany_mortality_india.htm

Stagnant water bodies are also a breeding ground for mosquitoes, which can cause malaria, filariasis, dengue fever etc. The malaria epidemics around the Indira Gandhi Canal in Rajasthan and Bisalpur dam in Madhya Pradesh are examples (CSE 1985). Similarly, in the early 1990s, about 389 million people were at risk of infection from filaria parasites; 19 million showed symptoms of filariasis, and 25 million were deemed to be hosts to the parasites.[13]

Contamination of groundwater and rural drinking water supplies by nitrates from livestock and human excrement, other organic waste, or chemical fertilizers are a potential health hazard. This particularly affects infants who drink contaminated milk and baby food. Infants having high levels of nitrates in their bloodstream suffer a condition called *methaemoglobinaemia* or 'blue-baby syndrome'. In such cases the body of the infant becomes progressively starved of oxygen and turns blue. With continuous exposure to high levels of nitrates the baby eventually dies (Pretty and Conway 2003).

7.3 Access to Safe Drinking Water

Safe drinking water is one of the most important factors that directly influence human and animal health. The most significant environment problem and threat to public health in rural and urban India is deterioration of drinking-water quality, which has seriously threatened the availability of safe drinking water. Many water-borne infections spread because of unsafe drinking water.

However, the word 'safe' needs further qualification. As per census of India, if a household has access to drinking water supplied from a tap, or a hand pump or tube well situated within or outside the premises, it is considered as having access to safe drinking water. Further, the lack of piped water supply in the household or in the vicinity would require spending a long time in fetching water from long distances. Piped water reduces drudgery and improves the productivity of labour. However, 'safe' is only an assumption. Though water from these sources is relatively safer than other sources, it is however possible for all these sources to get contaminated as a result of improper water treatment at the source of sewage infiltration into the sewer systems. State-wise evaluation of data reveals that Punjab, followed by West Bengal, has the highest number of households having access to safe drinking water. Only 18 per cent of Kerala households show access to safe drinking water; but the table does not consider wells as the source of water and they are very often dug by the family themselves (Table 7.2, Map 7.1).

For urban India as a whole, about 70 per cent of the drinking water supplied has been through taps. About 21 per cent comes through tube wells and hand pumps installed in some areas. Both in 1988 and 1998, around 70 per cent of urban India received safe drinking water through taps and municipal water supplies. The percentage of population covered has declined slightly from 72.2 per cent to 70.1 per cent. The provision of water through tube wells and hand pumps has increased from 17.2 per cent to about 21.3 per cent. It clearly shows that urban areas have not made any long-term arrangements to provide piped water to their residents. There has been heavy reliance on groundwater for all purposes. The total urban population covered by safe drinking water consists of about 91 per cent. There is still about 10 per cent of the population who do not get safe drinking water. An estimated 15 per cent of urban households do not get sufficient drinking water throughout the year.

[13] "Life Expectancy & Mortality India", op.cit.

Table 7.2

Index of Food Absorption

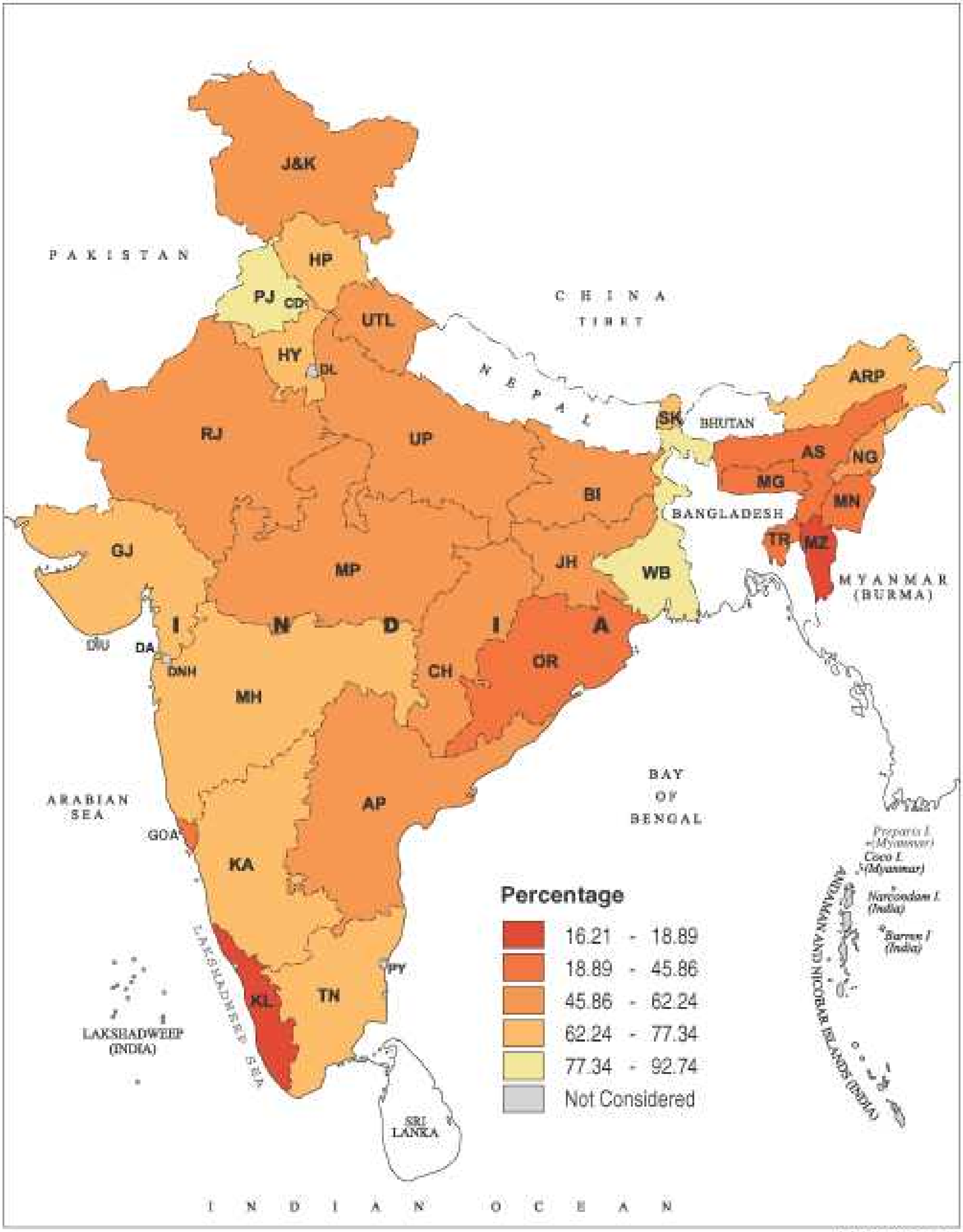
		1		2		3	
S.No	States	Percentage of households with access to safe drinking water 1991	Index	Infant Mortality Rate 1999	Index	Index of Food Absorption ABI	**Rank**
1	Andhra Pradesh	55.08	0.508	66.00	0.441	0.441	**19**
2	Arunachal Pradesh	70.02	0.703	43.00	0.677	0.677	**4**
3	Assam	45.86	0.387	76.00	0.320	0.320	**23**
4	Bihar	58.76	0.556	66.00	0.465	0.465	**18**
5	Goa	43.41	0.355	21.00	0.635	0.635	**7**
6	Gujarat	69.78	0.700	63.00	0.555	0.555	**12**
7	Haryana	74.32	0.759	68.00	0.554	0.554	**13**
8	Himachal Pradesh	77.34	0.799	62.00	0.610	0.610	**8**
9	Jammu and Kashmir	52.60	0.475	50.00	0.521	0.521	**14**
10	Karnataka	71.68	0.725	58.00	0.597	0.597	**10**
11	Kerala	18.89	0.035	14.00	0.518	0.518	**15**
12	Madhya Pradesh	53.41	0.486	91.00	0.279	0.279	**24**
13	Maharashtra	68.49	0.683	48.00	0.637	0.637	**6**
14	Manipur	38.72	0.294	25.00	0.581	0.581	**11**
15	Meghalaya	36.16	0.261	56.00	0.377	0.377	**21**
16	Mizoram	16.21	0.000	19.00	0.470	0.470	**16**
17	Nagaland	53.37	0.486	21.00	0.701	0.701	**2**
18	Orissa	39.07	0.299	97.00	0.150	0.150	**25**
19	Punjab	92.74	1.000	53.00	0.765	0.765	**1**
20	Rajasthan	58.96	0.559	81.00	0.376	0.376	**22**
21	Sikkim	73.05	0.743	49.00	0.661	0.661	**5**
22	Tamil Nadu	67.42	0.669	52.00	0.606	0.606	**9**
23	Tripura	37.18	0.274	42.00	0.468	0.468	**17**
24	Uttar Pradesh	62.24	0.601	84.00	0.379	0.379	**20**
25	West Bengal	81.98	0.859	52.00	0.701	0.701	**3**

IMR for rural areas of Nagaland is not available and hence the combined IMR of Nagaland is obtained using Urban IMR of Mizoram

In the months of April, May and June, about 11 to 15 per cent of households face severe drinking-water shortages. In many urban areas, those facing shortages resort to buying water or borrowing from neighbours who get water. About 18 per cent of urban households also depend on supplementary sources of supply (National Sample Survey 1999). Drinking water has been available either within the house or within the premises of dwellings for about 75 per cent of the households in urban areas. The remaining 25 per cent had to walk a distance of about half a kilometre or so.

Whereas for urban India as a whole the percentage of population without access to safe drinking water

HOUSEHOLDS HAVING ACCESS TO SAFE DRINKING WATER



Map No. 7.1

was not high, it varied widely across the States. We have used the NSS 49th Round 1995–1996 data, as the 1998 data were not available for all the states. Kerala had about 60 per cent of households without safe drinking water facilities. In urban Kerala, the main source of drinking water was not from taps and tube wells, but dug wells. Hence, it shows a high percentage without access to safe drinking water. There was no information on the quality of well water in urban Kerala. The percentage not having access to safe drinking water had come down to 56.2 per cent in 1998–1999, showing that an effort was being made to supply more people with water through taps and tube wells. In Orissa and Assam, about 25 per cent of the population depended on sources other than taps and tube wells in 1995–1996; in Orissa in 1998–1999 the percentage without access to safe drinking water increased to about 30 per cent. In Assam, the percentage declined to about 20 per cent. Tamil Nadu as well as Bihar had about 12 per cent population depending on unsafe sources however, in Tamil Nadu, this had declined to about 7.2 per cent.

The most significant environmental problem and threat to public health in rural India is deterioration of water quality. This has seriously threatened the availability of safe drinking water. The central and the state governments have taken initiatives to provide access to safe drinking water. The Accelerated Rural Water Supply Programme (ARWSP) was introduced in 1972–1973 by the Government of India to assist the states and union territories to accelerate the pace of coverage of drinking-water supply.

Millions of people in the country suffer from water-borne diseases on account of lack of access to safe drinking water. Punjab, followed by West Bengal, has the highest number of households having access to safe drinking water.

The National Family Health Survey (NFHS) surveyed the population having access to safe drinking water to 78 per cent in 1998-99 as against 62 per cent in 1991. The NSS 52nd round [1995-96] gives the distribution of households having access at the state level to be 77 per cent through tap or tube wells / hand pumps and 18 per cent to pucca well.

7.4 Infant Mortality Rate

Infant Mortality Rate (IMR), or the annual number of deaths of children under the age of one per 1,000 live births, is a sensitive indicator of infant population's health as well as socio-economic development. In addition, IMR is an indicator of the availability, utilization and effectiveness of health care, particularly pre-natal care (WHO 1981). The infant mortality rates have improved over time in India. Infant mortality decreased by 14.73 per cent between 1971 and 1981, 27.27 per cent between 1981 and 1991 and by about 15 per cent between 1991 and 2000.[14] The most recent figures show that the rate was 68 per 1000 live births (Sample Registration System 2000). Still, given India's population size, the number of infants dying each year is staggering.

In less-developed countries with poor nutritional and healthcare facilities, the chances of dying are greatest at infancy and remain high during the first few years of childhood. A newborn child is fragile and has not developed immunities to common ailments. Afflicted with diseases, they start their lives at a disadvantage and it is reflected throughout their life. When a country has a high rate of infant death, it usually signals high mortality risk from infectious, parasitic, communicable and other diseases associated with poor sanitary conditions and malnourishment. As a result, IMR is considered one of the most sensitive measures of a nation's health. IMR is also

[14] Survey results of Sample Registration System, Office of the Registrar General, 2000, cited in www.indiatogether.org/photo/2003/inf-mortal.htm.

an indirect measure of the ill health of the mother, and the resulting inability of the mother to provide sufficient nutritional care for her baby. It is also indicative of the inhospitable environmental circumstances of the household.

It is estimated that 1.5 million pre-school children in India die every year from diarrhoea. Reports of several deaths of children under five due to air-borne and water-borne diseases clearly spells lack of proper environmental hygiene. In India, infant mortality accounts for the bulk of under-five mortality. Illness, from lack of hygiene and low living standards, is frequently a consequence of malnutrition. Malaria, a major cause of child deaths in large parts of the world, also takes a major toll on child growth and development. The disease also has dangerous nutritional consequences for pregnant women. In addition, pregnant women are more susceptible to malaria, and children born to mothers with malaria run a greater chance of being born underweight and anaemic.

Data show that Madhya Pradesh (133) followed by Orissa (125) has very high IMR. The all-India average IMR is about 77. Arunachal Pradesh, Assam, Gujarat, Himachal Pradesh, Meghalaya, Rajasthan, Tripura and Uttar Pradesh have IMR higher than the national average. The lowest IMR has been recorded in Manipur (28) (Table 7.2, Map 7.2).

The data for IMR in rural areas for 1997 show that Orissa and Madhya Pradesh occupy the worst position with about 100 deaths per thousand live births. Rajasthan and Uttar Pradesh follow close behind. Kerala is in the best position with only 11 infant deaths per thousand births. Punjab, Maharashtra, Tamil Nadu and West Bengal show infant mortality rates ranging between 54 and 58 deaths per thousand live births. These are the next best states. They are no match to the achievement of Kerala at 11 per thousand. Most states have a rate of 60 to 70 deaths per thousand live births (MSSRF 2001).

The data we have used pertains to the 1997–1999 period. It was found that Orissa occupied the worst position with 65 deaths per 1000 live births, followed by Uttar Pradesh at 64 deaths. Rajasthan and Haryana occupy the third and fourth worst positions with 59 and 58 deaths respectively. Jammu & Kashmir was in the best position with 6 infant deaths per thousand births. Pondicherry occupies the second best position, with 15 deaths per 1000 births followed by Kerala and Karnataka with 16 and 24 deaths per 1000 births respectively. Other states fall in between (MSSRF 2002).

7.5 Index of Food Absorption

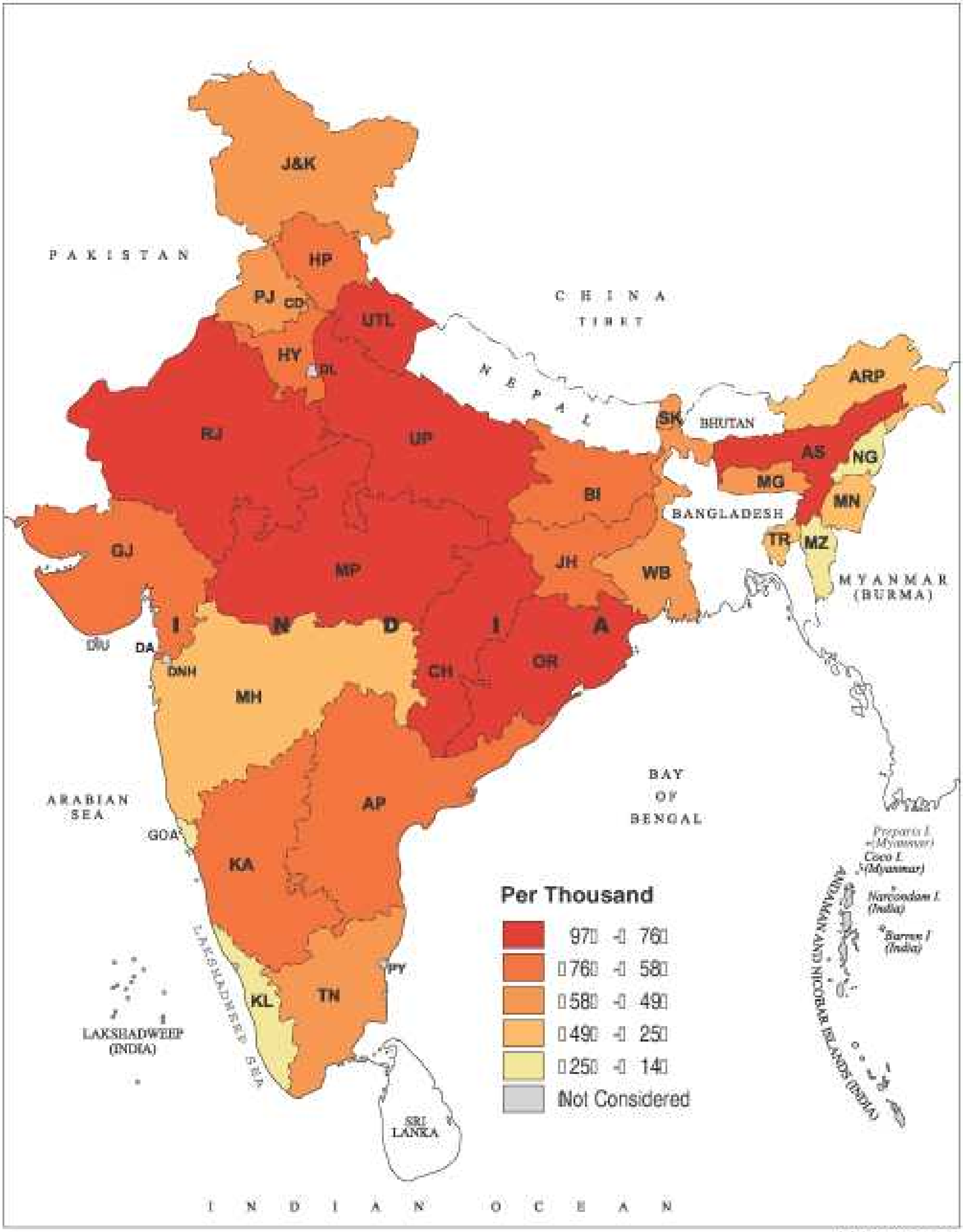
The indicators for the sustainability of food absorption, namely, percentage of households with access to safe drinking water and infant mortality rates, have been aggregated together to calculate the index (Table 7.2). The correlation of the indicators is presented in Appendix 7.6. All the same, this index is intended to measure the effect of environmental hygiene on the health of the people. The relative position of the states are shown in the map (Map 7.3)

7.5.1 Position of the States

Areas shaded dark green on the map: The most sustainable state with regard to Food Absorption is Punjab followed by Nagaland, West Bengal, Arunachal Pradesh and Sikkim. The infant mortality rates are very low compared to other states. The access to safe drinking water is very good in these states.

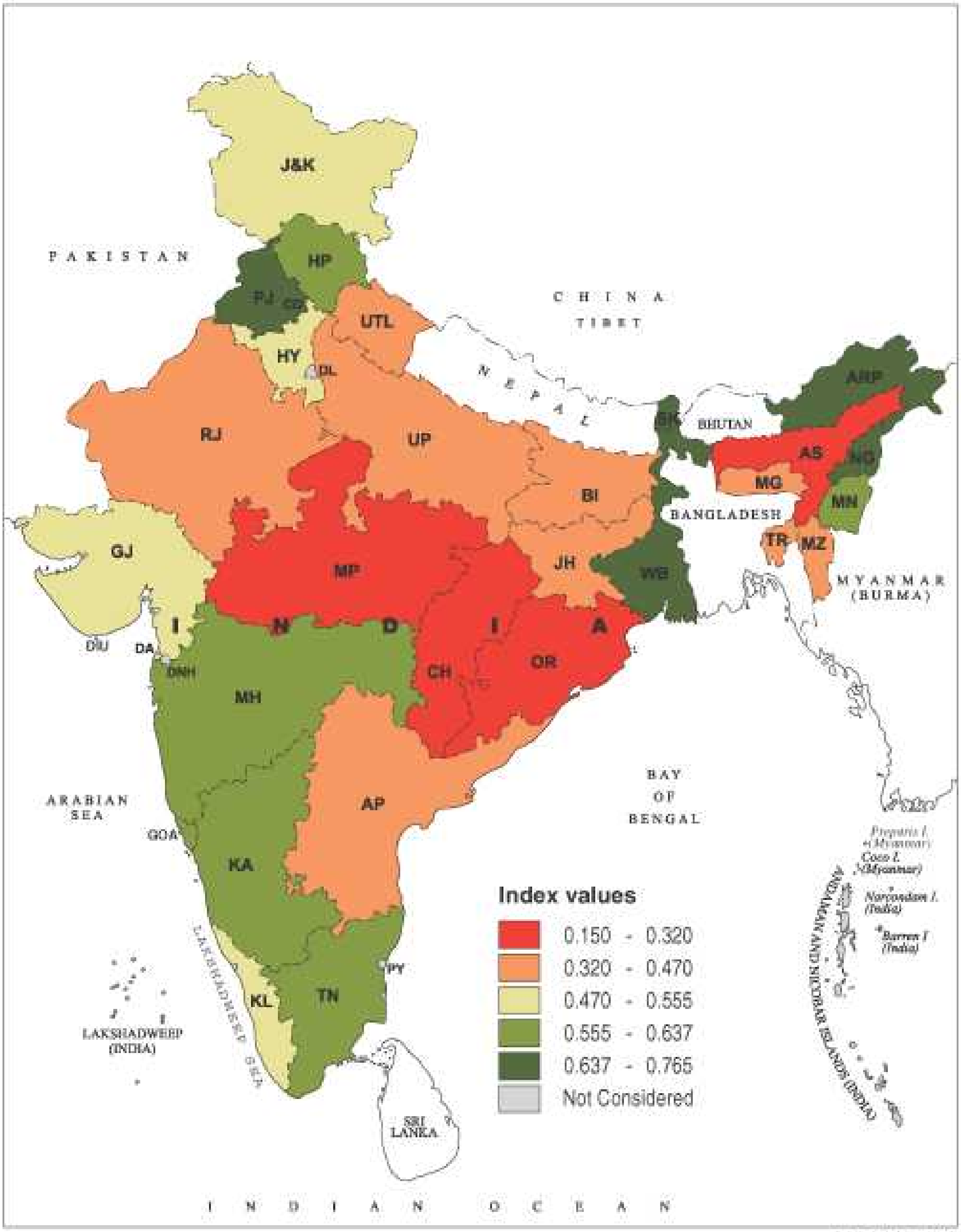
Areas shaded light green on the map: There are six states in the moderately sustainable category. They are Manipur, Karnataka, Tamil Nadu, Himachal

INFANT MORTALITY RATE



Map No. 7.2

FOOD ABSORPTION



Map No. 7.3

Pradesh, Goa and Maharashtra. Manipur and Goa have poor access to safe drinking water and have low IMR. Karnataka, Tamil Nadu, Himachal Pradesh and Maharashtra have good access to safe drinking water and also the infant mortality rates are low.

Areas shaded yellow on the map: The four states in the moderately unsustainable category ranging from 0.470 to 0.555 are Kerala, Jammu and Kashmir, Haryana and Gujarat. Kerala has a low IMR. Its higher literacy rates, lower population growth rates and better health care facilities have contributed to low IMR. The consideration for access to safe drinking water as provided in the National Human Development Report[15] does not include dug-wells. Kerala is thus an aberration because of the wide use of groundwater for drinking through open dug-wells. The other states have better access to safe drinking water.

Areas shaded orange on the map: Rajasthan, Meghalaya, Uttar Pradesh, Andhra Pradesh, Bihar, Tripura and Mizoram are the seven states in the unsustainable category that have a sustainability index value ranging from 0.320 to 0.470. In Meghalaya, Tripura and Mizoram the IMR is very high, but access to safe drinking water is poor. In Uttar Pradesh, Rajasthan and Andhra Pradesh, the IMR is high although access to safe drinking water is good. Hence the cumulative picture of absorption of food is not very good in these states.

Areas shaded red on the map: There are three states in the extremely unsustainable category with the index value ranging from 0.150 to 0.320. They are Orissa, Madhya Pradesh and Assam. The Infant Mortality Rates are very high in Orissa and Madhya Pradesh. Access to safe drinking water is very bad in Orissa, followed by Assam and Madhya Pradesh. The development of tube wells for withdrawing groundwater, the extension of the Rajiv Gandhi Drinking Water Scheme to cover more rural villages, etc are likely to have increased the drinking water scenario in the intervening period. High levels of poverty and illiteracy have caused severe micronutrient deficiency in these states.

[15] National Human Development Report, 2001.

PART IV

TOWARDS SUSTAINABILITY OF FOOD SECURITY

CHAPTER 8

Food Production and Market Forces

The discussion on the sustainability of food production is not complete without a reference to the decelerating growth in food production in the face of increasing population and incomes. It is important to examine the prospects of food production for the future, in the backdrop of environmental degradation of land and water resources. Demand on agriculture for food, fodder, fibre and other forest produce is bound to increase many-fold. Several projections have examined the capacity of the crop production sector to meet the projected demand for staple food. The demand and supply together determine whether we can produce enough or not.

Markets influence the use of natural resources. The input market and output markets for agricultural products are equally important. Indian agriculture is no longer insensitive to prices. As the economy gets more and more monetized, the need for cash income increases. Hence all farmers, big and small, would like to sell at least some part of their produce in the market. Some of the sales could also be distress sales. Most of the small farmers are net consumers. Marginal farmers sell their produce at low prices soon after harvest to repay the loans taken during the lean seasons. They take loans again for food consumption and buy back their produce at a higher price for consumption.

In the past six decades since independence, market forces have played an important role in shaping Indian agriculture. Input price incentives and output price incentives have been extensively used as instruments to achieve higher production of the desired commodities. In recent years, changing consumer choices to non-cereal foods and export and import demands have influenced output decisions in agriculture. Market prices are instrumental in changing the crop patterns in many regions.

This chapter deals briefly with these issues at the all-India level. The first section examines the rates of growth of food production to see if there has been any significant deceleration in the production. The second section discusses several studies on demand and supply projections and the gap expected in future. The third section examines the working of the input markets and the output markets and the likely impact on food production.

8.1 Deceleration of Growth Rates

The contribution of agriculture to the gross domestic product has been about 24 per cent in recent years. It provides livelihoods for two–thirds of the workforce of the country (Vyas 2003). India has made progress in agriculture since independence in terms of growth in output, yields and area under many crops. Indian agriculture as a whole has shown a growth rate of about 2.5 per cent per annum since independence despite high dependency on monsoons and climatic conditions. In order to sustain a growth rate of 7 per cent or so in the economy, the Indian agricultural sector has to show a growth rate of at least 4 per cent (Association of Indian Progressive Study Groups 1999).

The annual rate of increase of production of major crops has been mediocre at best in the past one and a half decades. The performance of the agricultural sector may be assessed with growth rates of production and yield. There are other measures as well that can be used to evaluate this sector's performance. The decadal rate of growth of production, area and yield has been estimated from the beginning of the planning period i.e. 1950 to 2000 for rice, wheat, coarse cereals, total pulses, sugarcane and oilseeds. Due to the paucity of data, the decadal growth rate for fruits and vegetables, milk, fish, egg and broiler production is restricted to more recent years. The log-linear trend equation of the form has been used to measure the rate of growth of production[1]. The performance of the agriculture sector in terms of growth rate of production, yield and area is reviewed for all the decades since independence.

$$\text{Ln } Y = a + bT \text{ —— (1)}$$

Where,

T is the time, varying for 1950–1960, 1960–1970, 1970–1980, 1980–1990 and 1990–2002

Y stands for production or yield or area.

A variant of the log-linear model with a dummy variable is used to estimate and compare the growth rates of two sub periods 1981–1990 and 1991–2000[2]. This model is used to determine whether the rate of growth is significantly different between the two periods. The model used in the study is as follows:

$$\text{Ln } Y = a_0 + a_1(D) + b_0 T + b_1 T \text{ —— (2)}$$

Where,

T is the time, varying from 1980–1981 to 1999–2000.

D = 0 for 1980–1981 to 1989–1990 and

D = 1 for 1999–1991 to 1999–2000

The Decade After Independence – 1950 to 1960: Top priority was accorded to irrigation and agriculture in the first decade of planning. Heavy budgetary inflows fuelled multi-purpose river valley projects to cater to the thirsty fields of millions of farmers. There was also a thrust on land reforms to remove functionless intermediaries and provide lands to the tillers. The strong impetus to agriculture during this decade brought forth positive results almost in all crops. The growth rate of production, area and yield of coarse cereals, total pulses, oilseeds, sugarcane and rice has been the highest in 1950–1960 compared to all the decades and has also been statistically significant for most of the crops. The decadal growth rate of coarse cereal production was as high as 3.59 per cent and the yield grew at a rate of 2.30 per cent (Table 8.1). Total pulses experienced a high, positive and significant growth rate of 4.02 per cent in production in this decade. The area under pulses grew as well at 3.08 per cent, which was the highest compared to the following decades. Sugarcane, oilseeds and rice witnessed high significant rates of growth of production of 3.83 per cent, 4.02 per cent and 4.36 per cent respectively. Wheat, among all the other crops, did not witness its peak during this decade; it did so only in the following decade. Nevertheless the growth rate of production was significant at 5.04 per cent and the growth rate of area under wheat was the highest compared to the other decades at 3.97 per cent.

Performance of Major Food Crops from 1960 to 1970: Compared to 1950–1960, which proved to

[1] The growth rate refers to the compounded annual rate of growth

[2] When two sub periods are considered, the rate of growth of the first sub period is given by the coefficient b_0 in the second equation. The rate of growth of the second sub period is given by the sum of coefficients $b_0 + b_1$. The significance of b1 shows whether growth rate of the second sub period is significantly different from the first sub period.

Table 8.1

Decadal Growth Rate of major food Items

Food Item	1950-60			1960-70			1970-80			1980-90			1990-2002		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Rice	1.26*	4.36*	3.1*	0.83*	1.18	0.36	0.87*	1.88	1.01	0.41	3.55*	3.14*	0.41*	3.55*	3.14*
Wheat	3.97*	5.04*	1.08	2.23*	6.59*	4.37*	2.37*	4.22*	1.86*	0.45	4.22*	3.06*	0.95*	2.78*	1.83*
Coarse Cereals	1.3*	3.59*	2.3*	0.66*	1.5	0.84	-0.87	1.11	1.98*	-1.35	0.35	1.7	-1.68	0.35	2.03*
Total Pulses	3.08*	4.02*	0.94	-1.33	-1.29	0.03	0.59	-0.39	-0.99	-0.1	1.48*	1.58*	-0.67	-0.31	0.36
Sugarcane	2.55*	3.83*	1.28*	0.63	1.78	1.13	1.88*	2.51*	0.65	1.45*	2.68*	1.21*	1.77*	2.4*	0.63*
Oil Seeds	2.47*	4.02*	1.55*	0.4	0.29	-0.11	0.4	0.73	0.33	2.41*	5.31*	2.9*	-0.71	1.55*	2.26*
Milk	—	—	—	—	—	—	—	—	—	—	5.27*	—	—	4.2*	—
Fish	—	—	—	—	—	—	—	—	—	—	4.3*	—	—	3.68*	—
Egg	—	—	—	—	—	—	—	—	—	—	8.12*	—	—	4.25*	—
Broiler	—	—	—	—	—	—	—	—	—	—	—	—	—	10.15*	—

Source: Estimated from the data published in GOI, Planning commission website. Area, production and yield of principal crops,2003

Note: * Denotes Statistical significance at 5% level be quite a brilliant decade in terms of agricultural production expansion, the performance in 1960–1970 was disappointing. The growth rate of production of coarse cereals, sugarcane, oilseeds and rice was as low as 1.5 per cent, 1.78 per cent, 0.29 per cent and 1.18 per cent respectively. The rates of growth of all these crops were statistically insignificant. Total pulses even witnessed a negative rate of growth of –1.29 per cent during this decade. The rate of growth of production was high only for wheat at a significant 6.59 per cent. The reason for such a poor performance in the 1960s was that India suffered consecutive droughts affecting the yield and hence total production. This largely led to rampant food shortage necessitating imports. The yield growth rates for coarse cereals, total pulses, rice and oil seeds were as low as 0.84 per cent, 0.03 per cent, 0.36 per cent and – 0.11 per cent respectively.

Performance of Major Food Crops from 1970 to 1980: The agriculture sector showed a very small improvement between 1970 and 1980. The rates of growth of production of rice, coarse cereals and oilseeds were positive but insignificant at 1.88 per cent, 1.11 per cent and 0.73 per cent respectively. The rate of growth of yield for total pulses was negative at –0.99 per cent. Oilseeds, sugarcane and rice had low positive but insignificant growth. Total pulses showed a negative growth of production (–0.39 per cent) whereas for wheat, the rate of growth of production and yield were high, positive and significant. The rate of growth of production of wheat was 4.22 per cent for the decade. The positive trend for wheat was due to the Green Revolution, which increased the productivity of wheat in the 1970s by the introduction of high yielding varieties, improved use of inputs, etc. The thrust was to increase production through the increase in yields rather than through area expansion, which means it entailed increased irrigation, fertilizers, extension services, etc.

The Green Revolution in fact was unfolding a process that gave rise to a series of revolutions over the next 25 years or so. More wheat meant more crop residue for animals, which spurred the milk revolution in 1971. Total pulses and oilseeds witnessed a positive and significant growth compared to an abysmally low rate of growth in the previous decades. The rates of growth of production of total pulses increased to 1.48 per cent from –0.39 per cent in 1970–1980 and oilseeds increased to 5.31 per cent from a mere 0.73 per cent in the previous decade. The rate of growth of production of coarse cereals has been on a decline since the 1960s largely due the decreased demand for such crops and a greater demand in superior crops like rice and wheat. Price supports for rice and wheat, distribution of rice and wheat in the Public Distribution System and lack of support for other crops were also instrumental for the declining cultivation of coarse cereals.

Performance of Major Food Crops from 1980 to 1990: The 1980s was a particularly good decade for rice. The production and yield growth of rice was very favourable. Rice productivity depends heavily upon the quantity of water and it appears that till 1980, the productivity gain for rice was entirely due to irrigation. However, irrigation systems at this juncture were also undergoing a major shift. Dam-based canal irrigation was the dominant mode until the 1980s. However, there was a slow shift towards groundwater-based lift irrigation systems as more and more bore-wells and tube-wells were drilled and quickly energized to provide water to farmers' fields. The considerable breakthrough after the mid seventies was the shift of control and management of lift irrigation to rice farmers from departmental hands, which reflected in increasing productivity of rice after 1980. The rate of growth of production and yield of rice was 3.55 per cent and 3.14 per cent respectively and was statistically significant. Rice had witnessed a considerable growth since the previous decade. The rate of growth of production of rice was low and insignificant at 1.88 per cent during 1970–1980 but significantly increased to 3.55 per cent in 1980–1990. Sugarcane is yet another water-driven crop which has a similar pattern as rice. The rate of growth of area, production and yield was positive and statistically significant for rice and sugarcane. The rate of growth of production increased to 2.68 per cent from 2.51 per cent in the previous decade and the acceleration was significant. The rate of growth of production of wheat stagnated but there was significant growth of yield during 1980–1990. The 1980s proved particularly good also for oilseeds. The rate of growth of oilseeds production increased to 5.31 per cent from a meagre 0.73 per cent in the preceding decade and the yield was the highest in 1980–1990 compared to the other decades.

Performance of Major Food Crops from 1990 to 2002: There was a paradigm shift in the thinking and state of affairs after 1991. In the recent decade gross capital formation and Government spending on agriculture has massively declined. All the major crops have witnessed a marked decline in production and yield in the post 90s. The rate of growth of production of rice has significantly decelerated from a 3.55 per cent in the previous decade to 1.93 per cent in 1990–2002. Wheat witnessed massive rates of growth of production and yield from 1960–1990. However, these growth rates have fallen in the recent decade. The rate of growth of production has fallen from a 4.22 per cent in 1980-90 to 2.78 per cent in 1990-02 and the yield also has suffered a significant drop from 3.06 per cent in the eighties to 1.83 per cent in the nineties. Total pulses witnessed a revival between 1980 and 1990 but in the recent decade it experienced a negative rate of growth of production of –0.31 per cent. The rate of growth of production and yield of oilseeds peaked between 1980 and 1990 but has significantly decreased in 1990–2002. The rate of growth of production has fallen from a 5.31 per cent in 1980–1990 to 1.55 per cent in 1990–2002 and the yields have fallen from a 2.90 per cent to 2.26 per cent.

To determine whether there were significant changes in the production of major food crops, milk and eggs in the sub period 1981–1990 and 1991–2000 equation (2) was used. The rate of growth of total cereals production was significant at 2.8 per cent during the first period considered (1981–1990) but there was a significant deceleration in the rate of growth to 2.17 per cent in the next sub period (1991–2000). The yields of cereals also showed a similar tend. Total pulses have shown a dismal performance in both the sub periods. The rate of growth of production declined from 1.47 per cent growth in 1981–1990 to a mere 0.65 per cent in 1991–2000. The rate of growth of yield also declined. It was insignificant in the second sub period (Table 8.2 and 8.3).

Changes in the total Food Grains: Total food grains had a positive significant growth in production during the sub period 1981–1990 of about 2.69 per cent, but there was a marked but insignificant decline to 2.06 per cent in the growth in the 1990s. The rate of growth of rice production was high, positive and significant in 1981–1990 at 3.5 per cent, but declined to 2 per cent in the 1990s. Wheat and sugarcane have witnessed the same trend as rice in terms of production. The rate of growth of yield of rice and wheat took a significant plunge in 1991–2000.

Trends in the Production of Other Foods: The decade of the 1980s saw a breakthrough in the production of fish and poultry but the rate of growth of fish, milk and egg has significantly decreased in 1990–2002 as compared to the previous decade. Milk production experienced a significant drop from 5.27 per cent in 1980–1990 to 4.20 per cent in 1990–2002. Fish production has also witnessed a significant drop

Table 8.2

Rate of Growth of Production of Food Items for Two Sub Periods

Food Items	1981-90	1991-2000
Coarse Cereals	0.350	-0.01
Rice	3.552*	2.003
Wheat	3.513*	3.507
Sugarcane	2.676*	2.699
Total Pulses	1.477	0.654
Total Cereals	2.806*	2.177
Total Foograins	2.697*	2.068
Fish	4.296*	4.080
Egg	8.119*	4.359*
Milk	5.269*	4.275*

Source : Estimated from the data published in GOI, Planning commission website. Area, production and yield of principal crops, 2003

* indicates statistical significance at 5% level

Table 8.3

Rate of Growth of Yield of Food Crops for Two Sub Periods

Food Items	1981-90	1991-2000
Coarse Cereals	1.696	2.122
Rice	3.139*	1.330*
Wheat	3.059*	1.806*
Sugarcane	1.223*	1.041
Total Cereals	2.838*	1.685*
Total Foodgrains	2.697*	1.642*
Total Pulses	1.577*	1.258

Source : Estimated from the data published in GOI, Planning commission website. Area, production and yield of principal crops, 2003

Note: * indicates statistical significance at 5% level

from 4.30 per cent in 1980–1990 to 3.68 per cent in 1990–2002. Egg production witnessed a massive decline from 8.12 per cent in 1980–1990 to 4.25 per cent in 1990-02. The rate of growth of egg production remained significant even in the nineties. Broiler production has had a high growth rate of 10.15 per cent in the recent decade. The decadal growth rate of fruits and vegetables for 1991–2001 has been positive and significant for area, production and yield. The growth of production during this decade has been 4.93 per cent but due to the paucity of data a comparison with previous decades could not be made.

The fall in the rate of growth of production may have been because of the fatigue of the green revolution. Achievement of peak yield within the limitations of soil and water resources may have acted as a constraint for further growth in some areas. Fragmented land holdings and mortgages for loans may also have had an adverse impact on the yield.

The significant deceleration of growth rates is also attributed to the wave of reforms that affected the agriculture sector from 1991. Some of these effects are direct and others are indirect. The policies of the Government such as the withdrawal of subsidies and the curtailment of public expenditure have a bearing on the employment situation and welfare level of the poorer sections of the population. The slow growth in employment and incomes could be one of the reasons for the deceleration of demand and production of foods such as milk, eggs and broilers.

A reduction of subsidies to all farmers was a part of the strategy recommended by international funding agencies as part of the structural reforms. No doubt, the reduction in subsidies on ground water pumping equipment and electricity and the pricing of water to reflect its value etc., are advisable. However, mere pricing without restrictions on sustainable use will only shift the use of the scarce resources to the benefit of those who can pay for them. High prices alone cannot stop the adverse impact on natural resources. The prices of the inputs into agriculture like rates of water supply, power and fertilizers have gone up not only due to the withdrawal of subsidy but also because of their cost of production and availability (GOI, Cost of Cultivation Survey 2003). Further, support prices are not available to all farmers in all areas. Farming has become unviable for many farmers.

This has proved particularly devastating for the smaller farmers who do not have a buffer of surplus production that can sustain an increase in the cost of inputs. Farmers involved in grain production throughout the country are getting squeezed from both directions, one by the rise in the input costs and the second by increased competition from capital rich farmers and multi-nationals investing in the production of cash crops. It has resulted in a drop in the total quantum of food grain production.

8.2 Decline in Total Factor Productivity Growth

Yield is the most commonly used measure of productivity. However, the yield measure of productivity does not reflect the use of other factors like labour, fertilizers, tractors, animal power etc. Changes in these inputs cause the yield to change, but at a real cost. Yield is thus an incomplete measure of economic efficiency. The Total Factor Productivity (TFP), or multifactor productivity as it is otherwise known is considered to be a true measure of economic efficiency. It is a composite measure of productivity, which relates the output to all the inputs simultaneously. The TFP measures the amount of increase in outputs, which is not accounted for by the increase in total inputs. This increase in productivity of inputs is usually attributed to technological change. However, there are other factors in addition to technology, like improvements in infrastructure, skills and institutions, which contribute to increases in TFP growth.

Several studies have highlighted a decline in the TFP growth in India in the eighties and nineties. The TFP growth for rice was 1.3 per cent per annum in the seventies. This declined to 1 per cent per annum in the eighties. For wheat, the TFP growth declined from 1.4 per cent annually in the seventies to 1.1 per cent in the eighties. The TFP growth rate for coarse cereals was 1.1 per cent per annum in the seventies. This declined to 0.9 per cent per annum in the eighties. This decline in the TFP growth in the eighties compared to the seventies was due to declining investment in agriculture (Kumar *et al*. 1995). The TFP growth for all cereals declined from 1.5–2 per cent per annum in the seventies and the eighties to 1 per cent per annum in the nineties (Kumar 1998).

The TFP growth for the all crop sectors from 1956 to 1987 was 1.13 per cent per annum. From 1956–65, the TFP growth was 1.10 per cent per annum. In the early green revolution phase (1966–76), the TFP growth increased to 1.39 per cent per annum. This declined to 1.05 per cent annually from 1977 to 1987. The extension services accounted for about 70 per cent of the TFP growth between 1956 and 1965. The TFP growth in the early green revolution period was largely because of the contribution of technology of high yielding varieties. Public research and private sector research helped technological improvement. The contribution of extension to TFP growth fell while that of irrigation and modern inputs rose. Between 1977 and 1987, the contribution of the extension services was restored. In fact for the entire period from 1956 to 1987, the public sector extension system was the largest source of growth (Evenson *et al*. 1999).

It is a well-accepted fact that future increases in agricultural production to meet the demands of the people will have to come from increases in the TFP. Several regions in the country have experienced severe environmental degradation. A positive TFP growth rate in these regions means that improvements in technology and infrastructure have more than compensated for the degradation of natural resources. However, this need not hold for the future where it is possible that the negative effects of natural resource degradation may nullify any positive impact of improvements in infrastructure and technology. Also, the decline in the extension services in the nineties is cause for concern. If this continues, we may well experience further declines in the TFP growth. It may even turn negative.

8.3 Demand and Supply Projections

India's food grain production was 82 million tonnes in 1960–1961. It reached 203 million tonnes in 1998–1999. It has increased at the rate of 2.68 per cent per annum during this period, which is a significant achievement. India has now become self-sufficient in food grains production from the near famine situation prevailing during the mid 1960s, which persisted up to mid 1970s. India imported as much as 4.5 million tonnes of food grains during the 1960s. The food scarcity situation was of critical concern for the first two decades in post-independent India. This led to a conscious thrust made by the Indian planners to make agriculture a self-reliant sector. Public investment in irrigation and other rural development infrastructures together with improved crop production techniques such as high yielding variety seeds, chemical fertilizers, plant protection measures, etc. have significantly helped to expand the food production. But what is more important is that the increase in foodgrain production will be sufficient to meet the increasing demand in the time to come.

In the recent decade with liberalization, public investments in agriculture have been declining, and the annual increment to gross capital formation in agriculture is now lower than in the early 1980s. This decline seems to be happening in all states in India, not just the poorer ones (Vyas 2002). Private investment in agriculture has increased modestly in recent years, but not by enough to fill the gap left by the decrease in public spending. Nevertheless, with increased economic growth, the structure of the food basket is undergoing a change as diets are diversifying from basic cereals to fruits, milk and milk products, meat, fish and eggs. Within the cereals, consumers seem to be shifting away from cheaper coarse cereals to rice and wheat. The food basket of an average person does undergo changes with changes in income. Once the consumption of cereals is stabilized, income calories elasticity becomes zero, which is Engel's law of consumption (1932). This is the situation at the all-India level. But one must not fail to notice that it ignores the fact that "diversification" is as much a feature of declining nutrition as of improving nutrition (Patnaik 2002). According to the NSS, the source of the share of spending figures shows diversification; it also shows that the per head daily calorie intake from all foods has been falling in both rural and in urban areas from already inadequate initial levels. The poorer majority of the population has been denied access to adequate food grains owing to the decline in their purchasing power. The increase in the issue price of the public distribution system (PDS), tagging of people as above poverty line (APL) and below poverty line (BPL) in an arbitrary manner has lead to lower access of food grains to the poor at affordable prices.

The food grains availability per head in the country has hit an all-time low of only 152 kg in the year 2001–nearly 23 kg lower than in the early nineties. Studies have forecasted the demand and supply situation of food grains for the year 2020 in view of the population growth, rise in per capita income, urbanization, change in taste and preferences, etc., which are likely to determine the supply and demand prospects for food in the years to come. Some studies have predicted that a rise in per capita income in the years to come will lead to a decline in demand for food grains. On the other hand, studies have predicted a rapid growth in cereal demand in the future because of the growing feed requirement of the livestock sector, which is fuelled by the demand for milk, meat and animal husbandry products (Bhalla *et al.* 1999).

The study has projected the cereal requirements for India for the year 2020, assuming per capita income growth rates of 2 per cent, 3.7 per cent and 6 per cent per annum. The total cereal demand, which includes the feed for livestock and food for direct human consumption, was estimated to be 258 million tonnes, 296 million tonnes and 374.3 million tonnes respectively for various per capita income growth scenarios. Bhalla's projections of total cereal demand for 2020 are higher than the other studies such as the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) (Rosegrant *et al*. 1995) and the model by Kumar in 1998. IMPACT has estimated the cereal demand to be 237.3 million tonnes for an expected per capita growth rate of 3–4 per cent. The model estimated by Kumar put it at 254.5 million tonnes (Appendix 8.1).

The difference between the models is largely due to the assumptions on the cereal requirements for livestock feed which is a derived demand. Demand for livestock feed, depends on future demand for livestock products. Increased reliance on cereals for livestock is not realistic at present. So far, the country is dependant on crop residue and fodder crops, rather than grain. The demand estimates of grain for cattle, for poultry and other dairy products seem to be rather large. It would prove to be more viable to increase production of leguminous fodder crops of short duration for consumption by livestock. It is cost effective to provide livestock with oil cakes, crop residues and root crops. In India, a major part of the milk production comes from animals that yield less than 2–2.5 kg. It appears uneconomical to feed them any concentrates.

Supply Projections: The supply projection for 2020 is 347 million tonnes, assuming that production will grow at 2.7 per cent per annum and taking into account the structural shifts in time from rice and wheat (Bhalla *et al*. 1999). The supply projections of other studies are much lower than Bhalla's projections. IMPACT supply projection of total cereal production for 2020 was 256.2 million tonnes, assuming production growth originates from the yield growth of 0.7 per cent, which are consistent with the figures of the previous three decades. The study by Kumar projects the supply of total cereal production to be 309 million tonnes which assumes changes in output prices, price of fertilizers, wage rates and trends in Total Factor Productivity growth. If TFP growth slows down, the supply projections fall to 269.9 million tonnes and they are in line with the IMPACT projection.

The increased use of inputs was incorporated in all the studies mentioned above. This resulted in greater total cereal production in 2020. In reality, the figures may be optimistic. The costs involved in closing the gaps between realized and potential irrigated areas and fertilizer use are very high.

Assessing the impact of degradation on the production is also not easy. A Study by Sehgal and Abrol (1994) is used as a benchmark for this purpose. This study gives the yield effects conditional on the severity of degradation. The IMPACT model shows that with 50 per cent of agricultural land under degradation, cereal production gets reduced by 8 per cent, from 256.2 million tonnes to 235.8 million tonnes.

Taking account of the demand and supply projections, a shortfall of production of about 115 million tonnes, assuming 6 per cent annual growth rate in per capita income, is predicted by Bhalla. The IMPACT model projects almost a market clearing situation while the study by Kumar projects a very modest gap conditional on the TFP growth.

There is no real danger to food production security, but the estimated production can be achieved mainly through improvement in productivity. A high rate of increase in productivity calls for a priority in agricultural research coupled with more capital investment for the development of new production technologies for main crops and farm products. The actual food grain requirements will certainly be much less as the assumptions underlying the models are not realistic.

8.4. Impact of Market Forces

Markets may not necessarily result in land being put to what would be its socially best use. This is because, like most natural resources, which are public goods, some land uses have an externality, which may not be reflected in the price. Consider the case of forests. Social benefits arise out of conserving forests because of the role forests play in carbon sequestration, preservation of soil, protecting genetic resources and as watersheds. This would not be reflected in the market price of timber, if deforestation took place to allow for timber production. Those who benefit from the exploitation do not bear the full social and economic costs of exploitation. Perhaps, this is why more often than not, markets are not allowed to operate freely to decide the use to which land would be put to.

In India, large areas of forests are cordoned off as reserved and protected forests, with strict limitations on access to forest produce in these areas. There are legal restrictions on the use of agricultural land for non-agricultural purposes. In the 1950s and 1960s, most of the advances in agricultural production were related to an expansion in cultivated and irrigated area. Large tracts of forestland were brought under annual crops. This resulted in the depletion and degradation of forests. The land utilization statistics does not show that the net area sown increased at the expense of forests because of under reporting and misreporting in the early years of collection of land use data. However, there are several case studies that show that expansion of agricultural land took place at the expense of forests. Between 1951 and 1972, 3.4 million hectares of forestland was lost to dams, new croplands, roads and industries. Of the 3.4 million hectares, 2.4 million hectares was diverted for agricultural purposes (Agarwal, 1982 : A Citizen's Report).

A study of the land utilization pattern in India reveals that there has not been much change in the reporting area of forests over the last 25 years. Though there are several inter state variations, there has been an overall increase in net sown area and area under non-agricultural uses and a decline in current fallows, pastures and grazing lands, culturable wastes and barren lands. The decline in pastures and grazing lands is particularly worrying, given our livestock population. Excessive livestock pressure often results in the degradation of forests and other commons due to overgrazing. Markets thus drive pastures to be converted to cropped land and forests to be degraded because of logging, grazing by livestock and conversion to agricultural uses. The short sightedness of the market may result in a socially inefficient outcome.[3]

[3] The expansion of agriculture has been the most important contributor of deforestation in the Brazilian Amazon. Despite awareness about the environmental impact of deforestation, forests are cleared to make way for pastures. This may be attributed to the relative private financial returns to alternative land use systems and the acute shortage of labour to manage these alternative land use systems. Returns to labour outweigh returns to land in this labour scarce region. A study of the profitability of different land uses reveals that farmers more interested in returns to labour than in returns to land would prefer improved pasture/cattle systems while farmers interested in both returns to labour and returns to land would prefer coffee/bandarra plantations and improved fallow systems. Labour returns from extractive forests are far below any alternate non forest land use systems (Vosti et al, 2000). Given this scenario, where economic decisions are governed by private returns, it is not surprising that large tracts of forest areas are being converted to alternative land uses at alarming rates. The deforestation in the eighties was encouraged by the fiscal policies such as lower tax rates for agricultural income, tax credit schemes for corporate livestock ranches etc., while in the nineties it was driven largely by market forces (Cattaneo, 2002).

Even economic planning in its conventional form has its shortcomings. As social benefits and externalities both beneficial and harmful are intangible and difficult to put a price on, they are often excluded in cost benefit analysis done to evaluate different land uses. Economic analysis usually favours the present value over that of the future. High discount rates are applied, which encourage depletion rather than conservation of natural resources like forests. It is therefore imperative that the land use policies are enforced to protect forests, tree cover, agricultural land, pastures and grazing land and prevent the diversion and misuse of land.

8.4.1 Rural Land Markets

Rural agricultural land markets are highly restrictive. Unlike the case of product markets and other factor markets, a very small percentage of the total agricultural land enters into the market for sale. The size of the land holdings has been declining over the years. In India as in the rest of South Asia, land is still the most important form of property. The amount of land owned by a person determines his/her economic well being as well as social and political status. Access to credit is governed by access to land. In this scenario, where land is a precious asset, there is a reluctance to part with it. In case of extreme poverty or absentee landlordism, land changes hands. The sale does not normally take place in a competitive market. Taking over of land by the creditors in case of default or through distress sales in the case of absentee landlordism is common. Another reason why the land markets are so restricted is because of the high transaction costs involved in the sale and purchase of land. These costs amount to almost a third of the value of land transacted.[4]

The land rental market in India as in the rest of South Asia has been characterized by sharecropping contracts. Even though tenancy has declined since Independence, lease markets continue to remain important for the poor. Active lease markets are observed even in states like Uttar Pradesh where leasing is legally prohibited. Though the incidence of reverse tenancy has been rising, leasing out of land by large to small operators continues to be the predominant practice. Reverse tenancy has been observed in the prosperous regions of Punjab and Western Uttar Pradesh. Large landowners leasing out land to landless and marginal farmers remain significant in less progressive states like Bihar and Orissa. Tenancy markets are most active in the agriculturally backward states of Uttar Pradesh, Bihar, Orissa and West Bengal as well as in the agriculturally progressive states of Punjab, Haryana and Tamil Nadu. The former set of states, which account for 65 per cent of tenants, is characterized by a high incidence of rural poverty. Though a trend towards fixed tenancy may be observed, sharecropping is still the principal form of tenancy contract. In the prosperous states, leasing land on cash basis is more common. Low rates of tenancy have been observed in Rajasthan, Jammu and Kashmir, Kerala, Gujarat, Madhya Pradesh and Himachal Pradesh. While in some parts of the agriculturally more progressive states, lease markets may have lead to a slight redistribution of land towards large land owners, lease markets have in most cases lead to a more equal distribution of operational holdings. (Mearnes 1999)

8.4.2 Emerging Water Markets

An interesting development in relation to both ground and surface water resources is the emergence of water markets. Water markets refer to a 'localised, village-

[4] Official costs include registration fees, stamp duties and surcharges while unofficial costs include bribes to expedite transactions, fees to informal land valuers etc., (Mearns. R, 1999)

level setup through which owners of modern water extraction methods supply water to other members of the community at a price" (Shah 1993). The same definition applies to both surface water markets and groundwater markets. The practice of selling water has been in vogue in many parts of the country. This was prevalent even under the traditional extraction methods-using cattle to lift water. The terminology used during those times was 'sharing' the resource. But this practice developed rapidly with the installation of modern water extraction devices. In surface and groundwater resources, water sellers are private well owners who have surplus water pumping capacity beyond their own requirements. They start selling this water to neighbouring farmers who are mostly small and marginal farmers. The terms of transactions may be as payment in cash and in kind.

The water market is an informal market and the transactions that take place between the sellers and buyers do not appear to have any legal status. In the case of selling of groundwater, there is no legislation to ban the selling of the resource. In the case of surface water resources, most state governments have prohibited unauthorized use of canal water in the command areas and also the digging of wells near the canal, which may lead to decrease in the flow of water in the canal. Since lifting water through pump sets and digging wells by the side of the canal is prohibited, the implication is clear. The sale of water is prohibited. Even in cases where farmers have taken permission to lift water, the question arises whether he can sell water to others. Since the act is silent on this issue, sale of water is assumed as legal. But these provisions have not been enforced by the irrigation department, which has resulted in illegal installation of pump sets in the command areas. This has created a situation where the sellers are in a position to use the loopholes in the legislation to their advantage.

Today we are witnessing the serious repercussions of efforts to privatise both ground and surface water. Though the emergence of water markets both in ground and surface water resources has helped in increasing the agricultural output, it has also widened the inequalities in the rural areas and has failed to protect the interests of the small and marginal farmers and other weaker sections of the society.

The above discussion raises an important question relating to the role of the State in the sphere of emerging water markets. The options left for the state are either to intervene by way of legalizing and privatising water markets or to regulate them to ensure conservation of these water resources. One has to seriously examine the consequences of the former option. It is important to mention that water markets are already privatised. Further, these markets appear to be working in an efficient manner. There are complaints from purchasers of water regarding some of the free services they have to undertake. This does not amount to any exploitation of the purchasers as their efforts are probably reflected while fixing the water rates. Further, these water markets cannot work unless there is a convergence in the interests of both buyers as well as sellers. In one respect these markets exhibit a characteristic not seen elsewhere. In a typical water market, a farmer can refuse to purchase water and also withhold permission on pipes to be laid through his lands. In such a case, a farmer on the other side who wants to purchase water may find it impossible to do so. At the very least, the seller and the potential purchaser (whose lands are not adjacent to seller's) may have to negotiate with the reluctant farmer. This might result in high transaction costs affecting the purchasers. Although such a case was not found in this fieldwork the possibility cannot be denied (Prasad 2001 and Prasad 2002).

Purchase and sale of water is common, not only in the case of irrigation water but also water used for household purposes. The boom in the bottled drinking water business also leads to commercial exploitation of water by companies and it affects irrigation water availability.

Next, the important question of legalizing these water markets arises. This measure may result in the entry of 'big operators' into rural areas as in urban areas. In urban areas the big operators have entered this sphere by installing pump sets of high capacity sometimes up to 40 horse power. Water extracted using the pump sets is supplied in tankers to various establishments at an exorbitant rate of per tank load of water. A similar situation may arise in rural areas if the big operators are allowed to tap water. This step may result in rapid deterioration of the prevailing situation.

Thus, the important question of regulating the use of both surface and groundwater arises. As far as regulating the use of groundwater is concerned, serious efforts were made at the national level to introduce a bill to regulate the use of groundwater in 1992. However, there was no unanimity among the state governments on this issue and a solution has yet to emerge. The track record of the state governments in enforcing the provisions of the legislations has not been satisfactory. The issue to be considered is to first bring forward a comprehensive legislation on water resources covering both ground and surface water resources. This should address the issue of emerging water markets also.

8.4.3 Credit Markets

One of the most important determinants of agricultural growth is the supply of credit to the agricultural sector. Empirical studies have established that there exists a significant and positive impact of credit on level of input usage on the gross value of output in agriculture (Puhazhendi and Jayaraman 1999). In the eighties, the growth rate of commercial bank credit to the agricultural sector was 8.8 per cent per annum while the growth rate of GDP originating in the agricultural sector was 4.97 per cent per annum. In the nineties the two growth rates came down to 1.7 per cent and 2.97 per cent per annum respectively. As priority sectors are critical determining factors in the growth and development of the country, it is of utmost importance that financial institutions extend adequate support to these sectors.

With the nationalization of commercial banks in 1969, the objective of social and development banking was adopted. Various measures were taken to achieve this end. For every branch opened in metropolitan or port areas, four branches had to be opened in un-banked rural areas. A conscious policy of lending to the priority sector was to be followed. The priority sector comprised of agriculture and allied activities and small scale industries. One third of total loan outstanding had to be extended to the priority sector by March 1979. This was raised to 40 per cent to be achieved by 1985. The target for agriculture was 15 per cent of total credit outstanding in 1979. This was made 18 per cent by March 1990. Ten percent of net bank credit was to be extended to Scheduled Castes and Tribes, agricultural labour and small and marginal cultivators. The RBI prescribed ceiling rates for loans given to the priority sector. Differential rate of interest (DRI) scheme was introduced in 1974 for loans to economically under privileged sections of the rural population. The Lead Bank Scheme was implemented in 1969 and Regional Rural Banks (RRBs) were established in 1975. With the adoption of the Integrated Rural Development Programme (IRDP) in 1980, banks became agencies through which the government directed subsidized credit to the rural poor for the creation of income generating assets. The National Bank for Agriculture and Rural Development (NABARD) was established in 1982 and was made responsible for all matters concerning policy, planning and operations in the field of credit for agriculture and other economic activities in rural areas in India.

A number of changes were introduced in the 1990s. The definition of priority sector was widened to include food processing, software firms and other industries with a credit limit of one crore rupees. Interest rate regulations on priority sector advances were removed. Banks, which failed to meet priority sector targets, could deposit the shortfall with the Rural Infrastructure Development Fund (RIDF) subject to a maximum of 1.5 per cent of the net credit limit of the concerned bank. Branch licensing policy was abolished in 1992.

Several studies have highlighted the impact of financial liberalization on rural credit (Ramachandran and Swaminathan 2002). There was a six-fold increase in the number of rural bank offices between 1975 and 1990. In the 1990s, the compound annual rate of growth in the number of rural offices became negative. The credit deposit ratio for rural offices rose till the beginning of the 1990s and declined thereafter. The fall in the credit deposit ratio of all bank offices was much lower than that of rural bank offices. This could be attributed to the rise in the credit deposit ratios for metropolitan and urban offices in the 1990s. The 1990s thus witnessed a flow of mobilized deposit resources away from rural centres.

Bank credit to agriculture grew fastest between 1975 and 1980 at around 17.2 per cent per annum. Growth rates slowed down to 8.8 per cent per annum between 1980 and 1990. In the 1990s, the growth rates were as low as 2.2 per cent per annum. The growth rates of credit to all priority sectors taken together were 16.2, 7.8 and 3.6 per cent for the periods between 1975 and 1980, 1980 and 1990, and 1990 and 2000 respectively.

In 1985, 17 per cent of total commercial bank credit went to agriculture. In 2000, this was only 10.7 per cent. While the growth rates of rural population in the 1970s and 1980s was 1.78 and 1.84 per cent per annum, the rates of growth of the number of rural offices were 15.54 and 7.15 per cent per annum. In the 1990s when the rate of growth of rural population was 1.66 per cent, the growth rate for number of rural offices became negative (-0.86 per cent) per annum.

The Rural Infrastructure Development Fund (RIDF) was constituted in 1995 with a corpus of rupees 2000 crores for giving loans to state government and state-owned corporations for quick completion of ongoing projects relating to medium and minor irrigation, soil conservation, watershed management and other forms of rural infrastructure. Banks failing to meet priority sector targets could deposit the shortfall (up to a maximum of 1.5 per cent of total bank credit) with the RIDF. The RIDF is thus a soft option for banks and provide an escape channel from the risks associated with priority sector lending. This has made commercial banks lax in fulfilling their commitments to the priority sector. Another major problem with the RIDF has been that the actual amount disbursed has been diminishing since its inception and now forms a very small portion of the amount sanctioned. In 1995, 89.4 per cent of the amount sanctioned was disbursed. In 1999 only 11.4 per cent of the amount sanctioned was disbursed.[5] The period following financial sector liberalization has witnessed a weakening of the link between commercial banks and rural areas. The focus has shifted away from the objective of social and development banking and moved towards prudential

[5] Chavan Pallavi, "Some indicators of development and distribution of commercial banking in Rural India before and after financial sector liberalization", Draft Note

regulations such as attainment of capital adequacy norms and reductions in non-performing assets.[6]

Rural Credit Cooperative Institutions (RCCI) are one of most important sources of rural credit. However, there has been a decline in the rate of growth of their resources and in the rate of growth of loans advanced since the mid seventies (Satyasai and Badatya 2000). Together with Regional Rural Banks (RRB), they account for over 50 per cent of rural credit. Both RCCIs and RRBs have very low financial viability because of poor recovery of loans, defaults, high transaction costs, etc. In 1997–1998, 19 State Co-operative Banks (cooperative institutions organized at the state level) made a combined profit of Rs.142 crores, while 9 others accounted for a loss of Rs.261 crores. The cooperative institutions at the district level (DCCB) performed no better. 211 of these institutions accounted for a profit of Rs.317 crores while a 156 incurred a loss totalling Rs.473 crores.

The redeeming feature of these rural cooperative institutions is their reach. These institutions are spread over large parts of the country. There is one PAC for every seven villages, which amounts to around 489 PACs per million hectares of gross cropped area. For the long-term credit structure, there is one branch for every 410 villages, which amounts to around 8.5 branches per million hectares of gross cropped area[7] (Satyasai and Badatya 2000). While both RCCIs and RRBs are in need of a major overhaul, it is essential that the basic structure of the cooperative institutions be retained so that maximum number of people in rural areas may benefit.

In recent years there has been an attempt to hand over banking functions in rural areas to NGOs. The bank loans provided to Self Help Groups formed by public banks increased from Rs.0.29 crores in 1992–1993 to over Rs.1026 crores in 2001–2002 (Annual report 2001–2002 of NABARD). NGOs controlled micro credit loans advanced to members of Self Help Groups (SHGs).[8] The repayment rates are dependent on monitoring by NGOs and therefore high repayment rates are accompanied by high monitoring costs. The administrative costs increase with scale of activity. Also, NGOs do not have the reach that cooperatives and commercial banks have. The interest rates on micro credit loans, though lower than the rates of interest on informal credit agencies, are much higher than the rates charged by cooperatives and banks.[9]

The lowering of bank rates appears to have benefited all borrowers except the poor. The average size of micro credit loans is very small. The average size of the loan per family between 1992–1993 and 2001–2002 in the SHG–Bank linkage was Rs.1308 only.[10] It therefore follows that the 'micro credit alternative' is not and cannot be an alternative to long-term institutional credit in rural areas. Agricultural investment and therefore agricultural growth is very much dependant on the supply of long-term institutional credit. The recent trends in the provision of long-term credit to agriculture have provided much cause for concern. To ensure sustainable agricultural production, it is of utmost importance that adequate, timely and inexpensive credit is supplied to the agricultural sector.

[6] Patnaik Prabhat, Financial Liberalization and credit policy, Draft Note

[7] NABARD, Dossier on Cooperatives, March 1997

[8] Se National Bank for Agriculture and Rural Development (NABARD), Dossier on Cooperatives, March 1997 cited in Satyasai

[9] Se KJS and Badatya KC, "Restructuring rural credit cooperative institutions", Economic and Political Weekly Jan 29-Feb 4, 2000.
of studies on interest rates on micro credit loans in India

[10] See Ten Years of SHG-Bank Linkage, 1992-93 to 2001-02 in www.nabard.org

8.4.4 Output Markets

Dual pricing has been the policy of the government to support food grain output. The producer has the choice of selling either in the open market or to the government procurement agency at a stipulated price called the Minimum Support Price (MSP). Farmers who can exercise this option are only a fortunate few in the states where the procurement is undertaken. They can switch between the two markets depending upon which of the prices is higher.

The Agricultural Price Policy is mainly meant for the support of farmers. However, farmers of only four major rice and wheat producing states, namely, Punjab, Haryana, Andhra Pradesh and Uttar Pradesh are benefited. Procurement operations are not undertaken in various regions across several states. Thus all the farmers have not benefited. West Bengal and Madhya Pradesh have opted for decentralized procurement.

Agricultural price policy essentially tries to stipulate the minimum support prices to various crops and procures some of them in some states, either directly or through millers and agents. The non-food crops are disposed off in the open market or released for export at a price below which the government has purchased. The food grains (wheat and rice) procured at MSP are stocked up and sold to the low-income consumers at a lower price through the Public Distribution System (PDS). The food grains are purchased at a price higher than the market rate from farmers and sold to the consumer at a price lower than the market rate. There is also the cost of administration and the cost of holding the stocks. This is popularly called the food subsidy. The credit extended by the banks to the government is referred to as food credit. Since procurement in the recent years mainly to benefit farmers bolstered the stocks, the cost of holding excess stock may be considered as farm subsidy instead of food subsidy.[11]

Now the question is about the impact of the procurement operations on the production of food grains and the likely impact of discontinuing procurement on the food grain production in general. Beyond any doubt, the procurement has provided price incentives for food grain production in the country all these years.

However, till very recently, the country was isolated from the rest of the world and the Indian market prices were determined by domestic factors. The open market wholesale prices were generally higher than the MSP announced by the government by a margin of 10 to 30 per cent. After the turn of the century, from 2000–2001 onwards, the rice prices have fallen along with the international prices. Another interesting feature after 2000 is that the prices of rice declined and that of wheat have stagnated despite a shortage of production in the country. Obviously, the domestic prices are in tune with reduced international prices, and the option of importing cheaper rice from other countries such as Thailand exists (GOI, Cost of Cultivation Surveys 2002). Hence the withdrawal of output support may have an immediate impact of decline in food grain production.

The government cannot maintain MSP to benefit the farmers for long, as the burden of holding stock is not tenable. To maintain current levels of food grain production in the country, the MSP operations should continue in the short run, by making the PDS universal and facilitating higher levels of lifting. However, in the long run, decentralization of procurement at the district and the state level would help. Forward trading and commodity exchanges

[11] The Expenditure Reforms Committee has recommended that it has to be under the head of farm subsidy and not under the budget head of consumer food subsidy.

should be actively encouraged to reduce the price risk to the farmers. The pepper exchange of Kochi is a case in point. Another important issue is to reduce the price spread between the farmers and consumers.

The Government of India has been planning (Tenth Five Year Plan 2002–2007) to reduce the [illegible] procurement operations. No private agency would agree to procure and supply to the Public Distribution System without a stipulated profit. The government will have to now give the subsidy amount to the private grain merchants. Privatisation would not solve any of the existing problems but add to the problems. This would not help in the improvement of efficiency. Introduction of forward trading is a better option. In this case, even the government can purchase the grain needed in advance through forward trading.

Government of India (GOI), Planning Commission, 2002. The Tenth Five Year Plan, 2002 – 2007.

Open Market: Grain trade in India is highly integrated. A few influential traders control the major portion of the grain trade. However, the marketed surplus of food grains is no more than 40 to 50 per cent of the total production. Most of the grain is consumed locally and never enters the major markets. Government procurement constitutes about 25 per cent of the wheat production and about 10 to 15 per [illegible] is controlled by the private trade is no more than a quarter of the production.

Grain trade was also highly controlled by the government till recently, with multiple restrictions on the movement of grain between the states. Credit is now available to trade against food grains stocks. Earlier there were credit restrictions on food grains stocks. Credit was denied earlier, fearing hoarding by the traders. Given the situation of low inflation and huge piles of food grains with the government, there was no incentive for the private trade to hoard. Private agencies became active in the supply of inputs after the 1990s.

Given the on-farm consumption, procurement by the government and the distress sales by the poor farmers, there is not much scope for prices to play an important role in determining the production, especially in the rain-fed regions. All the same, Indian farming is sensitive to prices in some places. The supply response studies undertaken show that wheat, rice and cash crops are more responsive to prices than coarse cereals and pulses. Pulses often show a perverse response. However the price responses are highly site-specific. The same crop is responsive to price in one region and non-responsive in other regions. Wheat and rice are more responsive to price in the areas where they are the main crops. Thus irrigated paddy and wheat are more responsive to prices than other crops. Prices of the competing crops are equally important in some areas, leading to crop pattern changes. Input prices such as fertilizer prices and wage rates turn out to be important for paddy. Wherever the acreage under coarse cereals is high, coarse cereals are also price sensitive.

The major driving force for production is not price. Non-price factors such as irrigation, rain fall in the kharif season, yield of the crop, relative yields etc., play an important role (Gulati and Kelly 1999). The [illegible] level of instability in their production.

Gulati, Ashok and Tim Kelly, 1999. "Trade Liberatisation and Indian Agriculture", Oxford University Press : New Delhi.

We may conclude that on the whole, while many crops show low price elasticity, profit seems to be the main decision variable. Profitability depends not only on output prices, but also on input prices and the yield levels. Hence farmers go in for a crop that yields most so that the profits are maximized.

In the recent years, after the decontrol of the economy and increased role of private sector in the supply of inputs, the government has been thinking of extending the role of the private sector in the form of contract farming and corporate farming. Corporate farming and contract farming have been suggested as solutions to the problem of unviable farming units (Planning Commission 2002). Hence it is worthwhile looking at the experiences.

8.4.5 Contract Farming

Corporate presence in agriculture has been increasing in India as in several other countries. The National Agriculture Policy envisages that "private sector participation will be promoted through contract farming and land leasing arrangements to allow accelerated technology transfer, capital inflow and assured market for crop production, especially of oilseeds, cotton and horticultural crops." Several States–Punjab, Andhra Pradesh, Gujarat and Tamil Nadu are encouraging contract farming by making the necessary changes in laws to facilitate it and by providing incentives including subsidies, tax rebates and lifting of land ceilings.

Contract farming may be defined as an agreement for the production and supply of agricultural products under forward contracts between farmers and processing/marketing firms. The purchaser provides some degree of production support through the provision of inputs and technical advice and the farmer commits to provide agricultural commodities at a quality and quantity determined by the purchaser. The transaction usually takes place at a pre-agreed price, but this need not always be so. The terms and nature of contracts may differ depending on the extent of input provision and managerial specification by the buyer. Some contracts may involve only an agreement for future sale and purchase while some contracts may require the farmer to follow recommended production methods, input regimes and cultivation and harvesting specifications.

The system of contract farming is said to have several advantages. The buyer usually provides the farmers with inputs and other production services under this system. Farmers get access to new technologies and can acquire new skills. It becomes easier for the farmer to access credit either from the buyer or from financial institutions. The farmer also gains entry into new markets. As the contract usually involves a pre-agreed price, the price risk of the farmer is greatly reduced. However, the experiences with contract farming in India have been mixed. There were instances of farmers benefiting from purchase arrangements. However, the experiences show that these benefits are not long lasting, and give way to other disadvantages. India has a long way to go before it can adopt contract farming successfully. Probably till rural transformation takes place and agriculture supports less people, contract farming may not be beneficial to farmers.

In Punjab, there is increasing dissatisfaction among the farmers who have entered into contracts with buyers because quality control has been used as a means to effectively reduce the output prices. The Punjab Agro Foodgrains Corporation has been forced to buy the basmati rice rejected by the contracting firms. The trend in lower prices has lead to loan defaults by farmers. It was thought that the system of contract farming would encourage diversification, which is essential for the ecological survival of farming in Punjab. However, much of the recent area that has come under contract farming has been for Basmati, a rice crop that is extremely intensive in its water usage. The private companies have not provided the required extension services[12] in the contracted areas. This has resulted in inappropriate agronomic practices and poor quality of grains in areas where

[12] There are positive externalities associated with extension services, which implies that private players may not adequately provide them.

basmati is not traditionally grown. Employment has increased because of diversification into labour-intensive crops like vegetables. However, it appears that male labour is being displaced by mechanization of the sowing and harvesting activities of wheat and paddy, and female and child labour is employed for the labour-intensive vegetable farming. Female and child wages are much lower than male wages. There is increasing competition due to greater in-migration and cessation of out migration and so wages remain at subsistence levels (Gill, 2001).

In Andhra Pradesh, the State Government through the Rural Development Department promoted the "Kuppam" project. It was to be a demonstration to prove the effectiveness of contract farming and has been heavily subsidized by the State. However, a study found that the project was overly expensive and environmentally unsustainable. The project was undertaken in an extremely undemocratic manner with the concerned farmers not knowing the details of the contract. The farmers did not hand over lands voluntarily to the Company. All the farming operations were manged by BHC Agri India Pvt Ltd. The average costs of cultivation were extremely high. Large amounts of expensive chemical pesticides and weedicides were applied. No organic manures were used. There was rapid depletion of ground water with no provision for either recharge or rainwater harvesting. The project was not viable in net energy terms. The Israeli drip irrigation technology followed was already introduced in Karnataka at much lower costs. Farmers who earlier cultivated their own land have become hired labourers on the project. They have not been allowed to use crop residues as fodder, which used to earlier support subsidiary occupations like dairy farming. The livelihood security of the farming community has been seriously undermined (Chowdry *et al.* 2002).

Contract farming of hybrid cotton in Kurnool, Mehboobnagar and Rangareddy districts in Andhra Pradesh employ young girls instead of adults to reduce the cost of labour. Credit is advanced to the parents of girls who are assigned to work for the cotton farmers. Interlinking of the credit and child labour market has become an important part of the contract farming strategy here. Men have begun to withdraw from work and the responsibility bringing in income has fallen on young girls and women (Venkateshwarlu and Corta 2001).

Globally, agriculture is being increasingly dominated by Trans National Corporations like Monsanto, Cargill, etc. These corporations are beginning to gain control of markets through vertical and horizontal integration. Markets worldwide are becoming oligopolistic with few agribusiness firms involved in processing, buying from a large number of farmers and selling to millions of consumers. The marketing margins or the difference between what the producers receive and what the consumers pay have been rising (Ghosh 2003). The experiences with contract farming in India provide much cause for concern. This system has not proved to be as beneficial as envisaged. The private sector has not been able to provide the required production and other extension services to the farmers. The use of low paid child and female labour is resulting in the casualisation of labour. Cultivators have begun to lose control over the production process and labour has been increasingly marginalized.

To conclude, it appears that markets and vested commercial interests play a role in determining the use of natural resources. However, other non-price considerations of livelihoods also play an equally important role in the use of natural resources.

CHAPTER 9

Sustainability of Food Security

Sustainability of food security is the ability of states to provide sufficient physical and economic access to food for everyone at present without compromising the ability to provide enough in future. The present study examines the ability of states in India to provide sufficient economic and physical access to food, water and clean air to all its residents for a long time to come. Achieving ecological health and economic development simultaneously is the ultimate aim.

9.1 Sustainable Food Security Indicators and Index

The index is a valuable guide to choose the path of sustainable development. It will enable the state to choose policies and programmes that will lead to sustainable food security. 'Sustainable' states are those with sufficient resources to continue food security at existing levels and that have the capacity to enhance food security in future. States that are high on sustainability but suffer low levels of food security should focus on enhancing livelihood access. They should adopt eco-friendly methods of doing so by utilizing available resources. States that are food-secure but low on sustenance should change their ways and ensure conservation of natural resources.

The balance between future Sustainability and present Security is important. Conservation of natural resources for it own sake while people are starving has no meaning. The goals of food production, livelihood generation, clean air, clean water and clean surroundings should be pursued and achieved through sustainable use of environmental resources.

The best state is the one that can claim present food security in terms of food availability, access and absorption and has also conserved natural resources required for future sustenance. The Index of Sustainable Food Security shows exactly which state has done what. It arranges states in the order of achievements on the two counts mentioned earlier and creates a composite ranking. It places the state in one of five final categories that range from sustainable food security to unsustainable food security.

The Food Production Security Index and Food Access Security Index are the two major composite indices of *present security*. The Sustainable Production Index and Sustainable Access Index are Indices of *future sustenance*. Future sustenance has been given more weight than present security (75 per cent for the former, 25 per cent for the latter). The reason being that if natural resources were to be destroyed, we cannot support the food and livelihood requirements of the people in any way and survival becomes impossible in that region. A weighted composite index of security and sustainability with respect to food production has been worked out and presented in Chapter 5. Likewise, a composite index of security and sustainability in respect of livelihood access leading to food access has been calculated in the Chapter 7.

Finally, proper absorption and assimilation of the food into the body at present and in the future can be ensured only through safe drinking water, pollution-free air, clean surroundings to live in, health infrastructure and basic amenities. While health infrastructure ensures health security at present, future well-being depends on environmental hygiene, availability of safe drinking water and clean air and the levels of pollution, which again depend on environmental endowments and good governance. However, because of the paucity of data for rural areas and the lack of reliable data on industrial and commercial pollution, we did not attempt to separate the issue of absorption into present security and future sustenance. It would have been possible to do so had we access to more accurate data. The index of absorption of two indicators is an unweighted simple index.

9.1.1 Indicators of Sustainability of Food Security

Seventeen indicators have been used for the weighted composite index. These indicators are first grouped into three sub indices: Availability Index, Access Index and Absorption Index; these three indices are then combined into a weighted final index. The following list reproduces the groupings used. A brief explanation given along with the indicators makes the reasons for inclusion clear (Tables 9.1 and 9.2).

I. Indicators of food production security

1. **Weighted net sown area:** This represents the irrigated equivalent of agricultural land base for food production.
2. **Percentage change in net sown area over 8 years:** This represents the possibilities of expansion of area.
3. **Food grain production per capita:** This represents demonstrated levels of assured current production.
4. **Per capita forest cover:** This represents the sustenance of watersheds.
5. **Unexploited surface water available for future use:** This represents unutilized potential surface water available.
6. **Unexploited groundwater available for future use:** This represents unexploited groundwater resources to total resources.
7. **Percentage of area degraded to total geographical area:** This represents eight varieties of lands that were degraded through human activity. It excludes natural wastelands such as sandy beaches and deserts.
8. **Percentage of leguminous crops in the gross cropped area:** This represents the sustainability of soil fertility with the adoption of viable crop patterns.

The first three indicators together constitute the food production security indicators. The next five indicators represent the environmental sustenance of food production. Together, the eight indicators describe the situation of sustainability of food availability.

II. Sustainability of food access

9. **Percentage of population below the poverty line in the entire state (both rural and urban populations):** This population is likely to face problems of food access. All those above the poverty line are assumed to have sufficient food access at present.
10. **Percentage of non-agricultural workers to total workers in the state in rural and urban areas put together:** This is an indicator of relative prosperity. While all non-agricultural employment by itself may not mean prosperity, it definitely means lower dependence on the primary sector and a shift to the higher-income secondary sector.

11. **Instability in cereal production in the past ten years:** This is more an indicator of food access than availability, because while trade-flows can make up for shortages in local cereal production, crop losses mean losses in incomes and purchasing power and an increase in indebtedness, all of which hurt access to food. Instability may be caused by factors other than weather. The major weather factors that routinely bring about fluctuation every few years are rainfall deficiencies. Other natural factors that cause instability are pests and diseases and floods. Fluctuations may also arise because of a crash in prices and changes in the market situation. As cereals are a staple food, production shortfalls will result in serious food access problems. This indicator captures the transient and seasonal food access problems arising out of natural and man-made situations.
12. **The average size of the holding:** This is a direct reflection of the pressure of population on cultivated land.
13. **Percentage of landless labour households to total households:** This reflects the indirect pressure of population on private and common property resources of land and water.
14. **Percentage of population in non-crop agricultural enterprises:** This reflects diversification of agriculture and better livelihood access for people who depend upon natural resources.
15. **Dense forest cover per lakh population:** This depends on the ecological sustainability of water resources, the sources of forest products, the extent of biodiversity and its use for populations with direct access to forests and also for populations who depend indirectly on these water resources and products.

Two indicators—percentage of population below the poverty line in the entire state and percentage of non-agricultural workers to total workers in the state—represent present access to food. The five indicators, from 11 to 15 in those listed here, represent sustainability of livelihoods for people who depend on natural resources such as land and forests either directly for food or earnings, or indirectly for water, fuel wood, wild foods and so on.

III. Food Absorption

16. **Infant mortality rate:** This represents the existing situation of health care facilities in the state, which has a bearing on long-term outcomes such as life expectancy. This is a key indicator that captures not the just the existence of health care but the working of the health care system in general. Wherever health care facilities are good, IMR is low. This indicator illustrates the existing level of security of food absorption provided through a system of health care facilities
17. **Percentage of population with access to safe drinking water:** This represents current as well as future possibilities for better health and food absorption. Access to drinking water is very closely related to poverty and the hardships suffered by women.

These two—infant mortality rates and access to safe drinking water—are key indicators that represent the state of health care and basic

Table 9.1

Indicators of Sustainability of Food Security

S.No	States	1 Weighted Net Sown Area* (NSA) ('000 hect.) (1998-99)	Rank	2 Percentage Change in NSA (in 1991-92 over 1998-99)	Rank	3 Foodgrain production Per Capita (Kgs/month) (1997-2000)	Rank	4 Per capita forest cover (Hect./person) (1998)	Rank
1	Andhra Pradesh	5108.60	**5**	-0.57	**18**	14.36	**11**	0.06	**15**
2	Arunachal Pradesh	69.90	**21**	24.16	**3**	15.48	**7**	6.24	**1**
3	Assam	1039.10	**14**	-0.18	**17**	11.53	**20**	0.10	**13**
4	Bihar	3702.10	**8**	-3.68	**23**	14.17	**12**	0.03	**21**
5	Goa	51.40	**23**	7.58	**5**	9.79	**22**	0.16	**11**
6	Gujarat	4125.40	**7**	4.12	**7**	8.42	**23**	0.03	**19**
7	Haryana	2225.20	**13**	3.42	**9**	48.14	**2**	0.01	**25**
8	Himachal Pradesh	205.90	**17**	-4.36	**24**	19.53	**5**	0.24	**7**
9	Jammu and Kashmir	343.50	**16**	-0.14	**16**	11.62	**18**	0.21	**9**
10	Karnataka	4143.50	**6**	-2.05	**22**	14.70	**10**	0.07	**14**
11	Kerala	827.70	**15**	0.49	**13**	2.05	**25**	0.05	**17**
12	Madhya Pradesh	8575.70	**2**	2.46	**10**	26.62	**3**	0.16	**10**
13	Maharashtra	6498.00	**4**	-0.91	**20**	10.06	**21**	0.05	**16**
14	Manipur	68.00	**22**	0.00	**14**	13.17	**14**	0.71	**3**
15	Meghalaya	85.50	**20**	9.41	**4**	6.84	**24**	0.68	**4**
16	Mizoram	36.30	**24**	67.69	**1**	11.65	**17**	1.96	**2**
17	Nagaland	103.50	**18**	34.54	**2**	11.54	**19**	0.67	**5**
18	Orissa	2650.40	**11**	-4.56	**25**	13.64	**13**	0.13	**12**
19	Punjab	2873.00	**10**	0.55	**12**	79.19	**1**	0.01	**24**
20	Rajasthan	7021.50	**3**	3.76	**8**	18.54	**6**	0.03	**20**
21	Sikkim	34.90	**25**	0.00	**14**	15.43	**8**	0.59	**6**
22	Tamil Nadu	2898.10	**9**	-1.59	**21**	11.80	**16**	0.03	**18**
23	Tripura	97.10	**19**	5.32	**6**	13.08	**15**	0.22	**8**
24	Uttara Pradesh	10351.90	**1**	2.14	**11**	21.29	**4**	0.02	**22**
25	West Bengal	2396.40	**12**	-0.68	**19**	15.16	**9**	0.01	**23**

5 Future availability Surface water (Percentage) (1998-99)	Rank	6 Future availability Ground water (Percentage) (1997-98)	Rank	7 Percentage of Degraded area to Total Geographical area (1998-99)	Rank	8 Percentage of Leguminous Crops to Gross Cropped Area (1998-99)	Rank	9 Percentage of Population Below Poverty Line (Rural + Urban) (1999-2000)	Rank
38.36	**16**	73.90	**11**	16.58	**16**	25.89	**5**	15.77	**9**
44.00	**13**	100.00	**1**	11.96	**10**	0.00	**18**	33.47	**18**
65.85	**2**	92.52	**5**	20.65	**20**	3.14	**13**	36.09	**21**
50.16	**9**	66.83	**14**	11.39	**8**	8.94	**10**	42.60	**24**
63.56	**3**	89.22	**6**	11.90	**9**	0.00	**18**	4.40	**2**
51.82	**8**	50.75	**18**	19.90	**19**	26.25	**3**	14.07	**7**
30.47	**18**	24.44	**21**	7.13	**4**	6.77	**11**	8.74	**5**
47.47	**10**	83.92	**8**	24.29	**21**	3.60	**12**	7.63	**4**
16.57	**22**	98.94	**3**	8.05	**6**	2.92	**14**	3.48	**1**
27.45	**19**	66.92	**13**	9.41	**7**	25.21	**6**	20.04	**11**
42.89	**14**	81.02	**10**	2.92	**1**	1.37	**16**	12.27	**6**
56.24	**7**	81.16	**9**	14.98	**13**	37.60	**1**	37.43	**23**
34.74	**17**	65.29	**16**	16.03	**14**	18.15	**7**	25.02	**13**
46.60	**12**	100.00	**1**	58.00	**25**	0.00	**18**	28.54	**15**
59.24	**5**	95.64	**4**	44.16	**23**	0.00	**18**	33.87	**19**
81.14	**1**	0.00	**23**	19.31	**18**	0.00	**18**	19.47	**10**
20.71	**20**	0.00	**23**	50.69	**24**	0.00	**18**	32.67	**17**
46.89	**11**	84.80	**7**	12.40	**12**	9.56	**9**	47.15	**25**
15.69	**23**	1.67	**22**	3.14	**2**	1.03	**17**	6.16	**3**
15.63	**24**	27.11	**20**	17.50	**17**	26.42	**2**	15.28	**8**
57.43	**6**	0.00	**23**	30.07	**22**	0.00	**18**	36.55	**22**
10.41	**25**	37.45	**19**	16.03	**14**	26.01	**4**	21.12	**12**
59.80	**4**	66.31	**15**	12.17	**11**	0.00	**18**	34.44	**20**
39.69	**15**	58.05	**17**	7.79	**5**	11.21	**8**	31.15	**16**
20.34	**21**	67.80	**12**	5.23	**3**	2.49	**15**	27.02	**14**

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Table 9.1 (Contd...)

Indicators of Sustainability of Food Security

S.No	States	10 Percentage of Non-agricultural workers to total workers (2001)	Rank	11 Instability of Cereal Production (Percentage) (1990-91 to 1999-2000)	Rank	12 Average size of holding hectare per (Household) (1990-91)	Rank	13 Percentage of landless labour (Household) (1991)	Rank
1	Andhra Pradesh	24.84	**18**	14.17	**17**	1.56	**12**	19.80	**22**
2	Arunachal Pradesh	27.47	**14**	12.13	**15**	3.71	**3**	2.40	**7**
3	Assam	40.96	**5**	5.57	**3**	1.27	**15**	8.00	**12**
4	Bihar	17.56	**24**	14.25	**18**	0.83	**23**	19.00	**21**
5	Goa	72.06	**1**	6.60	**5**	0.93	**19**	10.10	**14**
6	Gujarat	28.13	**12**	30.27	**24**	2.93	**5**	17.90	**20**
7	Haryana	34.98	**9**	7.51	**6**	2.43	**7**	7.80	**11**
8	Himachal Pradesh	26.28	**16**	9.42	**10**	1.21	**17**	0.90	**3**
9	Jammu and Kashmir	37.56	**8**	8.67	**9**	0.83	**23**	1.00	**4**
10	Karnataka	26.47	**15**	12.38	**16**	2.13	**9**	14.70	**19**
11	Kerala	71.34	**2**	16.32	**20**	0.33	**25**	3.60	**8**
12	Madhya Pradesh	14.50	**25**	11.29	**13**	2.63	**6**	12.70	**17**
13	Maharashtra	20.28	**22**	28.79	**23**	2.21	**8**	20.20	**24**
14	Manipur	34.75	**10**	22.80	**22**	1.23	**16**	1.60	**5**
15	Meghalaya	25.37	**17**	8.33	**8**	1.77	**11**	11.40	**15**
16	Mizoram	18.29	**23**	11.96	**14**	1.38	**13**	0.00	**1**
17	Nagaland	22.60	**20**	10.02	**11**	6.82	**1**	0.20	**2**
18	Orissa	27.66	**13**	21.82	**21**	1.34	**14**	12.00	**16**
19	Punjab	46.49	**3**	5.39	**2**	3.61	**4**	20.10	**23**
20	Rajasthan	22.70	**19**	33.22	**25**	4.11	**2**	4.90	**9**
21	Sikkim	37.95	**7**	7.85	**7**	2.09	**10**	1.70	**6**
22	Tamil Nadu	30.05	**11**	15.90	**19**	0.93	**19**	26.60	**25**
23	Tripura	40.62	**6**	10.98	**12**	0.97	**18**	8.90	**13**
24	Uttara Pradesh	22.29	**21**	4.52	**1**	0.90	**21**	7.60	**10**
25	West Bengal	41.60	**4**	6.51	**4**	0.90	**21**	13.90	**18**

14		15		16		17	
Percentage of Workers in Non crop Ag. Enpr. To Total Workers	**Rank**	Dense forest cover per lakh pop (Hectare per persons)	**Rank**	Infant Mortality Rate	**Rank**	Percentage of household with access to safe drinking water	**Rank**
(2001)		(2001)		(1999)		(1991)	
4.68	**4**	30.44	**15**	66.00	**18**	55.08	**14**
0.20	**23**	4963.26	**1**	43.00	**7**	70.02	**7**
0.80	**14**	58.37	**12**	76.00	**21**	45.86	**18**
0.40	**21**	12.11	**21**	66.00	**18**	58.76	**13**
3.36	**6**	74.03	**10**	21.00	**3**	43.41	**19**
9.96	**1**	12.52	**20**	63.00	**17**	69.78	**8**
0.61	**17**	1.75	**25**	68.00	**20**	74.32	**4**
0.97	**13**	157.31	**7**	62.00	**16**	77.34	**3**
0.19	**24**	109.43	**8**	50.00	**10**	52.60	**17**
5.13	**3**	47.13	**14**	58.00	**15**	71.68	**6**
5.63	**2**	26.55	**16**	14.00	**1**	18.89	**24**
1.99	**11**	101.93	**9**	91.00	**24**	53.41	**15**
3.97	**5**	24.41	**17**	48.00	**8**	68.49	**9**
1.57	**12**	206.69	**4**	25.00	**5**	38.72	**21**
0.60	**18**	175.36	**5**	56.00	**14**	36.16	**23**
0.79	**15**	487.96	**2**	19.00	**2**	16.21	**25**
0.18	**25**	175.35	**6**	21.00	**3**	53.37	**16**
2.55	**8**	71.11	**11**	97.00	**25**	39.07	**20**
0.42	**20**	2.10	**24**	53.00	**13**	92.74	**1**
2.29	**9**	6.53	**22**	81.00	**22**	58.96	**12**
0.32	**22**	448.29	**3**	49.00	**9**	73.05	**5**
3.33	**7**	13.97	**18**	52.00	**11**	67.42	**10**
0.51	**19**	57.00	**13**	42.00	**6**	37.18	**22**
0.62	**16**	13.15	**19**	84.00	**23**	62.24	**11**
2.12	**10**	4.43	**23**	52.00	**11**	81.98	**2**

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Sources for Indicators :

1 GOI, 2002, "Statewise land use classification and irrigated area" in Land Use Ststistics At A Glance (1997-98 & 1998-99)

Department of Agriculture and Cooperation, Ministry of Agriculture, Col 18

2 Centre for Monitoring Indian Economy, 2001. Agriculture, Page 20, data pertains for the year 1991-92

3 GOI-"Economic Survey" , 2000-2001 and "Census of India 2001"

4 Forest Survey of India, 1999. State of Forest Report. Data pertains to the year 1996-98; page 10, Table 2.1.b

5 GOI 2000. Water Related Statistics of India, Central Water Commission, page no 121: table no 2.19, col no.14

6 GOI 2000. Ground Water Resources of India, Central Ground Water Board (data are not available for Sikkim & Nagaland as the availability was not assessed. However we have taken it as negligible availability of ground water.

7 GOI 2000. Wasteland Atlas of India, Page 10 Table 4

8 Centre for Monitoring Indian Economy, 2001. Agriculture, Page 106 -124 & 146-151, Legumes include Gram, Arhar, Other Pulses, and Groundnuts, data pertains to year 1998-99

9 Sample survey data on Consumer expenditure, GOI-"Press Information Bureau" - (55th Round)-1999-2000

10 Census of India - 2001

11 Ministry of Finance Economic Division, GOI- " Economic Survey" 2000-21 (Various issue)

12 Agricultural Census Division, Ministry of Agriculture, GOI-" Agricultural Statistics at a Glance"-2000 pg-131

13 NSS 48th Round Report No. 419"Debt and Investment Survey" Household Assets and Liabilities as on 30.6.1991- Feb 1998.

14 GOI-Ministry of Statistics and Programme Implementation "Economic Census"-1998, Pg 35 Census of India "Provisional Population Total"-Distribution of Workers and Non-WorkersPaper-3 of 2001. The percentage is worked out by taking the number of workers given in the Economic census as a percentage of 2001 worker population.

15 Indian Council of Forestry Research & Education "Forstry Statistics India" - 2000

16 GOI 2001. National Human Development Report, Planning Commission, Table 3.6 data pertains to year 1991,

17 Census 1991

Note: Data on Safe Drinking Water for Jammu and Kashmir has been taken from the NSS 54th round

Table 9.2

Indicies of Sustianability of Food Security

S.No	States	1 Weighted Net Sown Area* (NSA) ('000 hect.) (1998-99)	Rank	2 Percentage Change in NSA (in 1991-92 over 1998-99)	Rank	3 Foodgrain production Per Capita (Kgs/month) (1997-2000)	Rank	4 Per capita forest cover (Hect./person) (1998)	Rank
1	Andhra Pradesh	0.492	**5**	0.055	**18**	0.160	**11**	0.008	**15**
2	Arunachal Pradesh	0.003	**21**	0.398	**3**	0.174	**7**	1.000	**1**
3	Assam	0.097	**14**	0.061	**16**	0.123	**19**	0.015	**13**
4	Bihar	0.355	**8**	0.012	**23**	0.157	**12**	0.003	**21**
5	Goa	0.002	**23**	0.168	**5**	0.100	**22**	0.024	**11**
6	Gujarat	0.396	**7**	0.120	**7**	0.083	**23**	0.003	**19**
7	Haryana	0.212	**13**	0.110	**9**	0.597	**2**	0.000	**25**
8	Himachal Pradesh	0.017	**17**	0.003	**24**	0.227	**5**	0.037	**7**
9	Jammu and Kashmir	0.030	**16**	0.061	**16**	0.124	**17**	0.033	**9**
10	Karnataka	0.398	**6**	0.035	**22**	0.164	**10**	0.010	**14**
11	Kerala	0.077	**15**	0.070	**13**	0.000	**25**	0.007	**17**
12	Madhya Pradesh	0.828	**2**	0.097	**10**	0.319	**3**	0.025	**10**
13	Maharashtra	0.626	**4**	0.051	**20**	0.104	**21**	0.007	**16**
14	Manipur	0.003	**21**	0.063	**14**	0.144	**14**	0.112	**3**
15	Meghalaya	0.005	**20**	0.193	**4**	0.062	**24**	0.107	**4**
16	Mizoram	0.000	**24**	1.000	**1**	0.124	**17**	0.314	**2**
17	Nagaland	0.007	**18**	0.541	**2**	0.123	**19**	0.106	**5**
18	Orissa	0.254	**11**	0.000	**25**	0.150	**13**	0.020	**12**
19	Punjab	0.275	**10**	0.071	**12**	1.000	**1**	0.000	**24**
20	Rajasthan	0.677	**3**	0.115	**8**	0.214	**6**	0.003	**20**
21	Sikkim	0.000	**24**	0.063	**14**	0.173	**8**	0.094	**6**
22	Tamil Nadu	0.278	**9**	0.041	**21**	0.126	**16**	0.004	**18**
23	Tripura	0.006	**19**	0.137	**6**	0.143	**15**	0.034	**8**
24	Uttara Pradesh	1.000	**1**	0.093	**11**	0.249	**4**	0.002	**22**
25	West Bengal	0.229	**12**	0.054	**19**	0.170	**9**	0.001	**23**

5		6		7		8		9	
Future availability Surface water (Percentage)	**Rank**	Future availability Ground water (Percentage)	**Rank**	Percentage of Degraded area to Total Geographical area	**Rank**	Percentge of Leguminous crops to Gross Cropped Area	**Rank**	Percentage of Population Below Poverty Line (Rural + Urban)	**Rank**
(1998-99)		(1997-98)		(1998-99)		(1998-99)		(1999-2000)	
0.395	**16**	0.739	**11**	0.752	**16**	0.689	**5**	0.720	**9**
0.475	**13**	1.000	**1**	0.836	**10**	0.000	**18**	0.310	**18**
0.784	**2**	0.925	**5**	0.678	**20**	0.084	**13**	0.250	**21**
0.562	**9**	0.668	**14**	0.846	**8**	0.238	**10**	0.100	**24**
0.751	**3**	0.892	**6**	0.837	**9**	0.000	**18**	0.980	**2**
0.585	**8**	0.508	**18**	0.692	**19**	0.698	**3**	0.760	**7**
0.284	**18**	0.244	**21**	0.924	**4**	0.180	**11**	0.880	**5**
0.524	**10**	0.839	**8**	0.612	**21**	0.096	**12**	0.900	**4**
0.087	**22**	0.989	**3**	0.907	**6**	0.078	**14**	1.000	**1**
0.241	**19**	0.669	**13**	0.882	**7**	0.670	**6**	0.620	**11**
0.459	**14**	0.810	**10**	1.000	**1**	0.036	**16**	0.800	**6**
0.648	**7**	0.812	**9**	0.781	**13**	1.000	**1**	0.220	**23**
0.344	**17**	0.653	**16**	0.762	**14**	0.483	**7**	0.510	**13**
0.512	**12**	1.000	**1**	0.000	**25**	0.000	**18**	0.430	**15**
0.690	**5**	0.956	**4**	0.251	**23**	0.000	**18**	0.300	**19**
1.000	**1**	0.000	**23**	0.702	**18**	0.000	**18**	0.630	**10**
0.146	**20**	0.000	**23**	0.133	**24**	0.000	**18**	0.330	**17**
0.516	**11**	0.848	**7**	0.828	**12**	0.254	**9**	0.000	**25**
0.075	**23**	0.017	**22**	0.996	**2**	0.027	**17**	0.940	**3**
0.074	**24**	0.271	**20**	0.735	**17**	0.703	**2**	0.730	**8**
0.665	**6**	0.000	**23**	0.507	**22**	0.000	**18**	0.240	**22**
0.000	**25**	0.375	**19**	0.762	**14**	0.692	**4**	0.600	**12**
0.698	**4**	0.663	**15**	0.832	**11**	0.000	**18**	0.290	**20**
0.414	**15**	0.581	**17**	0.912	**5**	0.298	**8**	0.370	**16**
0.140	**21**	0.678	**12**	0.958	**3**	0.066	**15**	0.460	**14**

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Table 9.2 (Contd...)

Indicies of Sustianability of Food Security

S.No	States	10 Percentage of non-agricultural workers to total workers (2001)	Rank	11 Instability of cereal production (Percentage) (1990-91 to 1999-2000)	Rank	12 Average size of holding hectare per (Household) (1990-91)	Rank	13 Percentage of landless labour (Household) (1991)	Rank
1	Andhra Pradesh	0.180	**18**	0.660	**17**	0.190	**12**	0.260	**22**
2	Arunachal Pradesh	0.225	**14**	0.730	**15**	0.520	**3**	0.910	**7**
3	Assam	0.460	**5**	0.960	**3**	0.140	**15**	0.700	**12**
4	Bihar	0.053	**24**	0.660	**17**	0.080	**23**	0.290	**21**
5	Goa	1.000	**1**	0.930	**4**	0.090	**19**	0.620	**14**
6	Gujarat	0.237	**12**	0.100	**24**	0.400	**5**	0.330	**20**
7	Haryana	0.356	**9**	0.900	**6**	0.320	**7**	0.710	**10**
8	Himachal Pradesh	0.205	**16**	0.830	**10**	0.140	**15**	0.970	**3**
9	Jammu and Kashmir	0.401	**8**	0.860	**9**	0.080	**23**	0.960	**4**
10	Karnataka	0.208	**15**	0.730	**15**	0.280	**9**	0.450	**19**
11	Kerala	0.988	**2**	0.590	**20**	0.000	**25**	0.860	**8**
12	Madhya Pradesh	0.000	**25**	0.760	**13**	0.350	**6**	0.520	**17**
13	Maharashtra	0.100	**22**	0.150	**23**	0.290	**8**	0.240	**23**
14	Manipur	0.352	**10**	0.360	**22**	0.140	**15**	0.940	**5**
15	Meghalaya	0.189	**17**	0.870	**8**	0.220	**11**	0.570	**15**
16	Mizoram	0.066	**23**	0.740	**14**	0.160	**13**	1.000	**1**
17	Nagaland	0.141	**20**	0.810	**11**	1.000	**1**	0.990	**2**
18	Orissa	0.229	**13**	0.400	**21**	0.160	**13**	0.550	**16**
19	Punjab	0.556	**3**	0.970	**2**	0.510	**4**	0.240	**23**
20	Rajasthan	0.143	**19**	0.000	**25**	0.580	**2**	0.820	**9**
21	Sikkim	0.407	**7**	0.880	**7**	0.270	**10**	0.940	**5**
22	Tamil Nadu	0.270	**11**	0.600	**19**	0.090	**19**	0.000	**25**
23	Tripura	0.454	**6**	0.770	**12**	0.100	**18**	0.670	**13**
24	Uttara Pradesh	0.135	**21**	1.000	**1**	0.090	**19**	0.710	**10**
25	West Bengal	0.471	**4**	0.930	**4**	0.090	**19**	0.480	**18**

14		15		16		17	
Percentage of Workers in non crop Ag. Enpr. To Total Workers	**Rank**	Dense forest cover per lakh pop (Hectare per persons)	**Rank**	Infant Mortality Rate	**Rank**	Percentage of household with access to safe drinking water	**Rank**
(2001)		(2001)		(1999)		(1991)	
0.460	**4**	0.006	**15**	0.373	**18**	0.508	**14**
0.002	**23**	1.000	**1**	0.651	**7**	0.703	**7**
0.063	**14**	0.011	**12**	0.253	**21**	0.387	**18**
0.023	**21**	0.002	**21**	0.373	**18**	0.556	**13**
0.325	**6**	0.015	**10**	0.916	**3**	0.355	**19**
1.000	**1**	0.002	**20**	0.410	**17**	0.700	**8**
0.044	**17**	0.000	**25**	0.349	**20**	0.759	**4**
0.080	**13**	0.031	**7**	0.422	**16**	0.799	**3**
0.001	**24**	0.022	**8**	0.566	**10**	0.475	**17**
0.506	**3**	0.009	**14**	0.470	**15**	0.725	**6**
0.557	**2**	0.005	**16**	1.000	**1**	0.035	**24**
0.185	**11**	0.020	**9**	0.072	**24**	0.486	**15**
0.387	**5**	0.005	**17**	0.590	**8**	0.683	**9**
0.142	**12**	0.041	**4**	0.867	**5**	0.294	**21**
0.043	**18**	0.035	**5**	0.494	**14**	0.261	**23**
0.062	**15**	0.098	**2**	0.940	**2**	0.000	**25**
0.000	**25**	0.035	**5**	0.916	**3**	0.486	**15**
0.242	**8**	0.014	**11**	0.000	**25**	0.299	**20**
0.024	**20**	0.000	**24**	0.530	**13**	1.000	**1**
0.216	**9**	0.001	**22**	0.193	**22**	0.559	**12**
0.014	**22**	0.090	**3**	0.578	**9**	0.743	**5**
0.322	**7**	0.003	**18**	0.542	**11**	0.669	**10**
0.034	**19**	0.011	**13**	0.663	**6**	0.274	**22**
0.045	**16**	0.002	**19**	0.157	**23**	0.601	**11**
0.198	**10**	0.001	**23**	0.542	**11**	0.859	**2**

amenities available in the state. The selection of indicators for food security, access or absorption is limited mainly by the availability of data. Sometimes data are not available for all the 25 states. Some important geographical areas such as Andaman and Nicobar islands are not included, as we do not have any comparable data on land and water for these islands. (Data are available from the Andamans only from the late 1990s). Indicators within each group are the factors that explain sustainability. Data on some more direct pointers to sustainability were discussed in detail in the relevant chapters but could not be included in the final index. The ratio of rainfall to evapotranspiration, which relates to cropping periods and sustainability of production, has not been included. The availability of common property land per hectare, which shows the noncommercial advantages of environmental health, has not been used. There is no indicator for biodiversity because of dearth of data.

Some of the indicators that are very closely related to those already included in the index have not been considered. The natural resource endowments of land, water and forests have already been included in the index. For example, the ratio of rainfall to evapotranspitration is very closely correlated with the indicators of surface water and groundwater resources. Common property resources per capita are again related to forest area per capita. Similarly, dense forest cover is related to the numbers of angiosperm species available in the states. There are also more data gaps in these indicators than in the indicators included. These aspects, however, have been discussed in detail in the chapters on water, forests and biodiversity. (Appendix 9.1 and 9.2)

9.1.2 The Final Index

The final index is nothing but the weighted average of the three indices: Sustainable Food Availability Index, Sustainable Food Access Index and Food Absorption Index described in Chapters 4, 6 and 7 respectively. The availability aspect gets a weight of 65 per cent, the access aspect gets a weight of 25 per cent and the absorption aspect gets a weight of 10 per cent. The final composite Index of Sustainability of Food Security shows the relative positions of the states vis-à-vis one another (Table 9.3).

Any composite index has problems of aggregation bias. While aggregating, despite the weighting system, the composite index does not reflect the state's specific strengths and weaknesses. These are apparent in the individual indicators and also in the analysis of a number of other related factors.

The value of the composite index varies from 0.266 to 0.558. The lower the index, the lower the sustainability of food security; the higher the index, the higher the sustainability of food security. Indexing is a better method than ranking because variations in the series and the extent of deviation of a state from the average position are better captured in an index of this type. However, further analysis and further categorization of the states will supplement the composite index.

The final Index of Sustainability is divided into five categories based on the index values. The natural break has been used for grouping the states. A few adjustments were made to decide on the final categories. These five categories ranging from 'sustainable' to 'extremely unsustainable' are represented in five different colours in the Map of Sustainability of Food Security (Map 9.1). The first two categories of sustainable states are in shades

Table 9.3

Sustainable Food Security Index

S.No	States	1 Sustainable Food Production Index AVI (FPI*.25+FSI*.75)	Rank	2 Sustainable Food Access Index WACI (PI*.25+SAI*.75)	Rank	3 Sustainable Food Absorption Index ABI	Rank	4 Sustainable Food Security Index WSAI (AVI*0.65+WACI* 0.25+ABI*0.1)	Rank
1	Andhra Pradesh	0.446	**3**	0.349	**16**	0.441	**19**	0.422	**6**
2	Arunachal Pradesh	0.545	**2**	0.544	**2**	0.677	**4**	0.558	**1**
3	Assam	0.397	**10**	0.372	**14**	0.320	**23**	0.383	**13**
4	Bihar	0.391	**12**	0.178	**25**	0.465	**18**	0.345	**19**
5	Goa	0.398	**9**	0.547	**1**	0.635	**7**	0.459	**3**
6	Gujarat	0.423	**5**	0.400	**11**	0.555	**12**	0.430	**5**
7	Haryana	0.321	**19**	0.453	**6**	0.554	**13**	0.377	**14**
8	Himachal Pradesh	0.337	**16**	0.449	**8**	0.610	**8**	0.392	**10**
9	Jammu and Kashmir	0.332	**17**	0.467	**5**	0.521	**14**	0.385	**11**
10	Karnataka	0.421	**6**	0.401	**10**	0.597	**10**	0.433	**4**
11	Kerala	0.359	**13**	0.529	**3**	0.518	**15**	0.417	**7**
12	Madhya Pradesh	0.594	**1**	0.305	**21**	0.279	**24**	0.490	**2**
13	Maharashtra	0.402	**8**	0.238	**23**	0.637	**6**	0.385	**12**
14	Manipur	0.261	**23**	0.344	**17**	0.581	**11**	0.314	**23**
15	Meghalaya	0.322	**18**	0.324	**20**	0.377	**21**	0.328	**22**
16	Mizoram	0.396	**11**	0.399	**12**	0.470	**16**	0.404	**9**
17	Nagaland	0.114	**25**	0.488	**4**	0.701	**2**	0.266	**25**
18	Orissa	0.404	**7**	0.235	**24**	0.150	**25**	0.336	**20**
19	Punjab	0.279	**22**	0.450	**7**	0.765	**1**	0.371	**15**
20	Rajasthan	0.352	**15**	0.354	**15**	0.376	**22**	0.355	**18**
21	Sikkim	0.210	**24**	0.413	**9**	0.661	**5**	0.305	**24**
22	Tamil Nadu	0.312	**21**	0.261	**22**	0.606	**9**	0.329	**21**
23	Tripura	0.358	**14**	0.332	**19**	0.468	**17**	0.363	**17**
24	Uttar Pradesh	0.443	**4**	0.343	**18**	0.379	**20**	0.411	**8**
25	West Bengal	0.314	**20**	0.372	**13**	0.701	**3**	0.367	**16**

of green in the map. The last two categories of most unsustainable states are shown in shades of red. Those in the middle range are coloured yellow.

These categories are only broadly indicative of the sustainability of food security. A change in one or two indicators can pull a state up to a higher category or push it down to a lower category. The method of determining class intervals can change the map. The natural break in the series has been our guide for placing states in their appropriate categories. Wherever the difference between two consecutive values is comparatively large, a natural break has been given. We have followed this system for all the maps, except in a few cases, where for easy comprehension the figures were rounded off to the closest five. Occasionally, on the basis of analysis and general perceptions, we have pushed the states up or down by a notch. This has been done only for those states for which the index number coincides with the upper or lower limit of the natural break.

9.2 The Weighting System

The Final Composite Index of Sustainable Food Security on all counts is a weighted index that emphasises sustainable food production. There are six aspects of security and sustenance for food availability, food access and food absorption. These six aspects constitute the final Sustainability of Food Security Index. A system of double weighting is followed in the final index. The first level of weighting gives more weight to sustenance than security. The second level of weighting gives more weight to food availability than food access, and the lowest weight to food absorption.

The present level of food production security gets a weight of 16.25 per cent. The sustenance of food production represented by natural resources gets a weight of 48.75 per cent. The present level of food access and livelihood access security gets a weight of 6.25 per cent. Sustenance of food access and livelihood access gets a weight of 18.75 per cent. Food absorption and health care gets a weight of 10 per cent. Thus, the natural resource endowments of states—land, forest cover, water in relation to population and use—claim almost half the weight of the index.

Individual indicators also have implicit weights, depending on the number of indicators that represent each of the six aspects of security and sustenance of availability, access and absorption. If we include the implicit weight assigned to an indicator, we get the individual weights of each indicator (Table 9.4).

The weighting system may appear arbitrary at first glance. A closer look reveals that all the indicators are interrelated. The weighting system has given importance to factors essential for a healthy and comfortable lifestyle for the present as well as the future. The reason for higher weight to the Index of Sustainable Food Availability is neither to underplay the importance of livelihoods and their sustainability nor the importance of food absorption and health care. There are three basic reasons for using a weighting system that gives overriding importance to the natural resource base of a state.

First, food production is important for several reasons. Sustainability of food availability ensures food security for both rural and urban populations. A country like India with a billion-strong population, more than a quarter of them[1] living below the poverty line, has to produce sufficient food on its own. Food shortages lead to price increases and hardships for its poor.

Further, food production-related activities employ a large majority of the rural population.[2] And if natural resources are intact, we can still produce a variety of non-cereal and non-food crops. Horticultural crops provide value additions

[1] 26.10 per cent of the combined urban and rural population live below the poverty line, as per the Planning Commission's estimates for 1999–2000 based on NSS 55th Round data.

[2] As per the census, about 72 per cent of the population live in rural areas and 58.40 per cent of all workers are either cultivators or agricultural labourers. If we add those engaged in other activities related to livestock, fisheries and forestry, the number would be even greater. Almost the entire rural population depends on land and water in one way or another.

Table 9.4

Weighting System of Indicators

		Indicator	Equal Implicit weight	Weights First wt. W1	Second wt. W2	Sub Group weights W1*W2	Indicator weights (pect)
	1	Weighted Net Sown Area (NSA)	0.330	0.250		Food production	5.416
	2	Percentage Change in NSA	0.330	0.250		Security	5.416
Sustainability	3	Foodgrain production Per Capita	0.340	0.250		gets 16.25 %	5.416
of food	**Total**		**1.000**				**16.248**
Availability	4	Per capita forest cover	0.200	0.750	0.650		9.750
65%	5	Future availability Surface water	0.200	0.750		Food Production	9.750
	6	Future availability Ground water	0.200	0.750		Sustainability	9.750
	7	Pect. of Degraded area to Total Geographical area	0.200	0.750		gets 48.75%	9.750
	8	Pect. of Leguminous Crops to Gross Cropped Area	0.200	0.750			9.750
	Total		**1.000**				**48.750**
	9	Pect. of Population Below Poverty Line	0.500	0.250		Food Access	3.125
	10	Pect. of Non-agricultural workers to total workers	0.500	0.250		Security	3.125
					gets 6.25 %		
Sustainability	**Total**		**1.000**				**6.250**
of	11	Instability of Cereal Production	0.200	0.750	0.250		3.750
food Access	12	Average size of holding hectare per Household	0.200	0.750		Food Access	3.750
25%	13	Pect. of landless labour (Household)	0.200	0.750		Sustainability	3.750
	14	Pect. of Workers in Non crop Ag. Enpr. to Total Workers	0.200	0.750		gets 18.75 %	3.750
	15	Dense forest cover per lakh Population (hect./persons)	0.200	0.750			3.750
	Total		**1.000**				**18.750**
Food	16	Pect. of households with access to safe drinking water	0.500	1.000		Food absorption	5.000
Absorption	17	Infant Mortality Rate	0.500	1.000	0.100	gets 10 %	5.000
10%	**Total**		**1.000**				**10.000**

in the food-processing industry. As long as the natural resource base is intact, any crop can be produced and exchanged for food to provide livelihood. Natural resources such as cropland, water, forests and biodiversity are most important for the sustainability of food production and also for sustenance of livelihoods and the health of the population. Natural resource endowments influence food production, livelihood access and the health of the population, though we have listed them as indicators of sustainability for future production. Our perception of food security in terms of availability, access and absorption is suitable for the purpose of analysis, but these are not watertight compartments. There are interrelationships between them. By giving more weight to Sustainability of Food Production, we are indirectly giving more weight to present security of food production. We are also implicitly giving importance to sustainability of all three components of food security. They are related directly or indirectly to natural resource endowments.

A detailed analysis of food access, affordability and livelihoods on the one hand, and the problems of food absorption, assimilation and health care on the other, has been carried out for both urban India and rural India in the two previous books on Food Insecurity. Hence, we have avoided repetition and concentrated more in this book on the environmental resources related to food production.

Second, the present condition of natural resources endowment of a state in relation to its population also reflects the precarious position of the state with respect to some specific resources. These resources may have been destroyed for the short-term commercial interests of a few to the detriment of the majority of the population. Industrial activities often pollute land, water and air with toxic wastes. Commercial activities of the primary sector (logging, mining, quarrying, plantations, creation of large reservoirs and large-scale inland and marine fishing) inflict damage on land, forests, water and biodiversity. The present study could not present a full picture of the damage to natural resources caused by commercial activities, because of the dearth of systematic time-series data. We have discussed mining leases in dense forest areas, case studies of salinity of prime agricultural lands caused by prawn fishing, etc. The effects of commercial activities could not be included in the index directly, but has been captured indirectly by the shrinking natural resource base as a result of over-exploitation.

Third, all the aspects related to present food security such as change in production patterns, increase in employment and improvements in health care are functions of governance and policy. Positive changes can be effected on this front through right policies and programmes and committed governance. But the loss of the natural resource base and the permanent damage inflicted on land, water, forests and biodiversity is irreversible. Hence, they need special attention for future policy.

It is important to highlight environmental hot spots. For this purpose, the index is weighted heavily towards environmental indicators.

9.2.1 Interpretation of the Weighted Index

Thirteen of the seventeen indicators relate to natural resources such as land, forests, water and their availability and sustainable use in relation to population pressure. They essentially get a weight of 83.3 per cent. Two indicators of agricultural land, five indicators of sustainable food production, five indicators of sustainable livelihood access to rural people and one indicator related to safe drinking water add up to thirteen essential environmental indicators. These describe the availability of natural resources with reference to population pressure and their sustainable use.

These 13 indicators have been discussed in detail in previous chapters. Let us recapture briefly what they mean to the Final Index. The health of the land is obvious from the indicator on weighted net sown area, as it implicitly gives a higher weight to irrigated areas. The sustainable use of land could be assessed from the change in cultivated land, land used for growing of soil fertility–replenishing crops and the extent of land degradation caused by human activities. The pressure of population on land is obvious from the indicators on size of land holdings and the extent of landless labour that is dependant on agriculture.

The country's status on forest cover and its sustainable use for ecological services and livelihoods are revealed by the indicators on total forest cover and dense forest cover per capita. The availability of water from rainfall and irrigation and their influence on food production is obvious from the indicator on instability in cereal production. The indicators on future availability of surface water and groundwater capture the availability of unused water resources, both from surface water and groundwater.

Workers in non-crop agricultural enterprises as a percentage of the total work force is an indicator of sustainable food access. This is because non-crop agricultural enterprises help in providing sustainable livelihoods to rural people by reducing pressure on cropland.

Juxtaposed to the indicators of natural resource endowments that reflect sustainability are the indicators of present food security. Six indicators show the present level of security in food production, food and livelihood access and food absorption and health care. These are food grain production per capita, weighted net area sown, change in the net area sown, extent of poverty, diversification of livelihoods towards non-agricultural work and the infant mortality rate. They carry a weight of 27.50 per cent. Some states are more food secure than others at present.

Some states are better endowed with natural resources, but currently remain poor. These states will have to pay special attention to poverty alleviation, with intensive and sustainable use of natural resources through eco-friendly and economically viable enterprises. The lower weight assigned to them in the final index does not make the problem less urgent or less important. The weights are meant to make the sustainability profile of the states prominent.

These indicators (along with the other information discussed in various chapters but not included in the final index) constitute a basis not only for determining the food security position of a state, but also for establishing policy links for sustainable development. Our task in this penultimate chapter is to assign a position to each state, acquire a good understanding of the situation and then suggest policies and programmes to achieve sustainable development in the future.

The index does not measure the existing level of food security against a goal or a norm. This is because norms and goals keep changing as technology, expectations and conditions change. Instead, the index merely compares one state with another and shows how far a particular state is placed from the best or the worst states in the country.

Sustainability is measured in a relative sense, not against any arbitrary figure or yardstick. A state that has more unexploited natural resources such as forests and water, more soil fertility in terms of lower land degradation and greater natural replenishment of soil fertility and a more stable crop production is considered as one that can sustain the present levels of food production.

Our index is unique, for it does not consider either environmental sustainability *per se* or food security *per se*. The index considers the present level of food security and the likelihood of sustaining at least the present level in perpetuity. If the food security of the state in terms of food production, livelihood access and health access is not up to the mark compared to the population pressure, its rank goes down. At the same time, if the state has unexploited resources such as fertile land, water, forests and safe drinking water, the rank goes up, showing that it has scope for providing the present level of food security far into the future. Sustainability of Food Security Index is thus a true combination of the indicators of food security and sustainability.

The index shows the future as it appears today. The assumption of *ceteris paribus* (everything else being the same) holds good. There are some underlying assumptions. A particular geographical region is tagged as sustainable or unsustainable given the present conditions of technology of food production, ability to ensure livelihoods and investments in health care, etc. The index also assumes that the present levels of degradation and exploitation of natural resources will not change.

If conditions change and commercial exploitation increases, a sustainable state may become unsustainable in no time. Or else, a massive conservation drive may turn an unsustainable state into a sustainable one. Similarly, the food insecurity scenario may change. It may change for the better with, say, technological breakthroughs in dry-land agriculture or removal of poverty through increasing levels of employment in non-agricultural enterprises. Likewise, things may change dramatically for the worse as a result of war, economic recession or natural disasters of large magnitude.

The index makes no value judgement on the sustainable development path as such. It only shows a state's unexploited stock of natural resources. It also shows the present level of food security in terms of food availability, food access and food absorption.

Availability of unused natural resources does not mean that they are readily available for use. Sustainable use of natural resources may entail considerable financial investment, both by the public and private sectors. It may also require other institutional arrangements, people's participation, government initiative, adoption of technologies and so on.

The aim is neither to assert that we are completely food-secure today nor to argue that it is enough if we ensure current levels of environmental health. The urgent need is to prevent further depletion and degradation of natural resources, which could undermine even the present levels of sustenance. The next important need is to alleviate existing poverty and deprivation and ensure better health through public interventions.

9.3 The Position of the States in the Index and Implications

Environmentally sustainable states are shown in shades of green in the map. The most sustainable index of 0.558 belongs to Arunachal Pradesh, followed by Madhya Pradesh with an index value of 0.490. Arunachal Pradesh and Madhya Pradesh come out on top as environmentally the most sustainable states. The position of a state in one of the five categories is determined by the actual index and not just by the rank. Thus, they are far ahead of many other states. Future availability of groundwater and surface water and adequate forest cover are common features that make the two states environmentally sustainable.

Arunachal Pradesh has a fairly meagre net sown area, being a small state, but the area has been increasing fast during the past decade. The state produces just about enough staple food for itself; hence, the present level of food production security is reasonably good. Environmental sustainability in terms of natural resource base and population pressure is the best in the country. The combination of a large forest area and few people dependent on natural resources makes Arunachal Pradesh sustainable.

Both Madhya Pradesh and Arunachal Pradesh are capable of sustaining their present levels of food security and livelihood access to their populations. This reflects the high levels of natural resource capital that can be sustainably tapped in the future. Madhya Pradesh has achieved the minimum food production security as well as environmental sustainability. It has a large net area sown, which has been increasing slowly over the past decade. Food grain production per capita is fairly high at 26.62 kilograms, next only to that of Punjab and Haryana. Madhya Pradesh has thus achieved a high level of security in staple food availability. It comes out as sustainable as it has more unutilized water sources, a large forest area and a more sustainable crop pattern. Madhya Pradesh has vast potential for expansion of food production. The country's most valuable forests are in this state. Though some of the northeastern states have a higher percentage of forest cover, Madhya Pradesh comes out as the best in terms of absolute area under forests. It is important to make sure that this wealth is preserved.

At present, Madhya Pradesh fares rather poorly as regards livelihood and health care. It is a shade worse off than Arunachal Pradesh in this respect. Madhya Pradesh should strive to enhance its livelihood security and alleviate poverty by augmenting crop yields in a sustainable way, encouraging eco-friendly enterprises and non-crop agricultural enterprises such as milk production, poultry, fisheries, goat and sheep rearing, bee keeping, sericulture and mushroom cultivation. It should encourage production and sale of non-timber forestry-related products. To achieve total food security, investment in health facilities and basic amenities including safe drinking water are imperative.

There are six states coloured in a lighter shade of green and described as **moderately sustainable.** The three southern states, barring Tamil Nadu fall in this category. Uttar Pradesh, Gujarat and Mizoram also fall in this category. Karnataka is better off then the other states followed by Gujarat and Andhra Pradesh. Kerala and Uttar Pradesh get the next ranking.

Karnataka gets a higher ranking because it is not only good in sustainable food production security but also fares well in sustainable food access. The state also fares well in terms of absorption index, in terms of percentage of area under leguminous crops, has very small percentage of degraded area and produces enough food grains for itself. The state has a lower poverty ratio and better diversification of rural non-crop enterprises.

Gujarat is an interesting state. Though it is a deficit state for food grain production and is not endowed with abundant water and forests, the state fares well because of sustainable farm practices such as growing legumes and diversification into non-crop agricultural enterprises and non-agricultural work. It is the sustainable food access that put the state in the green.

Andhra Pradesh also fares well as a result of good agricultural production scenario. The state has diversified well within agriculture into non-crop production and alleviated poverty for the present, though it has failed to provide non-agricultural work as in the case of Gujarat. The state has not done well in the absorption front.

Uttar Pradesh has a high level of current food security and fairly good sustainability in some aspects, such as small percentage of degraded land, larger areas under leguminous crops, low level of instability in cereal production and moderate availability of water. However, the state is low on sustainable food access because of a lack of diversification of livelihoods. The state also has high infant mortality rates showing poor health care.

Kerala is another unique state, in that it is deficit in food grains, fares badly in present food production security but good in food access and food absorption. The state has diversified into non-crop enterprises and provided requisite purchasing power to the people.

Mizoram is in the green—though many other states of the northeast, barring Arunachal Pradesh, are in shades of yellow—as this state has still retained a good forest cover, has good surface water availability and the net sown area has been increasing. The IMR is low, showing better health for the population. Livelihood access within agriculture is good, as many seem to have a piece of land leaving only a small percentage landless.

Environmentally unsustainable states have been shown in shades of red. The value of the final index varies between 0.266 and 0.558. Nagaland has an index value of 0.266 and falls in the category of extremely unsustainable. Nagaland occupies the worst position at the 25th rank, because of its environmental sustainability indicators. Nagaland is fairly secure as far as the sustainability of food access and livelihood are concerned. It ranks four on these counts. Both poverty and population pressure are low at present. The absorption index is also good. Nagaland is a case in point that shows high levels of food security at present but very poor sustainability. Sustainability of Food Availability Index gives it a rank of 22. Nagaland thus occupies the lowest position of 25 in the Composite Index. The other two indices cannot compensate for its performance on the environmental sustainability front. It has very little net sown area. Though the per capita forest cover is good at present, the unutilized surface water available for the future is very low. The economic and ecological feasibility of groundwater use appears uncertain. To increase its food grain production, the net area sown has increased, probably at the expense of forest cover. This is not a very good sign. Degraded land, degradation (of eight varieties) being caused mainly by human activities, constituted about 50 per cent of the total geographical area. Nagaland's position is

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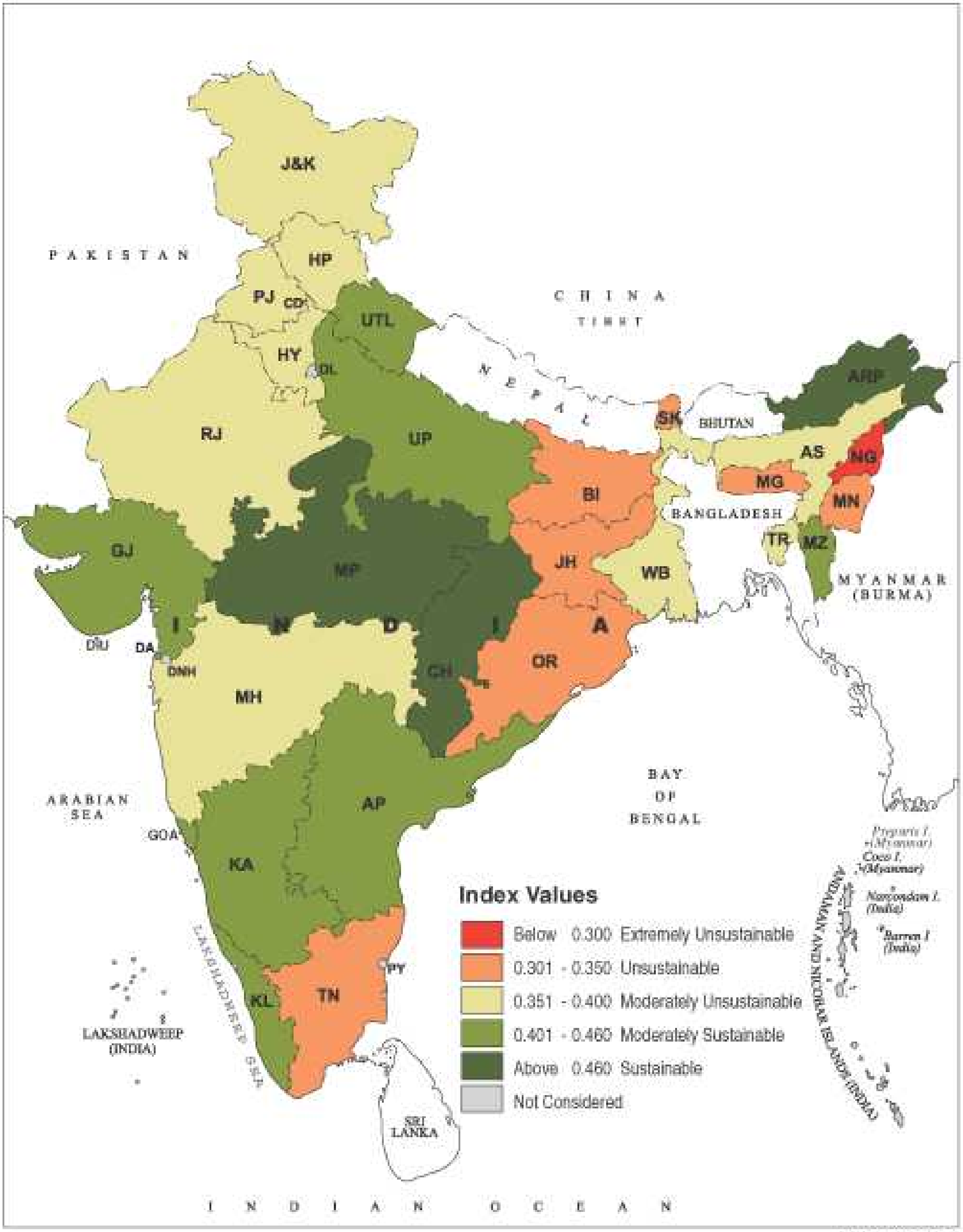

Map No. 9.1

precarious because it is a hilly area. Degradation of the forest on the hills leads to the formation of ravines and gullies and permanent damage to land. Most of the erosion is caused by water. Hence, high rainfall in itself is not enough to make a place sustainable. Sufficient vegetative cover and tree cover to hold the land and to prevent water erosion is more important. Though Nagaland has more forest per capita than other states, the cover is not sufficient to protect the hill slopes. The crop pattern has no legumes. About 33 per cent of the population live below the poverty line. More than half (53 per cent) do not have access to safe drinking water. Nagaland assures a cultivated land base to the majority of its people. Landless labour is totally absent. Yet poverty persists in the state. The high level of environmental degradation is responsible for the state being put in red.

The next category of unsustainable states (index between 0.300 and 0.350) includes Sikkim, Manipur and Meghalaya. Surprisingly, some of the environmentally most unsustainable states are in the Eastern Himalayan and the northeast hills, which are ecological sub-regions. These regions are generally believed to be rich in water and forests and biodiversity. They are represented in red for the same reasons as those that apply to Nagaland. As observed in the chapter on land, degradation levels (ranging from 20 per cent in Assam to 58 per cent in Manipur) are high in most of the northeastern states. Forest degradation and repeated erosion by water has put them in this position.

Hill slopes need more forest cover than plains to prevent water erosion. If the forests on the hills are lost, the damage caused by high rainfall is obvious. The soils in the northeast do not have much water-retaining capacity. The available water capacity (AWC) is medium to low. All the states in this region except Mizoram and Arunachal Pradesh seem to be rather unsustainable environmentally. These findings emphasize the importance of conservation and the most urgent need to stop further deterioration of land and forests in the ecologically fragile mountain ecosystems.

The second category of **unsustainable states** features Tamil Nadu, Orissa and Bihar, in that order. Tamil Nadu is worse off than Orissa and Bihar. Tamil Nadu comes under this category despite the relative prosperity of the state in terms of lower poverty and diversification of the state economy towards higher-paid jobs. While the Absorption Index for Tamil Nadu is good, the strong negative features are unsustainable food production and unsustainable livelihoods. The Sustainability of Food Production Index ranking for Tamil Nadu is 21 among 25 States.

Tamil Nadu's problem is over-exploitation of natural resources. Net sown area has been declining in recent years. The state has very little forest cover. Surface water and groundwater utilization is very high, leaving very little of unexploited water resources for the future. Most of Tamil Nadu is ecologically a semi-arid region. It has deep red loamy soils with low water-retaining capacity. About 16 per cent of the total geographical area has been degraded. These grim facts give the state a poor status as regards the Environmental Sustainability of Food Production Index.

Livelihood security in Tamil Nadu is relatively good at present. The state has a relatively low level of poverty, fairly good diversification into rural non-crop agricultural work and non-agricultural work. Yet about 70 per cent of the work force in Tamil Nadu still depends on agriculture. The sustainability of livelihoods of those still dependent on agriculture is bleak, because of excess pressure of population on land in this semi-arid region with low rainfall. Apart from the small size of the holdings, a large percentage of workers are also indirectly dependent on land. Despite very good irrigation, instability in production remains a high 15 per cent. Dense forest cover, which would strengthen watersheds is low, so is non-timber forest produce, which could help provide livelihoods for the poor.

Scarcity of surface water and groundwater in relation to its population size and irrigation needs is a serious problem. Very little of the water resource is available for the future. Hence, Tamil Nadu should change the pattern of agricultural development and shift to practices that consume less water. An occupational switch to non-agricultural work and non-crop activities is being noticed; this trend should be encouraged through enterprises in many areas including food-processing industries. Tamil Nadu has a pattern of more spread out urbanization, which is a welcome feature. Curbs on reckless groundwater exploitation should be imposed and implemented with rigour.

Orissa and Bihar have become unsustainable despite good rainfall, water and forest resources. Ecologically, Orissa is different from Bihar; it is situated mostly in the eastern plateau and the Eastern Ghats. Orissa fares well from the standpoint of sustainability of food production. But it ranks 24 in sustainable food access. The position with respect to absorption index is also quite low. Thus, despite all the natural endowments and potential for sustainable food production, the state is faced with poverty, unsustainable livelihoods and the lack of access to safe drinking water and health facilities.

Though food production is environmentally sustainable in Orissa, livelihood sustainability is in question because of the fluctuations in food production caused by poor water management and water erosion despite good rainfall. Most of the soils in Orissa are red and lateritic: their water-retaining capacity ranges from medium to low. Net sown area has been declining in the state. Poverty is very high at 47 per cent. Livelihood opportunities are limited, so are non-crop enterprises. The problems are compounded by the lack of safe drinking water and lack of health facilities.

The Bihar scenario is somewhat similar, though Bihar is situated mainly in the plains. Ecologically, Bihar is more varied than Orissa. It contains three major ecosystems—the fertile Bihar plain with alluvial soils; the Mahanadi Basin with clayey red and yellow soils and medium water-retaining capacity; finally, the north Bihar plains with deep loamy alluvial soils and medium-to-low water-retaining capacity. Bihar is environmentally more sustainable than Orissa. However, it still has some problems.

Net sown area has been declining. The state has a poor forest cover. It ranks 12 in the Sustainable Food Production Index, but gets the lowest rank (25) for Sustainable Food Access. The livelihood situation at present is not good. The state has 42.6 per cent of people below the poverty line. Only 17 per cent of the total work force is dependent on non-agricultural work. Less than 0.5 per cent of the rural population is engaged in non-crop agricultural enterprises. Landless labour constitutes a substantial percentage of the rural population.

Orissa and Bihar demonstrate that sustainability of food access and livelihood access are as important as sustainability of food production. High levels of poverty, fluctuations in production, loss of crop either from drought or floods or pests and debt burden undermine the capacity of the people to withstand risk. Diversification of livelihoods is not possible as risk-taking capacity is absent. Investments in agriculture and infrastructure are necessary. Critical minimum help has to be provided for a prolonged period to reduce risks and ensure smooth flow of incomes.

Moderately unsustainable states have been shown in yellow in the map. Nine states are moderately unsustainable. It is remarkable that highly food-secure states, in terms of food production, food and livelihood access and with good facilities for health care, such as Punjab and Himachal Pradesh belong to this category. Haryana is equally good for food production and food access but not so for health care facilities. These states belong to the middle category since they have very low environmental sustainability. They are characterized by excessive use of natural resources leaving very little for the future. Ideally, these states should stop further exploitation of natural resources and shift attention to environmentally friendly enterprises. It is difficult to reduce economic activity overnight, but it should be possible to organize gradual shifts in the population from being directly dependent on the land to non-crop enterprises.

9.4 Path to Sustainable Development

Sustainable food production and sustainable livelihood access may be described as components of an evergreen revolution. There are pathways to achieve this evergreen revolution. The path towards sustainable development differs from state to state. States with a better natural resource base can provide sustainable food production, but they may not be in a position to produce enough food at present. Likewise, some states have the resources and the potential to provide better livelihoods for rural populations, but the current levels of livelihood access are not good.

States are roughly classified into nine categories to help us to analyze the situation better. They are tagged as high, low and medium on Sustainable Food Production and Sustainable Food and Livelihood Access. Except Arunachal Pradesh, none of the states fare well in both the indices. None of the states have fallen in the category of low sustainable food production and low sustainable food access. Orissa, Bihar and Maharashtra fall in the category of moderately sustainable food production but very low on sustainable livelihood access.

States like Kerala, Punjab, Haryana, Jammu and Kashmir, Himachal Pradesh and Goa are all good in providing sustainable food and livelihood access but moderate on the sustainable food production front. Nagaland and Sikkim are also high on the sustainable livelihoods but low on sustainable production front.

On the other hand, Madhya Pradesh, Uttar Pradesh and Andhra Pradesh are high on sustainable food production but moderate on sustainable food access. Manipur is very low on sustainable food production and moderate on sustainable livelihood access (Table 9.5).

An interesting finding is that poverty, natural resource depletion and over-exploitation of resources need not necessarily go together. For example, in Madhya Pradesh, the major problem is sustainable livelihood access. The presence of natural resources in itself neither improves the

Table 9.5

Production and Livelihood Access Index

SUSTAINABLE PRODUCTION		SUSTAINABLE ACCESS INDEX		
		High	Moderate	Low
	High	ARP	AP, UP, MP	***
	Moderate	GOA, KL, J&K, HY, PJ, HP	AS, GJ, KR, MG, MZ RJ, TN, TR, WB	BI, OR, MH
	Low	NG, SK	MN	***

Note: Based on Natural breaks from Arcview

Sustainable Production Index and Sustainable Access Index given in Table 9.3

Sustainable Production Index

High - 0.594 - 0.443

Moderate - 0.443 - 0.279

Low - 0.279 - 0.114

Sustainable Access Index

High - 0.547 - 0.413

Moderate - 0.413 - 0.261

Low - 0.261 - 0.178

poverty situation nor leads to high levels of degradation. One has to look into other factors related to commercial exploitation of natural resources unrelated to the need of the poor. This aspect needs further research to decide the strategies of sustainable development.

Strategies of sustainable livelihoods will have to be chalked out for each state to achieve the path of sustainable food production and sustainable livelihood security. Poverty alleviation of the rural poor using the existing natural resource potential is the key issue for Madhya Pradesh. Similarly, the problems of Orissa and to some extent of Bihar are in increasing land productivity, diversification of agriculture, improving infrastructure and providing basic amenities and market linkages. Removing pressure on land and water and natural resource conservation for sustainable water supply is essential for Tamil Nadu. Forest restoration and natural resource protection are essential in Andhra Pradesh, Rajasthan and Gujarat. Policy shifts required and programmes needed to achieve the goal of evergreen revolution are elaborated in the next chapter on the policy implications of natural resource degradation.

CHAPTER 10

Policies and Programmes

This chapter takes a look at current policies and programmes on agricultural production and rural livelihoods and their impact. There is an attempt to see how the policies have been conducive to sustainable food production, conservation and sustainable use of natural resources such as water, land, forests and biodiversity and the participatory approach to conservation by village communities.

The policies are discussed here under six major heads:

- Food and crop production policies
- Policies of natural resource use
- Policies of community conservation
- Policies for sustainable livelihoods
- Policies of clean air, water and health care
- Gender-related policies

10.1 Food and Crop Production Policies

A number of issues such as technology, agricultural prices, export and import liberalization, import tariffs, agricultural subsidies, credit policy and investment policy together have an impact on the sustainability of future food production and food availability.

10.1.1 Technology

Technological progress has been the main driving force behind the increase in India's food production. Technology helped increase the production of food grains, vegetables and fruits. It ensured self-sufficiency in milk production and increase in poultry and fish production. Commercial interest in technology was driven mainly by the demand for high-value crops such as oilseeds, cotton, fruits and vegetables and certain animal products.

The Government of India has funded almost all the research in staple foods and milk production. The green revolution and the white revolution were made possible by the synergy between technology and public policy. Assured and remunerative marketing opportunities were the principal catalysts for the green revolution in wheat and rice and the milk revolution.

After the mid-1970s investment in agricultural research has been far less than what was required. Such investment has in fact decelerated since the 1980s and more so in the 1990s. Research expenditure increased at the rate of 7 per cent per annum during the eighties. It slowed down to 1.8 per cent per annum in 1993. Up to 1993, about 60 per cent of the investment was provided by the Central Government, about 20 per cent came from State Governments, about 12 per cent from private companies and the remainder from foreign donor agencies.

India has one of the largest institutionally developed systems of agricultural research in the world, with over 10,000 scientists engaged in research in different branches of agriculture. It is unfortunate that government initiatives in agricultural research and investment in food grain research have declined at a time when new technological inventions and innovations are needed to identify alternatives to irrigation–fertilizer technology in food grain production.

The green revolution was largely a public sector initiative. The gene revolution led by molecular genetics, in contrast, is becoming largely a private sector initiative (Swaminathan 2003a). Unless R & D work on "GM foods are based on the principles of bio-ethics, bio-safety, biodiversity conservation and bio-partnerships, there will be serious public concern in India and other developing countries about the ultimate nutritional, social, ecological and economic consequences of replacing numerous local varieties with a few new genetically improved crop varieties" (Swaminathan 2003).

10.1.2 The Fatigue of the Green Revolution

In all the areas that experienced high levels of productivity and production with seed-fertilizer-water technology in rice monocultures, fertility-depleting rice–wheat rotations and other rotations profited the farmers earlier but now have become highly unsustainable. This phenomenon is referred to as the *fatigue of the green revolution.* This fatigue has lead to a declining contribution of technology to productivity. Total Factor Productivity growth has been decelerating for many crops and become negative for some (Planning Commission 2002). More and more inputs are giving less and less of additional output.

From now onwards, eco-friendly technologies will have to be deployed to achieve sustainable food production. However, no specific policy for eco-friendly technologies has been formulated in India. We ought to examine how science can be mobilized to raise the biological productivity ceiling further without associated harm. An evergreen revolution, characterized by improved productivity without affecting ecology, has to be achieved.

10.1.3 Agricultural Extension

The gap between yields realized in demonstration plots and yields realized in farmer's fields is high. There is also a huge gap between the yield of progressive farmers and the yield of other farmers, even when natural resource endowments are the same. Up to the mid-1970s, and even during the 1980s, public-funded location-specific research and agricultural extension services stimulated the spread of high-yielding varieties. Rice technology could not spread as fast as wheat technology because of constraints such as water management and crop management. In the 1980s, the Central Government initiative to solve waterlogging, drainage and water management problems in eastern India (West Bengal, Bihar and Assam) improved rice production. There is much scope even now for enhancing the productivity of food crops using the available technology.

Extension machinery and information support to farmers have also suffered in recent years. Most of the information now reaches people through private agencies, traders and advertisements in the electronic media (Planning Commission 2003). There is considerable scope to create location-specific information content and disseminate it to target groups through radio, print media and electronic media. However, Information Communication Technology (ICT) alone cannot solve problems arising from technology adoption. Specialized agricultural extension services to farmers by qualified persons are necessary.

10.1.4. Agricultural Subsidies

The policy of pricing irrigation water in canal-irrigated areas and the subsidies on electricity to lift groundwater have promoted wasteful use of water. This has led further to ill effects such as flooding and alkalinity, receding water tables and sea- water ingression. In certain parts of the country where the groundwater potential is under-utilized and investment is the main constraint, such subsidies can be advocated till the system becomes viable. But subsidies on inputs should not be a long-term measure. Fertilizer subsidy on nitrogen fertilizers alone lead to the excess use of nitrogen compared to phosphorus and potash. Fertilizer also seeps into the water and causes water pollution. Subsidies on farm machinery and equipment have also been less useful in improving productivity. Sometimes the subsidies on machinery have displaced labour and affected livelihoods. Yields have fallen in some districts of the country. Land degradation has occurred in many locations. The current input subsidies are causing damage to natural resources and, hence, they need to be removed.

Farming no doubt needs subsidization of some sort to be viable. But the benefits should reach farmers in a different manner. Widespread access to credit, infrastructure, extension services and technology will improve productivity and profitability in a healthy manner. Equally important are setting viable market linkages and increasing market efficiency.

At present the gap between the consumer's prices and the producer's prices is wide. A move towards improving market efficiency is essential. Farmers need direct linkages with supermarkets, agro-processing units and farmers' bazaars. Careful study is necessary to identify the market for each scale of production and each type of product: perishables, non-perishables, those that need post-harvest operation and those that do not. Different approaches are needed to bring about market efficiency.

It is necessary to seriously re-look agricultural subsidies on seed, water, electricity and farm equipment. The idea is not to deprive agriculture of the meager subsidy it enjoys, but to make subsidies less damaging to land and water and more effective to the farmer. Subsidies should be in the form of credit, technology, extension, infrastructure and market linkages and help to make farming viable.

10.1.5 Agricultural Price Policy

The agricultural price policy directly benefits only some producers, consumers and intermediaries. But the impact of the policy, through the open-market prices of food grains, is felt on everyone (including producers and consumers who are not directly affected by Minimum Support Price and Consumer Issue Price). Since the Agricultural Price Policy affects 20 to 25 per cent of the marketed surplus of food grains, it is an important instrument that the government can use as an incentive or disincentive for food grain production.

The production of food grains has become highly price-sensitive in recent years. The government must ensure that farmers get remunerative prices. Hence, the Agricultural Price Policy requires a fresh look.

- It should aim at increasing local demand for food grains by making it affordable to people from all income groups.
- It should aim at using tariffs to curb the inflow of subsidized grain, which could depress prices and make food grain production unviable. Imports of subsidized grain hurt the poor more than the rich. When the poor lose their livelihood, they won't be able to buy enough food. Demand will go down too.

In the present context, Agricultural Price Policy has three aspects. The first is the domestic cost of cultivation and offering remunerative prices as Minimum Support Price (MSP) to the farmers. The MSP policy is important because when MSP is higher than the open market prices, there will be excess procurement, and unnecessary stocks pile up. Food grains are difficult to procure if MSP is lower than the open market prices. When market price is higher than MSP, farmers do not sell to the government.

The second aspect of MSP is the Consumer Issue Price (CIP) that determines whether food grains offered to Below-the-Poverty-Line (BPL) consumers and Above-the-Poverty-Level (APL) consumers ensures sufficient disposal of the stocks purchased at MSP. If the CIP is much higher than open market prices, the stock will not be lifted. If year after year, the stocks procured through a high MSP are not lifted, further purchase of food grains by the government will become difficult. Burdened by mounting stocks and maintenance costs, the government may even abandon procurement, thus discouraging production in the long run. A better match between MSP and CIP will ensure that sufficient quantity of food grain is produced and distributed.

Disposal of food grain stocks by the government to the open market and to exporters at a concessional price would be unethical. Traders should not get food grains from the government at the same rate as low-income consumers. Second, excess stocks released into the open market and the international market would depress prices for food grain producers and hurt their profitability. No doubt many non-price factors influence non-lifting of stocks by the Public Distribution System (PDS) but price is one of the major issues.

The third aspect is the export–import policy concerning food commodities and protection to domestic farmers from the onslaught of cheap products from abroad. If open-market prices in the domestic market are higher than prices in the international market, domestic products will suffer, unless sufficient import tariffs are levied. Domestic production will become unprofitable, the livelihoods of farmers will be hit and self-sufficiency in food will be far away.

The Agricultural Price Policy has to consider all the three aspects together. Policies undertaken in isolation will not work. Any one of these policies might create a disincentive for food grain production in the country.

The Agricultural Price Policy and the associated buffer stock policy have been criticized right from their inception as unrealistic in their aim of protecting producers from low prices and low-income consumers from high prices. The policy has been blamed for being partial to producers. Another criticism is that the stocks of the Food Corporation of India (FCI) are instrumental for shortages in the open market; these also lead to high prices for consumers as the buffer stocks reduce the surplus available in the market. Stocks pile up and rot because of inadequate storage facilities; on the other hand, people face seasonal starvation in other parts of the country.

Consistency of minimum support price with consumer issue price: It is important to balance the demand for stocks from the PDS with the supply of stocks from procurement. Till the 1980s, the price policy effectively increased the production of food grains by offering incentive prices to some farmers in some parts of the country. The MSP fixed by the Commission on Agricultural Costs and Prices (CACP) was based on data relating to the cost of cultivation. But the actual prices at which the government procured the grain were always higher than the recommended price. This led to the stockpiling of buffer stocks. This practice cannot continue for long. The government cannot procure food grains year after year when it is unable to sell them.

Several committees and commissions have urged the government to reduce grain stocks by making the PDS universal. The Kirit Parekh Committee recommended that the Food Corporation of India should whittle down the buffer stock level to 10 million tonnes (four million tonnes of wheat, six million tonnes of rice). The Commission on Agricultural Costs and Prices as well as the Abhijit Sen Committee on Long-term Grain Policy recommended a universal PDS at BPL prices. Such a policy would increase the subsidy consumers get at present. But it would generate some useful benefits.

The overall subsidy may not exceed present subsidy levels because

- Subsidy for producers will go down if the overall procurement is reduced.
- A reasonable MSP as recommended by the CACP will bring down the subsidy.
- Other subsidies to traders and exporters can be avoided.

The subsidy is also given to wholesale traders, retail traders and millers under the Open Market Sales Scheme (OMSS), (GOI "Report of CACP 2002"). When the government has surplus grain and market prices are low, OMSS is used not to stabilize prices but to dispose of the stocks. Subsidized prices for OMSS are fixed differently for different regions. These subsidies can be used to provide grains to APL families as provided under the BPL category.

The present distinction between a BPL card and an APL card is arbitrary and not based on the actual income of the household. The actual income can change from year to year. Families get into the BPL category when the monsoon fails. Families shift to APL when the monsoon is good. Hence all those who wish to benefit from the PDS should be allowed use it at the same price. In any case the non-poor do not use PDS.

No doubt universal PDS should also be accompanied by reform of the system to eliminate corruption. This can be done by handing over the PDS operation to self-help groups and consumer co-operatives, so that it is a genuine example of people's participation. Give the poor loans so that they buy food grains they need through PDS, and allow them to repay the loans in cash or kind from their earnings or from farm produce. Such a system would increase the demand for PDS grain from low-income families. Further, a decentralized system of procurement and distribution will enable a better match between local demand and local supply. Demand-based operations of the FCI for the PDS can facilitate effective movement of grain from surplus states to deficit states.

Making MSP and EXIM policies consistent: The heavy subsidies that rich countries give their farmers distort prices in international markets. Poor countries can't afford to dole out such massive subsidies to their farmers, so their commodities are priced higher than those of the rich countries. The failure of the WTO trade talks at Cancun has aggravated the problem. The threat of the onslaught of cheap subsidized food from the west is real and not imaginary. It may harm demand for domestic products in poor countries. This has already happened with oilseeds. However, rice imports have not been high—perhaps because of the taste preferences of consumers for local or specific varieties.

As a member of the WTO, India's options for blocking such imports are limited. India has already removed duties on many food products. The only way open to us is the tariff route. Hence the government should have a consolidated commodity-wise policy for MSP as well as for EXIM tariffs. At present these two policies are unrelated. If the MSP of some commodities is increased, tariffs on imports of the same commodities should correspondingly go up. Otherwise, consumers will opt for the cheap imports flooding the market, the government will be stuck with what it has bought, many farmers will be unable to sell their product and the MSP policy will be ineffective. To reiterate: **The MSP policy will have to be consistent with that of import tariffs.** The CACP has emphasized this point.

10.1.6 Agricultural Credit Policy

One of the most important determinants of agricultural growth is the supply of credit to the agricultural sector. There is a strong correlation between the rate of growth of credit to the agricultural sector and the rate of growth of GDP originating in the agricultural sector. The spread of the cooperatives has been unmatched by the spread of any other formal financial institutions. This is a result of the earlier initiatives taken by the Government. In 1996–1997, cooperative credit institutions accounted for around 49 per cent of the total rural credit disbursed. However, the defaults were high and continue to be very high because of a slackening in recovery. The writing off of loans of the agricultural sector in pre-election times and the loan 'melas' have further worsened the situation of repayments. All this has contributed to the choking of this avenue of credit. Unless the loans are repaid regularly, more loans cannot be provided. Every time an avenue of rural credit got choked, a new channel has been introduced. Thus a number of institutions such as land development banks, cooperative credit societies, rural banks, commercial banks and self help groups raising micro credit, operate in the villages, in addition to the informal credit obtained from moneylenders, landlords, traders and so on.

With the nationalization of banks in 1969, the objective of social and development banking was adopted. Branch licensing policy, priority sector lending, differential rates of interest, the Lead Bank Scheme, the Integrated Rural Development Programme (IRDP) scheme, the establishment of Regional Rural Banks, the establishment of the National Bank for Agriculture and Rural Development (NABARD) etc., were some of the initiatives taken.

However, several changes were introduced in the nineties. The term 'priority sector' was widened for the sake of lending to food processing and software firms. The Rural Infrastructure Development Fund has provided banks with soft options for 'priority sector lending. The branch licensing policy has been abolished. All these changes have resulted in a complete turnaround of the social and development objectives of banks, with very serious consequences. In the nineties, the credit–deposit ratios in rural areas have suffered a huge fall. The growth rates of credit to all priority sectors taken together and to agriculture in particular have declined substantially. The rate of growth of rural branches of credit agencies has become negative.

An attempt has been made to hand over banking functions in rural areas to NGOs and other self-help promotion institutions through the microcredit alternative. These institutions do not have the kind of reach that cooperatives and commercial banks enjoy. The rate of interest they have to charge for microcredit loans is much higher than that of formal financial institutions. Their monitoring costs are high. The average size of microcredit loans is very small. It follows that the microcredit alternative is not, and cannot be, an alternative to long-term institutional credit in rural areas.

Agricultural investment, and therefore agricultural growth, depends heavily on the supply of long-term institutional credit. It cannot be disputed that financial institutions are in need of a major overhaul. But the withdrawal of the state from its role as long-term credit provider to rural areas is not the solution.

10.1.7 Crop Insurance

In the changed circumstances after the global integration of food markets, Indian farmers face two types of risk. The first is weather risk and the other is market risk. There is a risk of crop failure from weather factors such as droughts, floods, cyclones, pests and diseases. Farmers are faced with crop failure even in the years of good monsoon from pests and diseases and untimely rains and cyclones. Earlier, up to 1998–1999, the prices of food grains had been consistently high. Since 1999–2000, the prices of many crops have been declining, except when the crops are procured by the government at a price far higher than the open market rate. Price risk leads to credit risk. Normally, when production declines, price increases and compensates for the lower production. However, in the internationally subsidized agriculture market, prices are determined by the world supply and not by the domestic supply.

The aim of crop insurance is to protect farmers from crop failure on account of natural calamities such as drought, flood, hail storm, cyclone, fire, pests, diseases, etc. Crop insurance is not totally new to India. However, so far very little benefit has been derived from it. The Government of India introduced a scheme called 'Comprehensive Crop Insurance Scheme' (CCIS) in the year 1985 in 19 states and union territories. In 1999–2000, it was expanded in scope and reshaped as the National Agricultural Insurance Scheme. A corpus fund was also created with contributions from the central and state governments to take care of claims beyond the liability of the General Insurance Corporation. It has been proposed that the National Crop Insurance Corporation refinance crop insurance. A special insurance scheme was introduced for commercial seed growers and seed breeders in selected states. The crop insurance schemes were first introduced by the Government of India. Later, under the World Bank initiative, such schemes, with some variations, were introduced by some of the private banks.

The CCIS had limited scope. The aim was to restore the creditworthiness of the farmers for the ensuing season. The insurance was a credit-linked insurance. Essentially, it was meant to cover any credit default by the farmer on account of crop failure. Hence, it was linked with the loans given to farmers on a short-term basis; it was also linked to the acreage under the stipulated crops. Initially, the scheme provided cover to only ten kharif crops and seven rabi crops. The scheme covered food grains and some oilseed crops such as groundnut and soybean. The terms of the insurance were attractive: 1.5 to 3.5 per cent of the sum insured had to be paid as premium. Further, small farmers and marginal farmers received a 50 per cent subsidy on the premium from the state and central governments. The burden of this subsidy was shared by the state and central governments on a 75: 25 basis; that is, the state governments provided 75 percent and the central government, 25 percent of the subsidy.

The state has provided an outlay of Rs. 50 million as its share of premium subsidy under the Ninth Five Year Plan (1997–2002). The Central and State Governments, the General Insurance Corporation of India, is a public sector undertaking, and the participating banks jointly implemented the CCIS.

The NAIS was introduced in 1999–2000 in the place of the CCIS in all the states. The new scheme is available to all farmers and not just to those who have taken short-term loans, as was the case in CCIS. It is available to all irrespective of the indebtedness and the size of the land holding. The scheme has now been extended to farmers growing commercial and horticultural crops. Eleven crops for which yield data are available for the past ten years have been included under the scheme. More crops are proposed to be included. The new scheme operates on the basis of an area approach. Defined areas for each crop notified are assessed for widespread calamities. Individuals are assessed for localized calamities such as landslides, hailstorm, flood, etc. So far, the basis of operation was only the area affected by natural calamities.

Crop insurance is not very widespread in India and is riddled with a number of problems. There are problems of coverage, of delayed payments, of assessment, of awareness and understanding and, finally, of viability.

From 1985 to 1999, insurance was restricted to the credit portion and did not cover the entire crop and it was available only to farmers who take short-term loans from commercial banks. However, after the introduction of the new scheme in 1999-2000, the scheme has become more widespread. Yet, the total coverage is still very low. The scheme had covered about two million farmers in the entire country by 2001. Region- wise break up is not available. Data on coverage of small and marginal farmers and big farmers are not available. The amount of subsidy actually disbursed to the small farmers is also not available.

The scheme appears to be highly unviable, judging from the figures of the premium collected and the claims settled. In the rabi crop season of 1999–2000, against Rs. 5.42 crores of premium collected, the claims settled were worth Rs. 7.69 crores. In the kharif season of 2000, against Rs. 206.51 crores premium collected, claims settled were worth Rs. 1179 crores. In the rabi season of 2001–2002, against Rs. 27.45 crores of premium colleted, Rs. 41.90 crores worth of claims were settled. Thus, claims have far exceeded the premium in each season, making the government incur losses season after season. The scheme was stopped for some time due to heavy losses.

The main reason for the losses appears to be the adoption of the area approach instead of the individual approach. The moment an area is declared drought-hit or flood-hit or a calamity area, all the claimants have to be paid at the stipulated rate, irrespective of the actual loses incurred by them. Some of them may have been using irrigation and may have realized much higher than the average yield.

Even if the government decides to shift to individual base from the areas base, the administration cost of crop insurance would be very high, as every farmer has to be assessed, based on his local conditions. Traditionally, the administrative costs of crop insurance are heavy, and in developed countries become a part of the farm subsidies.

Further, the premium rates charged are a fixed percentage of the sum assured or the actuarial rates or whichever is less. So far, actuarial rates have not been calculated for food crops and oilseeds. The actuarial rates have to reflect the probability of loss. It is not possible to calculate these rates unless the probable price at which the crop can be sold and the percentage loss, based on the past yield, to the farmers are available. So far, actuarial rates have been applied to commercial crops.

To rationalize the premium structure, the government proposes to set up an exclusive agency that can specialize in crop insurance. In this connection, it is worthwhile to contrast it with the World Bank–introduced weather insurance in some parts of Andhra Pradesh. The scheme stipulates that the premium should be 15 per cent of the maximum claim and links it to the weighted average Rainfall Index. The weightage to the rainfall in the plant-growing period is higher but it is the same for all crops across the region. Further, there is restriction on the deviation from the rainfall. Only a deviation of more than 200 mm is taken into consideration (World Bank

2003a). The basis of claim is not related to the area under the crop, but to the sum assured in the policy. This approach is more beneficial to the insurance company but less beneficial to the farmer. He may end up paying higher rates of premium for much smaller claims.

10.2 Policies Related to Natural Resource Use

Policies and public action have to enhance food availability in a sustainable manner. Conserving and enhancing the ecological foundations essential for sustainable advances in production and productivity are of utmost importance. Any policy on land, water or forests cannot be viewed in isolation. A land-use decision is a water-use decision and vice versa. Forests are needed for clean water. Water from the catchments of the fully or partly protected forests is cleaner and plentiful. The economic value of the water storage function of the forests is much more than the economic function of providing wood. Protecting forests around the water catchments is a necessity (World Bank 2003b). The importance of forests as watersheds cannot be undermined. Hence, an integrated approach to planning, managing and developing these natural resources must be adopted. Also, this cannot be done without taking into consideration the livelihoods of the people. Any policy must take into account ecological, economic and equity considerations. Massive afforestation and flood control and spread of vegetative cover and tree cover is also a very big job to achieve. Price incentives as well as legal sanctions are also important to prevent degradation.

10.2.1 Land Policy

Long-term sustainability was not given adequate thought either by the policy makers or by the landowners. The experience of Punjab and Haryana clearly shows that increased production has to come hereafter, from pathways that are environmentally unsustainable. Public policy in this area will have to address conserving prime farmland for agriculture.

Conservation of Prime Agricultural Land: In recent years, prime agricultural lands have degraded for a number of reasons. Lucrative commercial enterprises lead to change in land use and subsequent degradation. Prawn farming in the coastal paddy fields and brick kilns in the fertile lands of Haryana have degraded prime agricultural land. Agricultural land also shifts to non-agricultural uses in the vicinity of urban areas. There should be laws guiding land use. Often legal action is seen after the degradation has occurred, through Public Interest Litigations, as in the case of coastal prawn farms.

Wasteland Development: The 1970s saw the Government follow a policy of privatization of wastelands. However, this policy of land distribution to the poor was not accompanied by any fund allocation for development of these lands. Also, no specific Government department was made responsible for grasses and pasture development. As the needs of the people could not be met from these lands, degradation of forests continued. The late seventies saw a shift towards social forestry. However, the shares of the individuals, villages, Panchayats and the forest department were not laid down. This insecurity of benefits resulted in people being indifferent to these programmes.

In 1985, The Wasteland Development Board was formed to regenerate the health of wastelands and to promote people's participation. However, again, the people had no role in the planning or implementation of the programmes on their land. Besides, moisture conservation and water harvesting measures to control run off were not given importance. The new guidelines laid down by the

Hanumantha Rao Committee with effect from 1995 provided for development, through decentralized decision-making involving Panchayats and the local people dependant on watersheds, of the compact watershed and not just scattered pieces of land. A Watershed Development Fund was created. However, it has been felt that from the sustainability point of view, community-managed systems can succeed only with farmers' financial contributions. Although contributions to be collected from beneficiaries have been laid down, this has been difficult to follow in practice. Also, arrangements for handing over structures and maintaining plantations after completion of projects are absent. Several departments of the government implement watershed development projects without coordination with each other. There is insecurity of availability of funds at the grassroots level.

10.2.2 Water policy

National Water Policy: The National Water Policy in its present form appears to be a statement of intentions and does not have an action plan. It does not provide any authority or make anybody responsible for its implementation. The Policy does not provide the economic cost of water and investment scenarios. The constitutional provisions and legal issues have also not been addressed in the Policy. Hence, there is a need for evolving and operating the Policy according to a feasible action plan.

The National Water Policy of 2002 seems to cover the entire ambit of water-related issues: from irrigation, groundwater, drinking water, water quality to water conservation, flood control, resettlement and rehabilitation of people affected by projects, water quality and so on. However, there are several areas in which the policy is found wanting. Nowhere does it discuss community control over natural resources. While community participation in planning, designing, development and management of water resources schemes is mentioned, the actual powers, role and responsibility of the various stakeholders are not clearly defined. The policy talks about regulation of exploitation of groundwater resources. However, it does not draw any guidelines on how overexploitation of groundwater may be checked, particularly when subsidies on power are provided to farmers in various states. In its discussion on irrigation, the policy does not address how cropping practices leading to unsustainable utilization of water can be discouraged. The policy proposes inter-basin transfers as one way of meeting the needs of water scarce regions even when there is no consensus in the nation on the ecological and economical viability of interlinking rivers. 'The policy ignores the potential of rainwater harvesting and the importance of involving local communities to ensure that rainwater is trapped and refills natural aquifers in the ground[1]'. The policy also talks of private sector participation in building, owning, leasing, operating and transferring of water resource facilities, which is a cause for concern.

Watershed management: Watershed development has been given a major role for rainwater harvesting through afforestation, contour-grade bunding fortified by plantations, drainage line treatment with a combination of vegetative and engineering structures, check dams, desiltation of tanks, percolation tanks' groundwater recharge measures, agro forestry, increasing pasture lands and so on.

However, the tenth plan allocation to watershed management is woefully inadequate. It was less than Rs. 1000 crores per year in the 9th plan. The allocation

[1] Sunita Narian, "Bypassing Community rights", a flawed national water policy; in CSE. www.indiatigether.org

has increased to about Rs. 1850 crores per year on a basis of sharing of 50:25:25. The central government allocation is negligible at Rs. 4500 crores for all the five years. The rest has to come from the state governments and the local authorities. Financial requirements for an integrated landscape management of watersheds restoration, earthworks, water harvesting, afforestation and capacity building for joint management of forests, joint management of water and common property resource are quite substantial.

Augmenting water availability in these river basins: This is an important aspect of sustaining agriculture in these states. An in-depth study of the relationship between water availability in the river basins and the watershed ecosystem that they are a part of is of critical importance to policy. Almost all the river systems in India originate from watersheds. Even for the Himalayan Rivers that are fed by glaciers, watersheds are important for conserving and augmenting water.

The Watershed Atlas of India published by the All India Soil Survey and Land use Society has identified six major river basin drainage systems in India and the major watersheds in these basins. The ecological health of the watersheds in terms of adequate forest cover, stable hydrological regimes and least biotic interferences is critical for maintaining the availability and perennial nature of water in these river systems. They also minimize flash floods and landslides. In light of the current levels of degradation of watersheds in the country, disturbed hydrology of these watersheds, scarcity of water availability faced in most of the river basins and the conflicts arising thereof, the correlation between watersheds and river basins becomes very relevant. However, there is no concrete policy on this issue.

Planned increase of irrigation potential: At the end of the Ninth Plan, the total potential created through major and medium irrigation projects increased to 37.076 million hectares. In the Tenth Plan, a target of creating an additional 11.14 million hectares is envisaged. Thus, a total of 103 major, 240 medium and 62 extension, renovation and modernization projects are expected to be completed (Planning Commission 2003). The Ninth Plan also improved the minor irrigation potential created by another 3.64 million hectares (cumulative for surface and groundwater—separate figures are not yet available). The tenth plan envisages the creation of an additional 3 million hectares in surface water through minor irrigation projects.

Policy shift from major irrigation projects to minor irrigation projects*:* Based on the size of the area that can be irrigated by the river basins, the projects can be major, medium and minor. Irrigation projects with a culturable command area (CCA) of more than 10,000 hectares are categorized as major projects. Those with a CCA between 2000 hectares and 10,000 hectares form the medium projects. Major and medium surface water irrigation projects, estimated at the end of the Eighth Plan in 1997–1998, contribute to 58.465 million hectares, and minor surface water irrigation contributes to 17.378 million hectares. (The remaining 64.05 million hectares out of the total ultimate irrigation potential in India of about 139.893 million hectares is from groundwater irrigation schemes).

During the First and Second plan period, there was a conscious effort to expand irrigation through major canal irrigation projects. As these projects involved high cost overheads and could not be completed for long periods of time, the government policy has shifted towards medium and minor irrigation projects. Government investment in irrigation has declined considerably and that of the private sources increased. However, lack of investment in completing the projects undertaken and lack of maintaining the canal system and the tanks efficiently has been causing enormous loss of water. There is an urgent need to make the irrigation system more efficient and plug water losses.

The Command Area Development Programmes (CADP), integrated water resources management and watershed development programmes initiated by the government of India are aimed at bringing a multidisciplinary focus to address the problems. The Programme initiated in 1972 focuses on improving the efficiency of canal irrigation systems at below the outlet level at the farmers end. It integrates development of adequate irrigation systems along with on-farm development. Other ancillary activities such as construction of link roads, godowns and market centres, arrangements for supply of inputs and credits, agricultural extension and development of groundwater for conjunctive use are also taken up as part of the relevant sectoral programmes in the State Plan. The CADP has so far covered 236 major and medium schemes and clusters of minor irrigation schemes with a total culturable command area (CCA) of 23 million hectares.

Implementation of CAD programmes has increased efficiencies in irrigation and water use in some parts. However, there have been several shortcomings in programme such as slow progress, inability to motivate people into conjuctive use of water, recurrence of old problems like waterlogging and lack of coordination with the local farmers, etc. It was recommended that Command Area Development be handed over to the Water Users Association and integrate the essentials of participatory irrigation management to make it more effective (Planning Commission 2003).

The 10th Plan document lists the main reason between the lag between potential created and utilized. Non-construction of on-farm development works below the outlet, change in cropping pattern to more intensive crops and over-estimation of run off in hydrological planning of reservoirs as a result of which they do not get filled to their full potential are some of the reasons for reduced utilization efficiency.

Water use efficiency in canal and tank irrigation systems: It is important to simultaneously improve efficiencies of canal and tank irrigation systems. Maintenance and repair of the canal systems to prevent breaches of water, regulation of water supplied through sluices to the farms, constructing sufficient storage structures to contain surplus water and to minimize water scarcity will improve the efficiency of water supply. Evaporation of water from the canals can be minimized by sound engineering practices to suit climatic conditions. It is critical to modernize and recharge the tanks, and revitalize *kudimaramathu* activities. Modernization of tanks includes desilting of tanks to the desired levels[2] and excavation of link channels, reclamation of foreshore lands, improving bunds, repairing damages, construction of anicuts, checking weed growth and infestations, clearing underwood, and adopting soil conservation measures like vegetative tree cover. There are two types of tanks—n*on-system* tanks and *system* tanks. Non-system tanks are those that depend on rainfall in catchment areas and are not connected to major streams or reservoirs. System tanks, on the

[2] Desilting of tanks need to be carefully carried out. Usually, in a 10-year cycle, tanks get filled up fully only for an average of 3 years, for another 2 years, the tanks are part full, whereas for the remaining period, the tanks fail to meet the average irrigation requirement. Thus de-silting will help only during the 3 years of full water storage. Moreover, the earth removed during de-silting is difficult to dispose of. De-silting is also costly. It is therefore considered advisable to desilt only partially and to the desired level based on the local irrigation and consumption requirements.

other hand, are those that receive supplemental water from major streams or reservoirs in addition to the yields in catchment areas. Most of the tanks (> 90 per cent) are non-system tanks. Proper maintenance of the watershed is necessary to maintain the systems tanks that are hydrologically connected to each other and to the major river basin. Regulating groundwater extraction in the cultural command areas and tank ayacuts and at the same time ensuring adequate water in the tanks through sufficient storage is also important. Flood management and management of water scarcity in river basins is an integral part of improving the efficiency of canal and tank irrigation systems. The role of water users association (WUA) is very important in equitable and scientific appropriation of water in the tanks and their maintenance.

Regulating the development of groundwater: Several factors have simultaneously worked towards overexploiting and depleting a resource that is fast becoming one of the most precious resources on earth. The most critical issue in groundwater is its overexploitation. In order to regulate the use of groundwater, blocks have been categorized as 'white', 'gray' and 'dark' areas, dark denoting overexploitation. (Central Groundwater Board, 1995). A detailed state-wise evaluation of overexploitation was done in 1998. The number of dark and overexploited areas in the states of Punjab, Haryana, Tamil Nadu, Rajasthan, Gujarat and Karnataka is significantly high. The number of dark and overexploited blocks or watersheds has been steadily increasing in Tamil Nadu, Punjab and Rajasthan since 1984-1985. (Chadha 2002).

Chadha, D.K., 2002. "Ground Water Development and Artificial Recharge – way to prosperity in Sustainable Agriculture Water Resources and Earth Care Policies", Bhoovigyan Vikas Foundation: New Delhi.

Overexploitation has several consequences. The most visible expression of overexploitation is the reduction in the groundwater table. It has led to deepening of wells and sometimes to their being abandoned. Overexploitation has affected the quality of groundwater used for irrigation or for domestic purposes. In the coastal areas, this is followed by saline ingression from the sea making the water unfit for irrigation. In several other areas, geological formations have rendered deep groundwater aquifers saline or brackish. Excessive demand has resulted in using these waters for irrigation and drinking with the result that soil fertility is affected leading to severe health hazards. Increase in groundwater utilization for irrigation has led to the drying up of wells constructed principally for supplying drinking water, causing drinking water scarcity. When the right to water is the right to food, severe overexploitation can pose serious doubts on sustainable food security in the region. Several social and political factors have contributed to overexploitation. Electricity for running pump sets to draw water is highly subsidized or given free. Thus, it is critical to reverse the trend of overexploitation and facilitate augmenting of groundwater through adequate recharge for sustained agricultural production.

The National Water Policy, 1987 or 2002, does not mention the ownership pattern of groundwater. It has been assumed that ownership lies with the man who owns the land even though aquifers are considered public goods. Thus, ownership of private wells implies that owners can put up a groundwater-tapping device over their lands. The ownership of groundwater is still adapted from the Indian Easement Act, 1882, which rules that the owner of the land has the right to collect and dispose within his own limits of all water under the land. All groundwater existing and found beneath private property is fully under the

area of land. Further, it is easy for an individual to extract water by digging deeper into the ground without the knowledge of other well owners. This results in well owners tending to follow the 'riparian doctrine' under which each owner of a plot of land is allowed to extract as much water as he desires without regard to the effects on the owners of neighbouring plots (Das Gupta 1982). The doctrine, therefore, provides no protection to the owner of the well from the lowering of the water table in his land caused by a neighbour's actions. Hence, in the absence of any intervention, this has led to *competitive tapping* of groundwater that will lead possibly to an eventual ruin of the basin itself. Groundwater norms are not followed nor strictly enforced, leading to a proliferation of wells and overtapping. Administrative measures do not prevent farmers from tapping groundwater by sinking wells using their own resources or other private sources of credit. In such cases, the minimum distance between the wells is not observed (Ganesh Prasad 2001). Lack of community access to surface water resources has resulted in decisions made by central authorities placed far away from and ground realities. Many wells have also had to be abandoned because of inadequate yield and or the inability of the well owner to invest in further deepening. Several studies have reported 98 per cent failure in new borewells that have been constructed in severely overexploited areas, with the result that wells have become increasingly expensive, and, in some cases, the cost of erecting a borewell that yields water is three times more expensive than canal irrigation.

10.2.3 Forest policy

The government and the people have initiated several conservation efforts to reverse the trends of deforestation. There has been a steady increase in forest conservation initiatives by the various State Governments. The planned economic development of the country started in the year 1951 with the First Five Year Plan, which envisaged afforestation for the purpose of soil conservation. Subsequent plans included the introduction of a National Forest Policy, which emphasized the need to expand the forest cover to a minimum of 33 per cent of the total geographical area. The Forest policy of 1950 recommended afforestation of industrial economic species and plantations of fuel wood and fodder trees and plantations of fast-growing species. In the past, forests were leased out to contractors and wood-based industries, but in recent years, public undertakings, in the form of forest corporations, have been established by each State Forest Department to take over extraction. The 1980 Forest Conservation Act was a landmark in Indian Forestry. It put a check on the use of forests and promoted the conversion of forestland. It seeks to achieve a negative net (including afforestation) deforestation rate at the end of that decade (State of Forest Report, 1987).

Nevertheless, while a negative net deforestation rate is desirable, removing the existing forest cover and replacing it with new forest plantations may not be a desirable practice. Though it may help to maintain the tree cover, one must keep in mind that forest plantations really cannot replace the prime forests. Forest plantations typically consist of mono-specific, even-growth stands and, thus, are poor contributors to biodiversity. Hence, more than maintaining the tree cover through plantations, conservation of prime forests should be given priority.

Community participation was fully recognized in the Joint Forest Management (JFM) guidelines of 1990. Guidelines 2000 provided the legal support needed for the operations of the JFMs. It recognized the roles played by the women in conservation and allowed benefit sharing among the parties involved from the *forest harvests* (Anon 2000). A number of JFM have been formed in the recent years. However the evaluation reports show that it has been a success in a limited manner.

Recent trends in forest managements have shown that decentralized local management is more efficient in addressing local requirements.

10.2.4 Policies of Biodiversity Conservation

Human economic activity had reduced by 35 per cent the number of surviving animal and bird species as well as freshwater and marine fish, which provide a major source of food for many of the world's people (WWF Report 2002). Biodiversity has been declining in recent years and awareness about conservation of biodiversity has lead to a number of policies that promote conservation. There are two types of conservation: *in-situ* conservation means conservation in its natural habitat; e*x-situ* conservation means conservation in a protected habitat.

In-situ conservation: The Ministry of Environment and Forests is the nodal agency in the Government of India for planning, promotion and coordination with regard to biodiversity conservation including conservation and survey of flora, fauna, forests and wildlife, prevention and control of pollution, afforestation and regeneration of degraded areas and protection of the environment. The government has targeted ecosystems as a whole, or individual species or particular crop varieties, for conservation. Creating Protected Areas, Wildlife sanctuaries, Ramsar sites for preservation of wetlands, biosphere reserves are the important ways in which the Government of India has extended its conservational efforts, aimed at conservation of the ecosystems and populations of particular species. Currently, India has 578 wildlife protected areas comprising of 89 National Parks covering a total of 3.7 million hectares and 489 wildlife sanctuaries covering a total of 11.7 million hectares. Together they form about 4.7 per cent of the total geographic area of the country. The 'Man and Biosphere Programme' (MAB) aims at conserving the landscape, including humans. Local community participation, benefit sharing and local governance are the focus here.

Ex-situ conservation: *Ex-situ* conservation specifically aims at conserving genetic diversity in areas away from regions of their natural occurrence. The botanical gardens spread across India maintained by the Botanical Survey of India have large areas devoted to conservation of plant species from all over the world. Zoos, on the other hand, preserve wildlife under captivity. Gene banks conserve germplasm under regulated storage. This method facilitates conservation of large germplasm collections and makes it available later on demand. Several institutions have been engaged in exploring and collecting available genetic material.

It has been felt that several inadequacies have affected the efficiency of conservation efforts. Management inadequacies, lack of involvement of local communities in management, displacement of local communities have been acutely felt. Several biologically important regions, communities and species have been inadequately represented. Another major inadequacy is that an integrated approach to conservation of the ecosystem and preserving genetic diversity has not yet been extended to agricultural ecosystems, as it has been to other ecosystems. Yet, this will go a long way in preserving genetic biodiversity in agricultural systems.

Convention of Biological Diversity: Global perspectives on trade of genetic resources and its appropriation and use have influenced priorities on their conservation. This has been reflected in the legislation regarding the appropriation and use of genetic resources. Advancements in biotechnology and expansion of intellectual property rights, particularly patents, in biological systems have created opportunities to establish private ownership on genes and genetic material that were hitherto considered common heritage[3]. Appropriation of bio-resources by the developed nations, however, has taken place without adequate sharing of benefit with the farmers and the communities in gene-rich developing nations who are the traditional custodians of this genetic wealth. This has necessitated the development of a series of rules and regulations regarding access, use and commercial exploitation of biodiversity and associated knowledge. The Convention on Biological Diversity (CBD)[4] reaffirms genetic resources as national sovereignty and links access to these resources with the fair and equitable sharing of the benefits from them. It provides for the sustainable use of biodiversity, facilitates access to genetic resources through prior, informed consent under mutually agreed terms and equitable sharing of benefits derived from the commercial use of biodiversity.

The Protection of Plant Varieties Act and the Biological Diversity Act: The Protection of Plant Varieties and Farmers' Rights Act, 2001 and the Biological Diversity Act, 2002 provide a national legal framework for protecting Indian biodiversity and the legitimate interests of farmers under a regime of plant variety ownership. The Protection of Plant Varieties and Farmers' Rights Act enables protection of the rights of farmers to access, conserve and enhance plant genetic resources either by patents or through an effective *sui generis* system. The Act recognizes the farmer not just as a cultivator but also as a conserver of the agricultural gene pool and a breeder who has bred several successful varieties. This formulation allows the farmer to sell seed in the way he has always done. By giving the farmer the right to sell his seed, the Act recognizes the farming community as the country's major seed provider. The Act thus allows the farmers' ability to independently engage in his livelihood and support the livelihood of other farmers. The National Gene Fund, proposed in the Act, may also be used for on-farm conservation measures especially in areas rich in agro-biodiversity.

However, the recent decision of the Indian government to join the UPOV system (the international legislation for protection of plant varieties) has generated much criticism. Joining the UPOV will dilute the farmer's rights, as the UPOV does not have a notion of farmers' rights.

The Biological Diversity Act, 2002, provides for "conservation of Biological Diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith or incidental thereto". This Act fulfills three important objectives. First, it stamps India's sovereign right to genetic resources occurring within its geographical boundaries. Second, it prohibits free transfer of Indian genetic material outside India, for research, commercial utilization, bio-survey, or bio-utilization without prior approval. Third, it acknowledges the knowledge possessed by the local communities and provides for sharing of benefits accrued from this knowledge while providing for its protection. The Act entrusts the local governments to conserve, appropriate and use the biological resources through the Biodiversity Management Committees and to collect benefits arising out of its commercial use.[5]

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[3] The International Undertaking on Plant Genetic Resources for Food and Agriculture, 1981, gave a legal framework to the concept of genetic resources as common heritage of humanity that needs to be protected from further erosion and loss.

[4] The Convention on Biological Diversity was negotiated under the auspices of the United Nations Environment Programme (UNEP). It was opened for signature at the June 1992 UN Conference on Environment and Development (UNCED) and entered into force on 29 December 1993, ninety days after the 30th ratification. As of October 1998, more than 170 countries had become Parties.

[5] The Biological Diversity Bill, 2002 passed by the Houses of Parliament of the Government of India vide Bill No. 93-C of 2000

10.3 Policies Related to Community Conservation

Many Indian communities protect and manage specific territories containing wild and domesticated biodiversity. These could be areas of cultural and religious significance such as sacred sites, village forests, watersheds and pasture lands conserved to meet livelihood needs; wetlands conserved for drinking and irrigation facilities; traditional agricultural systems with diverse agricultural and natural niches and coastal and marine areas that protect traditional fisheries.

The management initiatives vary widely—initiatives taken through local institutions rooted in tradition, or through modified traditional systems, or through entirely new organizations and rules developed in response to a given situation. Such efforts may be entirely self-initiated by the community or taken with the help of external government or non-government agencies and individuals. In other cases, the interests of the local communities and outside society openly diverge and community-based conservation schemes are born as part of the struggle, with the communities fighting against commercial forces interested in exploiting the habitat's resources. These efforts can be collectively called **Community Conservation Areas (CCAs)**. CCAs are broadly defined as natural ecosystems (including those with minimum to substantial human influence) containing substantial wild and domesticated biodiversity value, being conserved or protected by local communities. Some examples of Community Conservation Areas are as follows:

1. Protection of 1800 ha of forest, for more than two decades, by the *Gond* tribal community in *Mendha (Lekha)* village in Maharashtra.
2. Regeneration and protection of 600–700 ha of forest, management of grasslands for sustainable and equitable use, struggle against limestone mining, and *in-situ* conservation of hundreds of varieties of indigenous crop by the villagers of *Jardhargaon* in Uttaranchal state.
3. Protection of sea turtle eggs, hatchlings and nesting sites by fisherfolk community in *Kolaipalam*, Kerala.
4. Traditional conservation of Painted Stork and globally threatened Spotbilled Pelican nesting sites by villagers in *Kokkare Bellur* village, Karnataka, and of the Blackbuck and other wildlife by the *Bishnoi* communities in Rajasthan and Punjab.
5. Religious protection to the Blacknecked Crane by Buddhist communities in *Sangti* Valley, Arunachal Pradesh.
6. Conservation of *Gursikaran* and *Sheoikha* wetlands by surrounding villagers in Uttar Pradesh.
7. Community forestry initiatives in several thousand villages in Orissa, initiated as early as 1936; many are now part of larger level federations for management, policy issues and conflict resolution.
8. Sacred groves preserved in many parts of India by local communities.

Community conservation of natural resources has some commonalities irrespective of the natural resource involved. Governance in community conservation is an important issue. Most community conservation initiatives are decentralized and site-specific in their objectives and approaches, based on local norms and regulations, thus enjoying higher social acceptance. However, while the local community is the most important actor, a critical role has been played by one or more external interventionists—either the forest department and government officials (who resolve serious conflict issues such as encroachment) or NGOs.

10.3.1 Economics of Community Conservation

For communities, the most common benefit of conservation is *livelihood security*, including gaining control over the resources they depend on. Other benefits include getting developmental inputs, strengthening of cultural associations with biodiversity, ecosystem service benefits and so on. In many areas in India, ecosystem conservation is in fact a spin-off of a larger move towards self-rule. True devolution of power appears to be a greater incentive for conservation than mere money. Examples from India indicate that large sums of money required for community conservation can be generated locally. In most situations, the communities prefer this, as it gives them a sense of ownership and ensures long-term financial sustainability. However, almost all regions in the country are dependant on external funding agencies. Pumping in of funds often breaks down existing systems of management and many prove to be a serious impediment for future, self-run processes. However inadequate funding also is an impediment to conservation.

Ecological sustainability: Community Conservation Areas show that communities can be strongly conservation-oriented. In all the above examples, people have strongly opposed commercial monocultures by the forest departments as they believe that they are neither beneficial for nature nor their livelihoods.

Equity concerns: Most local communities are ridden with internal inequalities of caste, class, gender and so on. These can be deterrents to natural-resource management. National recognition of local initiatives does not mean that distant centres of power are replaced by local ones. There are several cases where local communities have tackled this problem on their own (for instance, *Jardhargaon's* irrigation and grass-cutting practices and decision-making in *Mendha*). But there are many more instances where this has not been the case and external intervention became necessary. Inequities also necessitate identification of the primary stakeholders—women and nomadic communities, in particular, need special attention.

Laws and practices: In many of the initiatives cited earlier, communities have relied on traditional customary laws and social sanctions. But in the absence of statutory legal authority, they face problems (for instance, if outsiders were to cut down trees they have no legal powers to punish them). It is imperative then for legal and statutory authority to be given to village-level institutions and for long-term tenurial security.

Article 243G of the 73rd Constitutional Amendment Act of 1992 gives Panchayats the authority to implement schemes of soil conservation, watershed development, social and farm forestry, use of minor forest produce, fuel and fodder.[6] However many Panchayats have not given sufficient attention to conservation. They have also not raised sufficient funds for conservation.

Limitations in community conservation: Community conservation efforts are not foolproof, situated as they are within a highly dynamic social, economic and political context. Years of alienation have rendered the communities incapable of handling sudden power, which at times leads to failure of well-intended devolutionary steps such as the Gram Swaraj (village self-rule) Act in Central India. Younger generations are increasingly moving away from traditional knowledge systems and lifestyles even in the villages.

[6] THE CONSTITUTION (SEVENTY-THIRD AMENDMENT) ACT, 1992, Official web site of Government of India

10.4 Policies of Sustainable Livelihoods

The study of the living Planet 2002 has indicated that human economic activity had reduced by 35 per cent the number of surviving animal and bird species and freshwater and marine fish, which provide a major source of food for many of the world's people. The report observes that there was so much pressure on water supplies, forests, land and energy sources that the planet's riches could be exhausted within 150 years, with temperatures being pushed inevitably upwards.

It is believed that governments can reverse some of these negative trends and put humanity back on a path to sustainable development if they address certain key issues. These include improving the resource efficiency with which goods and services are produced, in particular moving energy supplies away from fossil fuels and promoting energy-efficient technologies, buildings and transport systems; encouraging equitable and sustainable consumption and conserving and restoring natural ecosystems to maintain their biological productivity and diversity. Urgent work is needed in integrated natural resource management that enhances livelihoods. Both demand and supply management with reference to key inputs like water and energy need urgent attention.

In this connection, improving the ecosystem and environment of the local communities and environmental awareness generation assume importance at the local level. Unless action is taken at the local level effectively, the overall objective cannot be achieved. At the Panchayat level, socio-demographic charters need to be adopted. These charters are aimed at improving the quality of life primarily through the fulfilment of the basic needs for survival and security. The following schemes should be included in the charter to promote environmental security: incorporating environmental issues as an integral part of the local level schemes, ensuring community involvement in environmental management and providing information access with regard to critical environmental factors that affect the local community, such as water, forests and land care.

10.5 Policies of Clean Drinking Water and Health Care

A clean environment is important for healthy living. Clean drinking water and unpolluted air are the basic requirements. In addition, primary health care has to be in place for complete food security and to ensure a long and healthy life. Both safe drinking water and clean air are environmental factors. Environmental policies affect the health of the people. Chemical, biological and gaseous pollutants harm people and cause disease.

10.5.1 Safe Drinking Water

Piped drinking water supply by the local authorities and groundwater are normally considered as safe for the purpose of statistics. The Government of India–sponsored Accelerated Rural Water Supply Programme (ARWSP) stipulates an average adult requirement of 40 litres per capita per day (lpcd). Based on this, the scheme envisages providing water within 1.6 km in the plains and a 100-meter elevation in the hilly regions. With normal output of 12 litres per minute, one hand pump or stand post is estimated to be required for every 250 persons. The scheme claims an impressive coverage of 98.05 per cent of the rural population and 97.59per cent of rural habitation for safe drinking water by 1999.[7]

However, independent reports conducted in several states revealed several inadequacies.[8] Frequent

[7] Address by the Union Minister for Rural Development, in 'International Workshop On Control Of Arsenic Contamination In Groundwater', 1999, held in West Bengal

water scarcity, leakage from ill-maintained pipes, improper drainage of water, contamination and unhygienic surroundings within the vicinity of the water supply source were recorded from several villages. Many of the problems identified by the Ministry during the 8th Plan persisted. These include fast depletion of groundwater level, which increases incidence of quality problems of contamination by arsenic and fluoride, drying up of sources because of deforestation and lack of protection, which reduced recharge of groundwater, heavy emphasis on new construction and poor attention to maintenance of existing ones, non-involvement of local people in operations and maintenance and neglect of traditional water management systems and practices. Clean drinking water is available in the catchments with well-protected prime forests. Only a few places in India have such water, without any sediments and pollutants from human and industrial activity (World Bank 2003).

Sector reforms were introduced to initiate community participation. However, some of the Gram Panchayats have shown an unwillingness to take control over the functioning and maintenance of piped water supply schemes and the monitoring of groundwater extraction. Several schemes have been abandoned. Therefore, the overall performance of piped rural water supply was only marginal.

Water quality is tightly linked to groundwater depletion and rural sanitation. Seventy to eighty per cent of the diseases are water-borne diseases, induced by water contamination and poor sanitation. Sanitation schemes have been hitherto limited to construction of latrines alone. The 10th Five Year Plan document on Rural Water Supply and Sanitation states that there has not been any significant change in the sanitary conditions in the villages in India (Planning Commission 2003). Proper integration of water supply schemes with the programmes on sanitation has been poor. Moreover, the government is not sufficiently equipped to handle issues relating to quality of water.

In an attempt to integrate rural water supply to sanitation and health, to bring in local governance under the Panchayats and to enable social mobilization to involve the local community, comprehensive guidelines on **'Swajaldhara'** were initiated in 2002.[9] What still remains to be seen is whether these local-level organizations become robust institutions of civil society participation, rather than new centres of control.[10]

10.5.2 Health Policy

The National Health Policy of 1983 envisaged the universal provision of primary health care by 2000 AD. However, the necessary prerequisites, in terms of investment, research and political will to make this possible, were absent. This is not to deny the significant progress made in eradicating certain diseases and reducing infant and maternal mortality rates. However, what has been achieved is absolutely inadequate when compared to the need. The Public Health Investment in the country has been very low. It further declined from 1.3 per cent in 1990 to 0.9 per cent in 1999. The central budgetary allocation for health over this period, as a percentage of the total Central Budget, has been stagnant at 1.3 per cent, while that in the states has declined from 7.0 per cent to 5.5 per cent. The current annual per capita public health expenditure in the country is no more than

[8] Surveys results carried out by Planning Evaluation Organization in 1996 of 87 villages in 29 districts of 16, those carried out by ORG (an NGO) in 8 districts of Madhya Pradesh, Samtek Consultants in 4 districts in Bihar,

[9] GOI, Ministry of Rural Development, Department of Drinking Water Supply, 2003. http://ddws.nic.in/Data/Swajal/sw_guidelines.htm

[10] TERI, 2003. Green India 2047, http://www.teriin.org/events/docs/lbct.pdf, p 11

Rs. 200. There exist large inequities in the attainment of health care goals across states and between rural and urban areas. Scheduled castes and tribes, women and children and lower income groups are particularly disadvantaged. The investment in research is also extremely low. In 1998–1999, for the public and private sector taken together, research expenditure was only Rs 1150 crores.

Another worrying trend has been the deregulation of price controls on drugs. The National Health Policy, 2002, focuses on the need for enhanced funding and an organizational restructuring of the national public health initiatives in order to facilitate more equitable access to health facilities. It aims at increasing public health investment to 2 per cent of GDP. The share of grants from the Central Government is to constitute at least 25% of total health spending and the State Government health spending is to increase to 8 per cent by 2010. The National Health Policy, 2002, aims at establishing more primary health centres and envisages a gradual convergence of all health programmes under a single field administration. The Policy lays down time limits for eradication of TB, malaria and blindness, zero growth rates of HIV/AIDS and reduction of maternal and infant mortality rates. The Policy urges all State Governments to consider decentralizing the implementation of disease control programmes to local self-government institutions by 2005. It recommends establishing an integrated system of surveillance, National Health Accounts and Health Statistics by 2005. It speaks of the need for integration of environment- related policies with health policies, but does not elaborate how and when this will be done. It talks of strengthening the user fees in public hospitals through targeting, ignoring the fact that this could backfire and worsen the situation of the poor as has been the case in the Public Distribution System. The Policy talks of a need for health care for women and allocation of funds to identified programmes. It recognizes the need to review the staffing norms of the public health administration to meet the specific requirements of women in a more comprehensive manner, but does not mention how and when this will take place. It talks of the privatisation of secondary and tertiary health care, ignoring the fact that this would result in increasing the unit cost of health care and thus adversely affect the poor. The Policy envisages tightening of foods and drug standards, but does not mention a time frame. The policy expresses concern about the likely increase in price of drugs in the post TRIPS regime, but is not able to clearly articulate how the interests of the people will be protected. It does mention a national patents regime. However, The Patents (Amendment Bill) 2002 has been criticized on several counts, in its inability to protect the interests of the people and its bias towards the patent holders. The National Health Policy of 2002 aims not at universal primary health care, but only at achieving an acceptable standard of good health for the people.

In recent times, the government has been trying to get out of public health care through privatisation of health services and through life insurance schemes. In the 10^{th} Plan Document as well as in the budget announcements of the government these intentions are made clear. Hence, it is worthwhile to look at the schemes proposed and the likely impact. Instead of investing in primary health centres, the government proposes to insure the low-income groups with a premium of Rs. 350/- a year. A scheme of insuring them for a year against any sort of medical illness has been proposed in the current budget (Economic Times 2003). However, in India, where even the literate urban middle classes find it difficult to get the health insurance claims in the event of their hospitalization, illiterate rural poor have little chance of getting such claims. Insurance companies cover people only for major illnesses and hospitalization upon production of a medical certificate. The money is reimbursed long after the illness, if the claim is within their stipulated terms and conditions. There are always 'small print' and 'pre-existing conditions'.

It is next to impossible for the rural poor to meet these conditions. Many poor do not have the financial means to be treated in private hospitals. Besides, private hospitals for the rural poor that are affordable are rarely found in their neighbourhood. They can neither afford to spend large amounts of money on hospitalization nor can they get involved in the paper work and the legal battles to be reimbursed expenses.

Insurance policies for the poor, even if the government pays the premium, will only help to line the pockets of the insurance companies and the agents and will not be of much use to the rural poor. Instead, the government should improve the primary health care and invest heavily in public health, at least for the rural poor.

10.6 Policies Related to Gender

Many policies of the government that are related to environment and livelihoods have a differential impact on women. There are some issues that are of utmost importance to women but sufficient attention has not been given them in policies and programmes. There are some policies of the government in which women were either made the target group or mainly involved, such as raising of microcredit through self-help groups, promotion of some livelihood-enhancing activities suited to women, biodiversity conservation, natural resource conservation, joint forest management etc. These policies give a central role to women. Often, all community-participatory labour-contributing programmes involve rural women. The success and failure of these programmes depend upon the level of participation and commitment of women.

Women directly benefit from some of these programmes either financially or through enhanced access to resources, which were not available to them earlier. On the flip side, women sometimes get burdened with community work and do not get sufficient compensation for their efforts either financially or through access to resources. Sometimes they are expected to contribute labour and time in the activities in which they have no direct stake. This brief note only highlights some important areas.

10.6.1 Property Rights

Despite a large number of women cultivators, women's ownership and control over agricultural land is limited. Women's control and access to land holds the key to procurement of other necessary resources like raw materials and, most importantly, credit. Traditionally, women have been discriminated against in possessing inherited property and even the Government largely has perpetuated this inequity in most states. The state transfers have favored male ownership even in matrilineal societies like the *Garos* in northeastern India.

The Eighth Plan directed state governments to allot 40 per cent of ceiling surplus land to women only and rest could be held in joint names. The ceiling surplus land available came to only 0.56 per cent of the arable land at the time of the Eighth Plan. It is time to call for more group rights and collective farm management for women. Women do not have the freedom to exercise control on the land even if they possess land. Decisions as to what to produce, cropping pattern, issues of sale and mortgage are often left to men. (Agarwal, Bina 1994). The Tenth Plan intends to adopt strategies and interventions at the macro-economic level to provide property rights to women. The Plan may bring forth, if necessary, amendments in the existing legislations.

10.6.2 Differential Wages

Legally, the existing Minimum Wage Regulations should be enough to ensure that employers do not exploit workers or discriminate between men and women in the payment of wages. The norm announced by the Government on the minimum wages for men and women itself prescribes a lower wage for women. Women's wages are, on the average, 30 per cent lower than men's wages. There is no infrastructure for implementation of Minimum Wage legislation in sectors like agriculture and home-based work, where women workers are concentrated. There is not a single state in India where men and women are paid the same wage for the same work.

10.6.3 Health-Related Policies

Women as an independent target group account for 48.3 per cent of the total population as per the 2001 census. A life cycle approach is needed to empower women, as every stage of the woman's life counts and requires priority in the planning process. The path of empowering women initiated in the Ninth Plan is continued in the Tenth Plan. The national policy for empowerment of women was adopted to eliminate all discrimination against women and to ensure gender justice, besides empowering them socially and economically. The Tenth Plan aims to mainstream gender perspectives in all sectoral policies and programmes of action in order to curb gender discrimination and ensure justice at all levels. While the plan documents make many general statements, very little is seen at the specific policy level and implementation level.

The National Health Policy 2001 promises to ensure increased access to women to basic health care and commits the highest priority to the funding of identified programs related to women's health. The reproductive and child health care program focuses on the reproductive health of the mothers. This includes access to essential obstetric care at close proximity to the community during the period of pregnancy, improving and expanding early and safe abortion services, treatment for reproductive tract infections, provision of adequate care at primary health care centres and treatment for sexually transmitted infections. However, all these policies had a marginal impact on the health of expectant mothers, lactating mothers and women in the reproductive age groups. Maternal deaths continue. Despite the pronouncements in the plan documents that measures should be adopted to take account of the reproductive rights of women and educate them to exercise their choice, very little has been done. The empowerment programmes and decision-making in respect of abortions, contraception and child-bearing has not succeeded.

The Medical Termination of Pregnancy (MTP) Act, which was sanctioned as long back as 1971 fails to be even noticed or emphasized today for its provisions on safety. Illegal abortions by local untrained persons under unhygienic and unsafe conditions are still common. In fact, abortions account for 8.9 per cent of maternal deaths. Discriminatory practices prevail in the access to health care, nutrition for women and the girl child.

The Integrated Child Development Scheme was started in 1974, a nation-wide scheme that aimed at promoting the holistic development of children up to six years of age, with the emphasis on the girl child, besides providing health care services for expectant and nursing mothers.

The maternal mortality rate was high, at 407 per one lakh live births in 2001. About 29.7 per cent of maternal deaths were the result of hemorrhage, followed by anemia at 19 per cent. Such maternal deaths could have been easily prevented through better reproductive health care facilities. It is disturbing to note that nearly 60 per cent of the women felt it was unnecessary to have a pregnancy-related check up according to the NFHS survey. That women refrain from seeking medical help is often because the majority of the doctors in rural areas are men; the Health Centres may be a considerable distance away and women often are conditioned from childhood to suffer in silence.

The Tenth Plan's proposed path of action includes reduction of maternal mortality rate to 2 per thousand live births and 1 per thousand by 2012. Without sufficient allocation of funds and more attention to the health care facilities and gender sensitiveness in health care, such targets are unrealistic.

The Tenth Plan seeks to strengthen the capacity of caregivers and communities to provide a physical and social environment conducive to the health of the child. Efforts are required to provide easy access to affordable and quality health care and nutrition to women and female children.

Deteriorating juvenile sex ratio: A serious problem that has lead to a fall in juvenile sex ratio has been sex selective abortions, infanticide and neglect of the girl child. In all these areas, precious little has been done to reverse the trends. Policies and programmes that address these concerns have not been implemented with vigour.

The Prenatal Diagnostic Techniques (Prevention and Misuse) Act of 1994 came into effect in 1996, when genetic sex determination was illegal. However, the Act has no impact on pre-natal tests and selective abortions. The law makes the registration of ultrasound equipment compulsory. It provides that no genetic-counselling centre, laboratory or clinic shall employ pre-natal diagnostic techniques, including ultrasonography, for the purpose of determining the sex of the foetus. It effectively debars the use of any such technique for the purpose of determining the sex of the foetus and prohibits any advertisement relating to pre-natal sex determination. Yet, a large number of equipment is in use without registration. More stringent enforcement is called for in this regard in all states, as female infant mortality rate was as high as 70.8 per thousand in 1999. The total infant mortality rate in the country is 93 per thousand live births and the target for the Tenth Plan is 45 per thousand.

Infanticide is still prevalent in many parts of the country. The 'cradle baby' scheme of the Tamil Nadu State Government brought out, in 1992, a scheme that involves the government taking up responsibility for bringing up any unwanted girl child. The state's intention was to reduce female infanticide although the act seemed to reinforce the 'unwanted girl child' phenomenon.

The approach to the Tenth Plan for empowering women is very distinct from the earlier plans as it stands on a strong platform of action with definite targets of socio-economic empowerment and gender justice at all stages in the life of a woman.

Sustainable Food Security Compact

A Nine-Point Action Plan for Developing and Implementing a Sustainable Food Security Compact in Every State and Union Territory of the Country

This Atlas is intended for appropriate public policies and action, which can help to enhance farm productivity and food security in perpetuity without associated ecological harm. Based on the findings reported in this Atlas, it is recommended that every State and Union Territory develop and implement a **Sustainable Food Security Compact** consisting of the following nine action points.

Action Point 1: Population Stabilization

Urgent efforts to stabilize population are essential, so that all the states of the country are able to achieve a balance between human numbers and the population-supporting capacity of the ecosystem. It would be prudent to mobilize people's action for achieving a demographic transition to low birth and death rates by assisting elected local bodies and educational institutions to prepare socio-demographic charters for their respective village or town, on the lines recommended by the Swaminathan Committee on Population Policy (1994). Such local socio-demographic charters, prepared by local communities and schools and based on the following parameters, will help to generate awareness of the urgent need to stabilize human and animal populations at a level the ecosystem can support in a sustainable manner.

Ecological security: The quality of land, water, biodiversity, forests, common property resources and atmosphere, the intensity of degradation/depletion and the need to avert/reverse the process.

Water security: Availability of water resources in relation to water requirements for domestic, agricultural, industrial and ecosystem-maintenance purposes and demand management in order to eliminate wasteful use and unsustainable consumption.

Energy security: Extent of availability of renewable and non-renewable energy sources and community energy audit.

Health security: Analysis of health problems arising from poor environmental hygiene, water pollution, HIV/AIDS and tuberculosis and promoting community involvement in preventing water pollution and in the bio-environmental control of malaria, filariasis and various gastro-intestinal disorders.

Food security: An understanding of the food, feed and fodder requirements of the village or town and methods of meeting these in an ecologically and economically sustainable manner.

Gender equity: Developing gender audit procedures to ensure that gender roles in the conservation and enhancement of natural resources are understood and structured in an equitable manner. Indicators of gender discrimination such as sex ratios should also be included in the gender audit procedure.

A second initiative that Panchayat Raj institutions and nagarpalikas can undertake is the organization of a **Child-friendly village and town movement**. Child-friendly villages and towns can adopt the following 12 indicators.

1. *Ensure that all children have birth certificates*
   - Ensure that all new born babies get a birth certificate
   - Over time, ensure that all children below 18 years have a birth certificate
2. *Ensure that all children live to celebrate their first birthday*
   - Keep track of how many children are born every year. A good way is to post the information month-wise on a public notice board.
   - Keep track of how many of these children live to be one year old – again use the public notice board to record infant deaths month-wise.
3. *Ensure that 100 per cent of children are fully immunized*
   - Ensure that all new-borns have an immunization card
   - Ensure that the card is filled up regularly
   - Over time, ensure that all children below 18 years have had the necessary immunization shots
   - Ensure that no child below the age of five years dies from preventable diseases
4. *Ensure that all children have access to pre-school facilities*
5. *Ensure that all children have access to a well-functioning* ***anganwadi*** *centre*
6. *Record male / female sex ratio at the time of birth and again at the age of 5 in the village*
7. *Measure the weight of children at birth*
   - In case of children weighing less than 2.2 kg. (that is, low birth weight children) take special steps for maternal and infant nutrition.
   - Sensitize the community for the need to avoid maternal and foetal under-nutrition resulting in LBW children, creating awareness of the linkage between LBW and impaired brain development.
8. *Ensure that no child is under-nourished*
   - Use the mechanism of the public notice board to list the total number of children in the village and the numbers malnourished
9. *Ensure that all children (and particularly girls) attend school*
   - Ensure that all children in the age group of 6–14 years are enrolled in school— both boys and girls
   - Ensure that all children attend school daily. Have a public notice board outside the school that shows total enrolment and attendance for the day; show details for boys and girls separately
   - Ensure that all children complete five years of primary schooling at least. Organize a public notice board that lists the number and (if not too many) names of children completing 5 years of schooling

10. *Ensure that all schools offer hot cooked meals*

    - Ensure that all children get a hot-cooked meal in school. Again, on the school notice board, record the days when food is served, and how many eat

11. *Ensure that there is no corporal punishment in schools*

    - Ensure that no child is beaten by the teacher in school

12. *Ensure that no girl child gets married before the age of 18 years*

    - Register all marriages
    - Post list of girls above 18 years getting married and their proportion to the general population
    - Ensure that all young girls receive appropriate life-skills education

The French mathematician Marquis de Condorcet said, "Population growth can be limited if people have a duty towards those who are not yet born, that duty is not to give them existence but to give them happiness." Children for happiness and not just existence is the best way of stabilizing our population. Without achieving stabilization of human and animal populations, the sustainable management of natural resources will not be possible. This is why the Swaminathan Committee mentioned in its report that "if population policies go wrong, nothing else will have a chance to go right."

Action Point 2 : Land Resources Conservation and Enhancement

Every State should implement a plan for the conservation and enhancement of land resources, with the following components. A restructured State Land Use Board could guide and monitor that these components are integrated suitably in all land-based development programmes (MSSRF 2001).

Conservation: Prime farmland should not be diverted to non-farm uses without compelling reasons. Also, all forest and biodiversity rich areas, including areas rich in agro-biodiversity, should be preserved for posterity through both government and community efforts.

Restoration: All wasted and degraded lands should be treated in a scientific manner, so that their biological potential is restored.

Sustainable intensification: Soils that are suitable for intensive agriculture using Low External Input Sustainable Agriculture Techniques (LEISA) and precision-farming methods should be reserved for agriculture. In such soils, household Soil Health Cards should be given to facilitate continuous monitoring of soil fertility and productivity.

Land for domestic and industrial uses: In the future, land which is not very suitable for farming, like degraded and waste lands should preferably be used for house and factory construction and other non-agricultural uses.

Action Point 3 : Water Security

Water will be the most important constraint in the future for domestic as well as agricultural needs. Every state should prepare a Sustainable Water Security System comprising the following components.

Supply augmentation: All avenues of increasing water supply, such as rainwater harvesting, should be mobilized with the active involvement of local communities. All sewage and effluent water sources should be treated and recycled. Over-exploitation of groundwater resources should be prevented and groundwater should be regarded as a social and not a private resource.

Demand management: Maximum emphasis should be placed on the promotion of water-use economy and efficiency. There is immense scope for the well-to-do sections to economize on domestic water consumption, including the use of water for toilets and lawns, so that the poor can get another pot of water. There is also great scope for enhancing irrigation water-use efficiency. Hereafter, agronomists should give the authorities crop yield data in terms of yield per litre of water and not just yield per hectare. Great care should also be taken to ensure that water does not get polluted with pesticides, sewage, effluents and toxic chemicals.

Tapping untapped sources through new technologies: Action research on bio-remediation, solar desalination and seawater farming should all receive added attention. Seawater constitutes 97 per cent of global water supplies and this is a unique social resource. It can be used in a scientific manner for fostering the prosperity of coastal communities, following the methodology developed at MSSRF. This methodology consists of

- Mixed cropping of halophytes like mangroves, *salicornia* and *atriplex*
- Inter-row culture of prawns / shrimps
- Cultivation of casuarina, cashewnut and coconut a little away from the shoreline
- Promotion of sustainable capture fisheries through the use of remote sensing data and adoption of a code of conduct for sustainable fisheries.
- Creation of new livelihood opportunities in coastal areas through the bio-village paradigm of job-led economic growth.

Action Point 4 : Forests

It will be advisable for every state and union territory to develop and implement a Sustainable District Forestry Programme consisting of the following three components.

Conservation and restoration forestry: The protected area network consisting of National Parks, Biosphere Reserves, World Heritage Sites, Botanical and Zoological Gardens, etc., needs strengthening and expansion. Degraded forestlands should be upgraded through appropriate techniques of restoration ecology. Also, participatory systems of management involving all stakeholders should be introduced. The Gulf of Mannar Biosphere Trust is an example.

Community forestry: Community or social forestry programmes will have to be initiated and managed by local bodies, with overall guidance from Gram Sabhas. The choice of tree species (fruit, fodder, medicinal, etc.) should be decided based on considerations of both ecology and peoples' needs and preferences, particularly of women.

Commercial forestry: This could meet the wood needs of large and small industries. Ecological considerations, particularly the water requirements of the species to be cultivated, should be kept in view in designing this programme.

With the help of remote sensing and GIS data, every district in the country could have a Sustainable District Forestry programme to meet in perpetuity the multiple needs of conservation, restoration, community and livelihood requirements and commercial enterprises. Gender mainstreaming in such a programme is a must.

Action Point 5 : Biodiversity

Local communities have to be familiarized with the provisions of the Biodiversity Act (2002) and the Protection of Plant Varieties and Farmers' Rights Act (2001). Capacity building in the preparation of community biodiversity registers and in the implementation of the prior informed consent and benefit-sharing provisions of the Biodiversity Act is an urgent need. A genetic and legal literacy movement has to be launched for this purpose by the State Biodiversity Board. There is also a need for identifying areas rich in genetic diversity in economic plants, like the Jeypore tract of Orissa in the case of rice genetic resources, and for declaring them as "Agro-Biodiversity Sanctuaries". Genetically modified varieties should not be grown in the vicinity of such Agro-Biodiversity Sanctuaries.

Action Point 6 : Atmosphere

There has to be sensitization at the local level on methods of reducing the emission of greenhouse gases and of enhancing carbon sequestration through green plants. There is also need for a climate literacy programme and for the training of local level Climate Managers who are in a position to guide farmers on methods of maximizing the benefits of good monsoons and minimizing the adverse impact of poor monsoons. Such Climate Managers (at least one woman and one man in each village) should also be familiar with methods of reducing damage to the ozone layer and on alternative and contingent cropping strategies to suit different rainfall patterns.

Action Point 7 : Management of Common Property Resources

To avoid the tragedy of the commons, it is important that Panchayats and elected local bodies are empowered to discharge effectively the tasks assigned to them in Schedule 11 of the 73rd Constitution Amendment. In this context, it will be useful to remind ourselves of the wisdom contained in the following statement of Mahatma Gandhi:

"I have not pictured a poverty-stricken India consisting of ignorant millions. Establish gram swaraj - make each village self-contained as regards the essential needs of its inhabitants."

Action Point 8 : No Time to Relax on the Production Front

The grain surplus available in the country is an index of under-nutrition of the poor, and not of over-production of crops. With the diversification of diets involving a higher quantity of animal products, more feed grains will be needed. Therefore, accelerated efforts must be made to foster sustainable intensification of crop and animal production, diversification of farming systems and value-addition to primary products. There has to be a proper match between production and post-harvest technologies and on-farm and non-farm employment.

Action Point 9 : Formation of a State Coalition for Sustainable Food Security

It would be useful to organize in every state and union territory, with the Chief Minister as the Chairperson and having a whole-time eminent Food Security Professional as Executive Vice-chairperson, a Coalition to monitor the progress in the implementation of the different action points of the Sustainable Food Security Compact. Such a Coalition should include representatives of governmental, academic and non-governmental organizations as well as private sector, business and industry, farmers' and women's associations, mass media representatives and appropriate bilateral and multilateral agencies. The Coalition could meet once a year to monitor progress and promote the conservation and enhancement of the ecological foundations essential for environmentally sustainable food security through an integrated package of regulation, education and social mobilization. Full use should be made of the elected local bodies. Community initiatives like local-level Gene, Seed, Water and Food Banks may be encouraged in order to link symbiotically conservation, cultivation and consumption. The routine Food for Work programmes should be recast as Food for Social and Human Resource Development programmes, which can help use food for supporting skilled work and development of social capital. The Coalition should also help in mobilizing the tools of the Internet, cable TV, radio and the regional language press for spreading information on all aspects of sustainable agriculture and food security.

In the earlier two Atlases relating to food insecurity in rural and urban areas, detailed suggestions have been made on the steps we should take to address effectively the following three components of food security:

- *Availability of food*, which is a function of home production and imports when and where necessary
- *Access to food*, which is a function of purchasing power and livelihood opportunities
- *Absorption capacity*, which is a function of safe drinking water, environmental hygiene, primary health care and education

The **State Coalition for Sustainable Food Security**, as recommended in this report, can review concurrently issues relating to the environmental, social and economic sustainability of the freedom-from-hunger movement. A systems approach is needed at both the planning and implementation levels. Above all, the programmes must be people-centred and driven, so that transaction costs can be kept low and success assured. "Think, plan and act locally, and support at the state and national levels" should be the motto. If the recommendations made in all the three Atlases are implemented in an integrated manner, **food for all and forever** will become a reality, not just a desirable objective.

APPENDICES

Appendix 1.1

Definitions of land use classifications

The definitions of different land classifications are as adopted by the Ministry of Agriculture, Government of India and are given below.

Geographical Area: The figures for geographical area are as furnished by the Central statistical Organisation, based on the Surveyor General of India's data.

Reporting area for land utilization purposes: The Reporting area stands for the area for which data on land use classification is available. In areas where the land utilization figures are based on land records, reporting area is the area according to village papers, i.e.; the papers prepared by the village accountants. In some cases, the village papers may not be maintained in respect of the entire area of the state. For example, the village papers are not prepared for forest areas, but the magnitude of such areas is known. Also there are some tracts for which no village papers exist, but for which ad-hoc estimates of classification of area, etc; are framed to complete the coverage.

Forests: Area under forests includes all land classed as forests under any legal enactment dealing with forests or administered as forests, whether State owned or private, and whether wooded or maintained as potential forest land. The area of crops raised in the forest and grazing land or areas open for grazing within the forests should remain included under the forest area.

Area under non-agricultural uses: This includes all lands occupied by buildings, roads and railways or under water, i.e., rivers and canals and other lands put to uses other than agriculture.

Barren and unculturable land: This covers all barren and unculturable land like mountains, deserts etc. Land that cannot be brought under cultivation except at an exorbitant cost should be classed as unculturable, whether such land is in isolated blocks or within cultivated holdings.

Area not available for cultivation includes area under non-agricultural uses and barren and unculturable land.

Permanent pastures and other grazing lands: These cover all grazing land, whether they are permanent pastures and meadows or not. Village common grazing lands are included under this head.

Miscellaneous tree crops and groves not included in the net sown area: This includes all cultivable land that is not included in "Net area sown" but is put to some agricultural use. Lands under Casuarina trees, thatching grasses, bamboo bushes and other groves for fuel, etc; which are not included under 'Orchards' are classed under this category. **Culturable Waste:** This includes lands available for cultivation, whether not taken up for cultivation or taken up for cultivation once, but not cultivated during the current year and the last five years or more in succession for one reason or other. Such lands may be either fallow or covered with shrubs and jungles, which are not put to any use. They may be assessed or unassessed and may lie in isolated blocks or within cultivated holdings. Land once cultivated but not cultivated for five years in succession is also included in this category at the end of five years.

Permanent pastures and other grazing lands, miscellaneous tree crops and groves not included in the net sown area and Culturable wastes together constitute **Other Uncultivated Land excluding fallow land**.

Fallow land other than current fallows: This includes all lands that were taken up for cultivation but are temporarily out of cultivation for a period of not less than a year and not more than five years. The reasons for keeping a land fallow may be one of the following: (1) poverty of cultivators; (2) inadequate supply of water; (3) malarial climate; (4) silting of canals and rivers and (5) unremunerative nature of farming.

Current fallows: This represents cropped area, which are kept fallow during the current year. For example, if any seedling area is not cropped again in the same year, it may be treated as current fallow.

Fallow lands include both current fallows and fallow land other than current fallows.

Net Area Sown: This represents the total area sown with crops and orchards. Area sown more than once in the same year is counted only once.

Appendix 1.2

All India Land Use Pattern (‘000 hectares)

	1	2	3	4	5	6	7	8	9	10	11	12	13
Year	Reporting area	forests	area under non agricul-tural uses	barren and unculturable land	total area not available for cultivation (3+4)	permanent pastures and other grazing lands	land under misc. tree crops and groves	culturable wastes	total uncul-tivated land excluding fallows (6+7+8)	fallows other than current fallows	current fallows	total fallows (10+11)	net area sown
1950-51	284315	40482	9357	38160	47517	6675	19828	22943	49446	17445	10679	28124	118746
1955-56	291917	51343	13921	34475	48396	11473	5885	21537	38895	12544	11583	24127	129156
1960-61	298458	54052	14840	35911	50751	13966	4459	19212	37637	11180	11639	22819	133199
1965-66	305535	61543	15170	34327	49497	14810	4076	16965	35851	9262	13184	22446	136198
1970-71	303758	63917	16478	28161	44639	13261	4299	17500	35060	8759	11116	19875	140267
1975-76	304329	66699	18660	21578	40238	12592	3630	17743	33965	9229	12546	21775	141652
1980-81	304159	67473	19656	19962	39618	11974	3610	16744	32318	9916	14832	24748	140002
1985-86	304698	67067	20631	20090	40721	11783	3563	15718	31064	10051	14894	24945	140901
1990-91	304862	67805	21087	19389	40476	11404	3818	14995	30217	9662	13703	23365	142999
1999-00	306054	69024	22967	19440	42407	11040	3618	13828	28486	10108	14798	24906	141231
		-1768											

Source: GOI, Indian Agricultural statistics, 1992-93, Ministry of Agriculture

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Appendix 1.3

State Wise Land Use Classification (As a Percentage of Reporting area)

S.No	State/ Union- Territory/	Geographical Area			Reporting area for land utilisation statistics		
		1974-75	1991-92	1999-00	1974-75	1991-92	1999-00
			1			2	
1	Andhra Pradesh	27682.00	27504.50	27507.00	27440.00	27440.00	27440.05
2	Arunachal Pradesh	8358.00	8374.30	8374.00	5643.00	5544.20	5504.00
3	Assam	7852.00	7843.80	7844.00	7852.00	7851.60	7850.00
4	Bihar	17388.00	17387.70	17388.00	17330.00	17329.60	17329.65
5	Goa	381.00	370.20	370.00	370.00	361.10	361.11
6	Gujarat	19598.00	19602.40	19602.00	18812.00	18822.10	18811.80
7	Haryana	4422.00	4421.20	4421.00	4404.00	4384.60	4400.43
8	Himachal Pradesh	5567.00	5567.30	5567.00	2932.00	3390.50	4531.83
9	Jammu and Kashmir	22224.00	22223.60	22224.00	4524.00	4505.40	4505.00
10	Karnataka	19177.00	19179.10	19179.00	19050.00	19049.80	19049.84
11	Kerala	3886.00	3886.30	3886.00	3859.00	3885.50	3885.50
12	Madhya Pradesh	44284.00	44344.60	44344.00	44263.00	44342.00	44353.13
13	Maharashtra	30776.00	30771.30	30771.00	30758.00	30758.30	30758.30
14	Manipur	2236.00	2232.70	2233.00	2211.00	2211.70	2211.00
15	Meghalaya	2249.00	2242.90	2243.00	2249.00	2239.00	2241.00
16	Mizoram	2109.00	2108.10	2108.00	2102.00	2201.90	2108.70
17	Nagaland	1653.00	1657.90	1658.00	1653.00	1538.90	1560.16
18	Orissa	15578.00	15570.70	15571.00	15540.00	15540.00	15571.00
19	Punjab	5036.00	5036.20	5036.00	5033.00	5032.70	5033.23
20	Rajasthan	34222.00	34223.90	34224.00	34268.00	34253.20	34257.86
21	Sikkim	730.00	709.60	710.00	_	710.00	710.00
22	Tamil Nadu	13007.00	13005.80	13006.00	13032.00	13018.90	12991.32
23	Tripura	1048.00	1048.60	1049.00	1048.00	1049.20	1049.00
24	Uttara Pradesh	29441.00	29441.10	29441.00	29861.00	29794.00	29793.52
25	West Bengal	8785.00	8875.20	8875.00	8856.00	8686.00	8689.03
	All India	**328778.00**	**328726.30**	**328726.00**	**304142.00**	**304899.90**	**306054.25**

Forests as a % Reporting area			Not available for cultivation Area put to non-agri. uses as a % Reporting area			Not available for cultivation Barren & unculturable land as a % Reporting area		
1974-75	1991-92	1999-00	1974-75	1991-92	1999-00	1974-75	1991-92	1999-00
	3			4			5	
22.81	22.89	22.59	7.51	8.57	9.50	8.33	7.55	7.68
91.33	93.79	93.64	_	0.52	_	0.66	1.05	0.78
25.87	25.27	24.59	10.72	11.64	13.39	19.84	19.62	18.59
16.24	17.02	17.02	9.22	12.27	14.02	6.12	5.86	5.83
28.38	29.16	34.75	5.68	5.46	10.28	4.32	3.71	_
8.33	10.01	9.91	5.56	5.95	6.06	14.30	13.86	13.84
2.43	3.87	2.62	8.13	6.32	8.36	8.13	2.30	2.18
26.60	26.62	24.14	4.93	4.93	6.67	20.83	20.85	18.91
60.90	60.97	60.98	7.54	6.46	6.46	5.02	6.51	6.47
15.10	16.14	16.08	5.11	6.26	6.83	4.60	4.20	4.18
27.13	27.83	27.83	7.64	7.76	9.12	1.68	1.42	0.74
32.27	32.41	33.17	4.81	5.42	5.68	5.23	4.56	3.86
17.39	16.69	17.44	3.02	3.79	4.05	5.65	5.32	5.52
27.23	27.22	27.23	1.18	1.21	1.18	64.18	64.14	64.18
36.59	41.81	41.87	3.56	3.75	4.29	10.18	6.34	6.31
61.99	59.19	75.81	0.48	0.45	_	9.56	9.13	1.13
17.42	56.05	56.11	_	1.81	4.18	75.80	_	_
39.18	35.28	36.00	3.47	4.81	5.38	2.19	3.21	3.97
4.21	4.17	6.06	8.11	7.61	1.14	2.42	1.42	6.69
4.79	6.92	7.53	4.11	4.78	5.04	13.07	8.04	7.53
_	36.20	36.20	_	13.66	13.66	_	24.39	24.37
15.09	16.49	16.42	12.31	14.23	15.23	5.39	3.90	3.66
59.92	57.78	57.77	4.48	12.68	12.68	0.57	_	_
17.18	17.34	17.50	7.18	8.30	8.58	4.10	3.42	3.12
13.41	13.75	13.72	_	17.21	18.77	6.58	0.74	0.32
21.57	**22.26**	**22.55**	**5.63**	**7.04**	**7.50**	**7.79**	**6.32**	**6.35**

(Contd...)

Appendix 1.3 (Contd...)

State Wise Land Use Classification (As a Percentage of Reporting area)

S.No	State/ Union- Territory/	Not available for cultivation Total (col.4+col.5) as a % Reporting area			Other uncultivated land excluding Permanent pastures & other grazing lands as a % Reporting area		
		1974-75	1991-92	1999-00	1974-75	1991-92	1999-00
			6			7	
1	Andhra Pradesh	15.74	16.12	17.17	3.62	3.03	2.48
2	Arunachal Pradesh	0.66	1.39	0.78	_	_	_
3	Assam	30.57	31.26	31.97	2.52	2.35	2.13
4	Bihar	15.34	18.13	19.85	0.93	0.74	0.61
5	Goa	10.00	9.17	10.28	0.27	0.36	0.36
6	Gujarat	19.86	19.81	19.90	4.54	4.51	4.51
7	Haryana	2.70	8.64	10.54	0.98	0.57	0.51
8	Himachal Pradesh	25.76	25.79	25.58	28.78	28.00	32.47
9	Jammu and Kashmir	12.56	12.97	12.93	2.79	2.78	2.79
10	Karnataka	9.71	10.46	11.01	8.08	5.76	5.14
11	Kerala	9.33	9.18	9.86	0.73	0.05	_
12	Madhya Pradesh	10.04	9.98	9.53	7.18	6.17	5.69
13	Maharashtra	8.67	9.11	9.57	5.28	3.70	4.36
14	Manipur	65.36	65.35	65.36	_	_	_
15	Meghalaya	13.74	10.08	10.60	0.76	_	_
16	Mizoram	10.04	9.58	1.13	0.19	0.18	1.07
17	Nagaland	75.80	1.81	4.18	_	_	_
18	Orissa	5.66	8.02	9.35	3.49	4.67	3.43
19	Punjab	10.53	9.02	7.83	0.08	0.09	0.07
20	Rajasthan	17.17	12.82	12.57	5.32	5.22	5.00
21	Sikkim	_	38.06	38.03	_	9.72	9.72
22	Tamil Nadu	17.69	18.13	18.89	1.59	0.94	0.94
23	Tripura	5.06	12.68	12.68	2.86	_	_
24	Uttar Pradesh	11.28	11.72	11.70	0.93	1.01	0.99
25	West Bengal	6.58	17.94	19.09	_	0.09	0.06
	All India	**13.42**	**13.36**	**13.86**	**4.22**	**3.71**	**3.61**

Other uncultivated land excluding Fallows Land under Misc. tree crops & groves not incl. in net area sown as a % Reporting area			Other uncultivated land excluding Fallows culturable waste land			Total (Col 7+8+9) as a % Reporting area as a % Reporting		
1974-75	1991-92	1999-00	1974-75	1991-92	1999-00	1974-75	1991-92	1999-00
	8			9			10	
1.04	0.95	0.88	3.86	2.79	2.85	8.52	6.78	6.22
0.34	0.80	0.80	2.64	_	0.60	2.98	0.80	1.40
3.43	3.14	3.01	1.95	1.32	1.02	7.90	6.81	6.15
1.24	1.59	1.99	2.80	2.30	1.85	4.97	4.64	4.45
0.27	0.17	0.16	25.14	24.59	15.26	25.68	25.12	15.78
0.03	0.02	0.02	11.79	10.53	10.49	16.36	15.06	15.02
0.02	0.10	0.11	0.93	0.98	0.52	1.93	1.64	1.14
1.02	1.17	1.42	3.16	2.82	2.63	32.96	31.99	36.52
2.39	1.59	1.60	3.49	3.07	3.11	8.66	7.43	7.50
1.61	1.66	1.60	3.13	2.34	2.27	12.83	9.75	9.01
2.54	0.89	0.48	1.87	2.39	1.50	5.13	3.32	1.98
0.31	0.18	0.03	4.47	3.53	3.39	11.96	9.88	9.11
0.63	0.92	0.73	3.28	3.14	2.89	9.19	7.76	7.98
1.09	1.09	1.09	_	_	_	1.09	1.09	1.09
6.40	6.95	6.86	20.14	22.01	20.05	27.30	28.96	26.92
0.14	0.14	1.45	3.52	3.34	5.75	3.85	3.66	8.27
_	8.62	7.94	_	6.09	4.19	_	14.71	12.13
3.98	5.50	4.97	2.74	3.68	2.86	10.22	13.85	11.26
0.10	0.14	0.11	1.29	0.71	0.74	1.47	0.94	0.92
0.03	0.06	0.04	16.65	16.24	14.56	21.99	21.51	19.60
_	0.70	0.70	_	0.14	0.14	_	10.56	10.56
1.78	1.74	1.87	3.35	2.39	2.68	6.72	5.08	5.50
7.92	2.57	2.57	0.67	0.07	0.10	11.45	2.64	2.67
2.65	1.84	1.83	5.14	3.45	3.01	8.73	6.31	5.84
6.07	0.61	0.88	_	1.14	0.49	6.07	1.84	1.43
1.36	**1.23**	**1.18**	**5.54**	**4.92**	**4.52**	**11.13**	**9.86**	**9.31**

(Contd...)

Appendix 1.3 (Contd...)

State Wise Land Use Classification (As a Percentage of Reporting area)

S.No	State/ Union- Territory/	Fallow lands other than current fallows as a % Reporting area			Fallow Land Current fallows as a % Reporting area		
		1974-75	1991-92	1999-00	1974-75	1991-92	1999-00
			11			12	
1	Andhra Pradesh	3.58	4.98	5.29	7.36	8.99	10.06
2	Arunachal Pradesh	2.09	0.88	0.65	0.9	0.45	0.51
3	Assam	1.88	1.07	1.04	1.4	1.13	1.83
4	Bihar	5.44	5.95	5.32	9.86	9.75	10.45
5	Goa	_	_	_	–	–	–
6	Gujarat	1.88	0.19	0.13	11.35	5.56	3.64
7	Haryana	_	0.00	_	4.9	5.83	4.97
8	Himachal Pradesh	0.10	0.49	0.35	1.36	1.15	1.24
9	Jammu and Kashmir	0.20	0.15	0.18	2.34	2.18	2.14
10	Karnataka	3.16	2.26	2.24	5.1	5.17	7.81
11	Kerala	0.54	0.69	0.83	0.65	1.13	1.86
12	Madhya Pradesh	2.06	1.91	1.71	1.83	2.16	1.61
13	Maharashtra	2.56	3.66	3.74	3	4.6	3.75
14	Manipur	_	_	_	–	0.005	–
15	Meghalaya	12.18	7.47	7.07	2.45	2.65	2.82
16	Mizoram	12.32	11.77	8.08	8.71	8.32	2.37
17	Nagaland	_	7.14	4.93	–	7.68	5.9
18	Orissa	1.45	1.18	2.16	6.69	0.88	2.22
19	Punjab	0.04	0.31	0.11	2.44	1.81	0.88
20	Rajasthan	5.92	6.35	7.33	9.39	7.18	7.7
21	Sikkim	_	1.27	1.27	–	0.56	0.56
22	Tamil Nadu	4.60	8.17	8.77	13.28	8.15	8.35
23	Tripura	0.19	0.07	0.10	0.48	1.8	0.38
24	Uttara Pradesh	1.99	2.94	2.49	3.36	3.91	3.45
25	West Bengal	4.09	0.54	0.39	–	2.87	2.4
	All India	**3.04**	**3.26**	**3.30**	**5.42**	**4.81**	**4.84**

Note: The reporting area for land utilisation statistics of Jammu & Kashmir dose not include the areas under illegal occupation by China and Pakistan.
The 1999-2000 figures for area under forest and barren unculturable land have been used for the years 1974-75 and 1991-92 in Himachal Pradesh to adjust for under reporting in the earlier years.

Fallow Land Total (Col.11+12) as a % Reporting area			Net area sown as a % Reporting area		
1974-75	1991-92	1999-00	1974-75	1991-92	1999-00
	13			14	
10.93	13.97	15.35	41.88	40.24	38.67
2.99	1.33	1.16	2.04	2.69	3.02
3.29	2.19	2.88	32.39	34.46	34.41
15.30	15.70	15.77	48.15	44.52	42.91
_	_	_	35.95	36.55	39.19
13.20	5.75	3.77	42.22	49.36	51.39
4.90	5.83	4.98	79.90	80.01	80.72
1.46	1.63	1.59	13.22	13.97	12.17
2.54	2.33	2.33	15.34	16.30	16.28
8.26	7.43	10.05	54.10	56.22	53.85
1.19	1.82	2.68	57.22	57.86	57.63
3.89	4.07	3.32	41.83	43.67	44.86
5.56	8.26	7.49	59.19	58.18	57.52
_	0.005	_	6.33	6.33	6.33
14.63	10.12	9.89	7.74	9.02	10.72
21.03	20.10	10.45	3.09	2.94	4.33
_	14.82	10.82	6.78	12.61	16.76
8.14	2.07	4.37	36.80	40.78	39.01
2.48	2.12	0.98	81.30	83.75	84.21
15.31	13.53	15.03	40.73	45.22	45.27
_	1.83	1.83	_	13.35	13.38
17.88	16.32	17.13	42.62	43.98	42.06
0.67	1.87	0.48	22.90	25.04	26.41
5.35	6.85	5.94	57.47	57.78	59.02
4.09	3.41	2.79	69.84	63.05	62.97
8.46	**8.07**	**8.14**	**45.41**	**46.45**	**46.15**

Source: 1974-75: The Fertiliser Association of India “Fertiliser Statistics”-1977-78
1991-92: Government of India, Ministry of Agriculture “Indian Agricultural Statistics”-1992-93
1999-00: Webside: http://www.agricoop.nic.in/

Appendix - 1.4

Area under food-grains as a percent of gross cropped area for triennium ending 1990 & 2000

S.No	State	Rice		Wheat		Coarse Cereals		Cereals		Pulses		Foodgrains	
		1990	2000	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000
1	Andhra Pradesh	30.16	30.51	0.08	0.09	19.21	11.25	49.45	41.85	11.85	12.38	61.30	54.23
2	Arunachal Pradesh	51.42	46.99	1.87	1.54	23.80	21.26	77.09	69.80	0.00	2.89	77.09	72.68
3	Assam	63.63	63.10	2.68	2.08	0.77	0.75	67.08	65.94	3.30	3.00	70.38	68.94
4	Bihar	50.21	50.60	19.88	21.10	9.04	8.75	79.13	80.44	11.28	8.89	90.42	89.33
5	Goa	35.29	32.97	0.00	0.00	1.83	1.33	37.11	34.30	0.00	5.97	37.11	40.27
6	Gujarat	4.72	6.44	4.64	6.15	22.42	17.10	31.78	29.69	6.82	7.74	38.60	37.43
7	Haryana	10.29	16.67	33.14	35.51	15.76	12.62	59.19	64.81	9.73	5.23	68.92	70.04
8	Himachal Pradesh	9.01	8.56	38.19	38.92	36.99	35.86	84.18	83.34	4.34	3.50	88.52	86.84
9	Jammu and Kashmir	25.45	24.57	22.62	22.63	31.97	32.13	80.03	79.33	3.88	2.90	83.92	82.23
10	Karnataka	9.59	11.65	2.08	2.16	36.43	32.19	48.10	46.00	13.95	14.85	62.05	60.85
11	Kerala	19.81	13.31	0.00	0.00	0.24	0.22	20.05	13.53	0.87	0.72	20.92	14.25
12	Madhya Pradesh	21.96	21.04	15.65	17.88	19.09	10.38	56.70	49.30	20.46	19.47	77.16	68.77
13	Maharashtra	7.07	6.76	3.91	4.24	42.13	33.61	53.11	44.62	15.38	15.66	68.49	60.28
14	Manipur	88.13	77.48	0.00	0.00	2.76	1.74	90.89	79.22	0.00	2.05	90.89	81.27
15	Meghalaya	44.99	40.38	1.94	1.57	9.02	7.77	55.96	49.72	1.31	1.60	57.27	51.32
16	Mizoram	73.48	58.16	0.00	0.00	8.21	6.96	81.69	65.12	0.63	4.07	82.32	69.19
17	Nagaland	63.37	52.22	0.00	1.28	11.54	14.99	74.92	68.50	3.68	6.27	78.59	74.77
18	Orissa	45.94	52.93	0.44	0.16	5.87	4.14	52.25	57.23	21.71	15.53	73.96	72.75
19	Punjab	24.44	30.34	43.14	41.09	3.89	3.33	71.47	74.76	2.10	0.98	73.57	75.74
20	Rajasthan	0.69	0.84	9.90	12.85	40.95	28.64	51.54	42.33	15.34	18.27	66.88	60.60
21	Sikkim	12.76	12.52	8.31	6.33	33.45	36.22	54.52	55.07	8.76	5.35	62.81	60.42
22	Tamil Nadu	29.31	34.00	0.00	0.00	20.62	11.83	49.94	45.83	12.69	9.75	62.63	55.58
23	Tripura	62.09	56.37	0.79	0.33	0.00	0.34	62.88	57.04	2.10	1.87	64.98	58.91
24	Uttara Pradesh	20.77	22.10	34.42	34.95	13.81	10.53	69.01	67.58	11.84	10.34	80.85	77.92
25	West Bengal	66.53	64.02	3.99	3.92	1.11	0.69	71.63	68.63	4.02	2.28	75.65	70.90
	All India	**22.95**	**23.32**	**13.22**	**14.28**	**21.12**	**15.76**	**57.29**	**53.36**	**12.69**	**12.08**	**69.98**	**65.44**

Source: GOI, Ministry of Agriculture-"Area and Production of Principal Crops in India"-1990-93
Reports of the Commission For Agricultural Costs and Prices for the Crops Sown
During 2000-2001 Season, Department of Agriculture and Co-operation, Ministry of Agriculture, GOI, New Delhi- 2001
GOI, Ministry of Agriculture "Indian Agriculture in Brief"- Jan 2000, Webside: http://agricoop.nic.in/statistics/st3.htm.

Appendix 1.5

Area under Non food-grains as a percent of gross cropped area for triennium ending 1990 & 2000

S.No	State	Edible Oilseeds		Sugarcane		Spices and Condiments		Non food grains	
		1990	2000	1990	2000	1990	2000	1990	2000
1	Andhra Pradesh	19.37	18.52	1.18	2.51	2.69	2.88	38.70	45.77
2	Arunachal Pradesh	7.69	6.81	0.00	0.13	0.00	0.18	22.91	27.32
3	Assam	9.07	2.61	1.11	0.76	2.20	2.38	29.62	31.06
4	Bihar	1.40	1.64	1.19	1.05	0.17	0.15	9.58	10.67
5	Goa	0.62	0.39	1.17	0.39	0.00	0.00	62.89	59.73
6	Gujarat	19.53	23.57	0.89	2.04	0.24	0.35	61.40	62.57
7	Haryana	7.17	8.54	2.44	2.20	0.09	0.03	31.08	29.96
8	Himachal Pradesh	1.75	1.55	0.28	0.34	0.00	0.00	11.48	13.16
9	Jammu and Kashmir	6.10	6.57	0.04	0.01	0.00	0.00	16.08	17.77
10	Karnataka	19.57	17.79	1.95	2.83	2.13	2.63	37.95	39.15
11	Kerala	0.85	0.47	0.28	0.22	10.14	11.95	79.08	85.75
12	Madhya Pradesh	12.34	21.84	0.19	0.25	0.72	1.06	22.84	31.23
13	Maharashtra	11.45	6.91	1.58	2.39	0.69	0.55	31.51	39.72
14	Manipur	1.81	0.00	1.12	0.32	0.00	0.00	9.11	18.73
15	Meghalaya	3.70	0.00	0.02	0.00	5.27	5.84	42.73	48.68
16	Mizoram	3.57	0.00	1.01	0.63	0.00	0.00	17.68	30.81
17	Nagaland	5.71	0.00	1.81	0.00	0.00	0.00	21.41	25.23
18	Orissa	11.19	3.77	0.49	0.38	1.73	1.84	26.04	27.25
19	Punjab	2.47	1.94	1.38	0.53	0.06	0.04	26.43	24.26
20	Rajasthan	13.13	19.31	0.12	0.10	1.20	1.12	33.12	39.40
21	Sikkim	9.14	0.00	0.00	0.00	15.36	14.36	37.19	39.58
22	Tamil Nadu	18.66	16.64	3.23	4.79	1.85	2.02	37.37	44.42
23	Tripura	2.64	0.00	0.45	0.15	0.28	0.52	35.02	41.09
24	Uttara Pradesh	6.20	5.52	7.10	7.46	0.14	0.13	19.15	22.08
25	West Bengal	6.07	5.10	0.17	0.27	0.77	1.00	24.35	29.10
	All India	**11.14**	**12.61**	**1.88**	**2.19**	**1.12**	**1.22**	**30.02**	**34.56**

Source: GOI, Ministry of Agriculture-"Area and Production of Principal Crops in India"-1990-93
Reports of the Commission For Agricultural Costs and Prices for the Crops Sown
During 2000-2001 Season, Department of Agriculture and Co-operation, Ministry of Agriculture, GOI, New Delhi- 2001
GOI, Ministry of Agriculture "Indian Agriculture in Brief"- Jan 2000, Webside: http://agricoop.nic.in/statistics/st3.htm.

Appendix 1.6

Correlation Matrix

	Instability	Wasteland	Deforest	Var in Rainfall
Instability	1	0.550*	0.206	0.159
Wasteland	-	1	0.345	0.12
Deforest	-	-	1	-0.12
Var. in Rainfall	-	-	-	1

Appendix 1.7
Water resource Regions of India

	Drainage basin	Area in lakh hectares	Number of watersheds	States
1	**Indus drainage**			
A	Sutlej	52.42	49	PJ, HP
B	Beas	19.68	27	PJ, HP
C	Ravi	13.42	15	HP
D	Chenab	29.14	28	JK
E	Jhelum	28.76	28	JK
F	Indus	134.79	134	JK
G	Ephemeral	30.01	21	JK
		308.22		
2	**Ganga drainage**			
A	Lower Ganga	283.33	293	BH, East MP, WB
B	Upper Ganga	195.44	291+	UP, BH
C	Yamuna	205.43	190	DL, HY, S & W MP, Part of UP, Part RJ
D	Chambal	135.95	134	RJ, MP
		820.15		
3	**Brahmaputra drainage**			
A	Right Bank	106.01	120+	
B	Left Bank	101.42	102	Northeastern
C	Drainage flow to Bangladesh	56.95	74	states
D	Drainage flow to Burma	26.95	34	
		291.33		
4	**Drainage to Bay of Bengal except 2 & 3**			
A	Cape Comorin to Cauvery	38.74	38	TN
B	Cauvery	87.59	72	TN, K
C	Cauvery to Krishna	146.06	132	TN, Part K, AP
D	Krishna	272.08	271	K, AP, MH
E	Godavari	313.2	358	North AP, MH, South OR, South tip of MP
F	Godavari to Mahanadi	50.84	53	OR, NE tip of AP
G	Mahanadi	142.49	137	West OR, SE part of MP
H	Mahanadi to Ganga	79.48	89	OR, S tip of BH, S tip of WB
		1130.48		
5	**Drainage to Arabian Sea**			
A	S.W.Ghats	56.2	59	KL, KR
B	N.W.Ghats	58.4	58	KR, Goa, MH
C	Tapi	65.95	86	MH
D	Narmada	93.99	129	SW part of MP, S tip of J, N tip of MH
E	Mahi	38.63	51	GJ, W tip of MP
F	Sabarmati	27.05	33	GJ
G	S. Kathiawar	38.86	46	GJ
H	Drainage to Gulf of Kutchh	50.43	51	GJ
		429.51		
6	**Western Rajasthan - mostly ephemeral drainage**			
A	Great Rann of Kutch and Luni	90.26	73	RJ
B	Ephemeral (Balmer to Jaisalmer, Nagaur, Sikar)	61.62	?	RJ
C	Ephemeral (Jaisalmer, Bikaner, Churu)	69.03	?	RJ
D	Ghagar (and old Saraswati)	52.5	33	N of RJ, W of HY, S of PJ
		273.41		

Source: GOI, All India Soil Survey, “Watershed Atlas of India” -1991

Appendix 1.8

Dark and overexploited groundwater resources

Sl.No.	State	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		No. of blocks/ mandals / taluks/ watersheds	1995 No. of blocks, mandals, taluks, watersheds						No. of blocks/ mandals / taluks/ watersheds	1998 No. of blocks, mandals, taluks, watersheds					
			Over-exploited >100%		Dark >85%			Total		Over-exploited >100%		Dark, >85%			Total
			No.	%	No.	%	No.	%		No.	%	No.	%	No.	%
1	Andhra Pradesh	1104	6	0.54	24	2.17	30	2.72	1104	12	1.09	14	1.27	26	2.36
2	Arunachal Pradesh	48	0	0.00	0	0.00	0	0.00	-	0	0.00	0	0.00	0	
3	Assam	134	0	0.00	0	0.00	0	0.00	134	0	0.00	0	0.00	0	0.00
4	Bihar	585	0	0.00	1	0.17	1	0.17	589	3	0.51	9	1.53	12	2.04
5	Goa	12	0	0.00	0	0.00	0	0.00	12	0	0.00	0	0.00	0	0.00
6	Gujarat	184	12	6.52	14	7.61	26	14.13	184	13	7.07	15	8.15	28	15.22
7	Haryana	108	45	41.67	6	5.56	51	47.22	108	33	30.56	8	7.41	41	37.96
8	Himachal Pradesh	69	0	0.00	0	0.00	0	0.00	69	0	0.00	0	0.00	0	0.00
9	Jammu and Kashmir	123	0	0.00	0	0.00	0	0.00	123	0	0.00	0	0.00	0	0.00
10	Karnataka	175	6	3.43	12	6.86	18	10.29	175	7	4.00	9	5.14	16	9.14
11	Kerala	154	0	0.00	1	0.65	1	0.65	154	0	0.00	0	0.00	0	0.00
12	Madhya Pradesh	459	0	0.00	3	0.65	3	0.65	459	2	0.44	1	0.22	3	0.65
13	Maharashtra	1503	0	0.00	34	2.26	34	2.26	231	2	0.87	6	2.60	8	3.46
14	Manipur	26	0	0.00	0	0.00	0	0.00	26	0	0.00	0	0.00	0	0.00
15	Meghalaya	29	0	0.00	0	0.00	0	0.00	29	0	0.00	0	0.00	0	0.00
16	Mizoram	20	0	0.00	0	0.00	0	0.00	20	0	0.00	0	0.00	0	0.00
17	Nagaland	21	0	0.00	0	0.00	0	0.00	21	0	0.00	0	0.00	0	0.00
18	Orissa	314	0	0.00	0	0.00	0	0.00	314	4	1.27	4	1.27	8	2.55
19	Punjab	118	62	52.54	8	6.78	70	59.32	138	72	52.17	11	7.97	83	60.14
20	Rajasthan	236	45	19.07	11	4.66	56	23.73	236	74	31.36	20	8.47	94	39.83
21	Sikkim	4	0	0.00	0	0.00	0	0.00	4	0	0.00	0	0.00	0	0.00
22	Tamil Nadu	384	54	14.06	43	11.20	97	25.26	384	64	16.67	39	10.16	103	26.82
23	Tripura	17	0	2.12	0	0.00	0	0.00	17	0	0.00	0	0.00	0	0.00
24	Uttar Pradesh	895	19	0.00	22	2.46	41	4.58	819	19	2.32	21	2.56	40	4.88
25	West Bengal	341	0	0.00	0	0.00	0	0.00	341	0	0.00	1	0.29	1	0.29
	All India	**7063**	**249**	**3.53**	**179**	**71.89**	**428**	**6.06**	**5711**	**310**	**5.43**	**160**	**51.61**	**470**	**8.23**

Source: Col.1-7, Central Groundwater Board, 1995, Col.8-14, Central Groundwater Board, 1998

Appendix 1.9

Water Requirements and Water Use Efficiency

Crops	Duration (Days)	No. of Irrigation	Water Requirement	WUE ($kg^{-1}ha^{-1}mm^{-1}$)
Rice	110	20	1240	4.0
Sorghum	110	8	500	9.0
Maize	110	12	675	8.0
Ragi	110	10	310	10.3
Black gram	65	6	280	4.4
Soyabean	85	8	320	5.5
Groundnut	110	9	510	5.9
Sesame	85	2	114	6.2
Cotton	165	10	500	6.0
Sugarcane	360	24	2800	6.0

Source: Improving Irrigation Efficiency, Palanisami and Chandrasekaran, 2001

Appendix 1.10

Improved technologies in water management

Achieving technological efficiency is an important aspect of water security. Water-saving technologies play a pivotal role in economizing water use in order to bring more areas under irrigation, improving water application in the fields, and to improve productivity per unit of water applied without much degradation of the soil quality. Soil type, crops to be grown, differential water requirements at different growing phases of the crop, topography, conveyance and distribution pattern of irrigation, drainage of water from the farms, methods of water application, etc are some of the important aspects that are taken into consideration while planning for appropriate irrigation techniques. Broad bed furrow system, alternate furrow systems like skip furrow and paired row furrow systems, Border strip irrigation on gently sloping lands, allow for efficient water application below the root zone at the same time are effective drainage systems as well. They are most suited for closely cropped annual crops. Graded contour furrows, Contour ditches, Square basin method on plain land and semicircular basin method on sloppy and unleveled lands are most suited for tree/ fruit crops that are less closely spaced. Surge irrigation involves applying water at one end through inlet pipes intermittently. Water efficiency is found to be highest in this method because application of water is controlled with 40% water saving, 25% yield increase.[1] This will lead to, water saving, increased productivity. Some of them are also important water harvesting methods.

Micro-irrigation and fertigation

Micro-irrigation is an advanced technology that not only economises the use of water but also doubles the area that can be irrigated. It simultaneously improves the productivity per unit area and per unit of water. Drip irrigation, micro-jet irrigation systems, micro and mini sprinkler irrigation etc are the different types of micro-irrigation systems. The spread of micro-irrigation in the country is poor. Analyses reveal that drip irrigation has spread to 0.27 m ha of agricultural lands and sprinkler irrigation to 0.6 m ha in India, so far. This covers only 1.6% of the total irrigated area in the country. This can be compared to other nations like Germany and Israel, which have 100% of their irrigation through micro-irrigation. Great Britain follows closely with 99% coverage. Affordable micro-irrigation must be propogated that are suitable for small farmers having access to less water than what is necessary to irrigate the land through conventional irrigation systems and who face high water use inefficiencies due to the smallness of their farms. Technology transfer and micro-credit enables successful lab to land transfer of these technologies.

[1] Palanisami, K and Chandrasekharan, B, 2001, p 22-34.

Advantages of micro irrigation as against gravity irrigation are:-

- Increased water use efficiency (90-95%)
- Water saving of 50-60%
- Higher crop yield (40-100%)
- Decreased tillage requirement
- High quality of the yield
- Higher fertiliser use efficiency in fertigation (30% saving on fertiliser)
- Lesser weed growth
- Less labour intensive

Sprinkler Irrigation: In *Sprinkler irrigation* water under pressure is let out through sprinkler nozzles, placed at regular intervals on lateral lines, to form a gentle rain over the crops. Surface water runoff is minimised as the soil and plants absorb the water applied. Soil remains soft and less tillage is required. 40 to 60% water saving is effected through sprinkler irrigation. The main disadvantage is the high rate of loss of water through evaporation as the water remains in the air for a longer time. Micro sprinklers are more effective as they have smaller stalks are apply water closer to the soil. They are less costly than drip irrigation systems.

Sprinklers are effective in tea and coffee plantations, cardamom and orchard gardens except paddy and jute. They have also been tried on cotton, groundnut, green gram, black gram etc with improved yields by 25 to 40% and water saving of 20 to 50%. Results on sprinkler irrigation in black gram revealed that with the same quantity of water, irrigated area could be doubled without any loss in productivity. Micro-sprinkler kits with a set of 15 micro-sprinklers with pipes are available that can irrigate an area of 250 sq.km.

Drip irrigation: Drip irrigation can be defined as the precise and slow application of water in the form of discrete continuous drops applied at the root zone of crops, through 'emitters'. Studies have revealed that drip irrigation is ideally suited for vegetable and fruit crops that have are more space between the crops and not suitable for wheat or paddy. Coconut, grapes, mango, banana, etc are found to give higher yields while consuming less water. Yield increases of 25-50% have been registered and water saving of 40 to 50% over surface irrigation. Refer table 2.2.22. Studies conducted on crops such as tomato, cotton and tapioca showed that drip irrigation improved root characters in terms of root number, root length, root volume and root dry weight. Drip irrigation is suited for undulating terrain, shallow soils and water scarce areas. Drip irrigation can be extended to wastelands after planting trees and horticultural crops, in the hilly areas, semi arid zones, coastal sandy belts, community well command areas, etc. There are several affordable micro-irrigation kits like the bucket kit and the drum kit ideally suited for home gardens and small commercial vegetable gardens.

Fertigation: Nutrient management is an important factor that promotes water use efficiency in crops. Nutrients in the soil solution are normally taken up by the roots through diffusion and mass flow. Decreasing moisture content in the soil and reduced permeability affects mobility of nutrients in the soil. Application of fertilizers directly to the soil enables maximum utilization of the nutrients by the roots. Fertigation is an improved method of application of water-soluble fertilisers mixed in appropriate proportions with water through drips and sprinklers. Advantages are controlled and precise application at the root zone according to crop demand, minimum loss of nutrients, uniform flow to all the crops, and fertiliser saving of 25-30%. Studies carried out in drip irrigation coupled with fertigation in capsicum shows that yields are higher by about 30%, water use efficiency increased by 70% and fertiliser use efficiency increased by 30% over surface irrigation methods.

Appendix 1.11

Statewise Fish Production in 2000-01 (Tonnes)

S.No.	States	Marine	Inland	Total
1	Andhra Pradesh	182502	407186	589688
2	Arunachal Pradesh	-	2500	2500
3	Assam	-	158620	158620
4	Bihar	-	222160	222160
5	Goa	67328	4240	71568
6	Gujarat	620474	40261	660735
7	Haryana	-	33040	33040
8	Himachal Pradesh	-	7020	7020
9	Jammu & Kashmir	-	17510	17510
10	Karnataka	175906	127468	303374
11	Kerala	566571	85234	651805
12	Madhya Pradesh	-	48844	48844
13	Maharashtra	402838	123266	526104
14	Manipur	-	16050	16050
15	Meghalaya	-	6179	6179
16	Mizoram	-	2860	2860
17	Nagaland	-	5500	5500
18	Orissa	121086	138556	259642
19	Punjab	-	52000	52000
20	Rajasthan	-	12121	12121
21	Sikkim	-	140	140
22	Tamil Nadu	367855	113560	481415
23	Tripura	-	29420	29420
24	Uttar Pradesh	-	208286	208286
25	West Bengal	181000	879230	1060230
26	Chattisgarh**		43386	43386
27	Uttaranchal**		9074	9074
28	Jharkhand**		43600	43600
29	Deep Sea Fishing	30000		30000
Total		**2810510**	**2845832**	**5656342**

** For the period December 2000 to March 2001
Source: GOI, Department of Agriculture and Statistics 2002.
Agricultural Statistics At a Glance. www.agricoop.nic.in

Appendix 2.1

Broad Grouping of Forest Ecosystems In India and Their Distribution And Extent

Sl.No	Forest Type	Area (million hectares)	Percent of forest area	Ocurrence in States/UTs of India
1	Tropical wet evergreen forest	4.50	5.80	Arunachal Pradesh, Assam, Karnataka, Kerala, Mizoram, Manipur, Nagaland, Tamil Nadu, Sikkim, Andaman & Nicobar, Islands and Goa
2	Tropical semi-evergreen forest	1.90	2.50	Assam, Karnataka, Kerala, Maharashtra, Nagaland, Orissa, Tamil Nadu, Andaman & Nicobar, Islands and Goa
3	Tropical moist deciduous forest	23.30	30.30	Andhra Pradesh, Assam, Bihar, Gujarat, Karnataka, Kerala, M.P., Maharashtra, Manipur, Meghalaya, Mizoram, Tripura, Nagaland, Orissa, Tamil Nadu, U.P., West Bengal, Andaman & Nicobar Islands, Goa and Dadra & Nagar Havelli
4	Littoral and swamp forest	0.70	0.90	Andhra Pradesh, Gujarat, Maharashtra, Orissa, Tamil Nadu, West Bengal and Andaman & Nicobar Islands
5	Tropical dry deciduous forest	29.40	38.20	Andhra Pradesh, Bihar, Gujarat, Haryana, Himachal Pradesh,. Karnataka, Kerala, M.P., Maharashtra, Jammu & Kashmir, Punjab, Rajasthan, Tamil Nadu and U.P.
6	Tropical thorn forest	5.20	6.70	Andhra Pradesh, Gujarat, Haryana, Himachal Pradesh,. Karnataka, M.P., Maharashtra, Punjab, Rajasthan, Tamil Nadu and U.P.
7	Tropical dry evergreen forest	0.10	0.10	Andhra Pradesh and Tamil Nadu
8	Sub tropical broad leaved hill forest	0.30	0.40	Assam and Meghalaya
10	Sub tropical pine forest	3.70	5.00	Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Nagaland, Sikkim, Haryana, U.P. and Punjab
11	Sub tropical dry evergreen forest	0.20	0.20	Himachal Pradesh and Jammu & Kashmir
12	Montane wet temperate forest	1.60	2.00	Arunachal Pradesh, Karnataka, Manipur, Nagaland, Sikkim and Tamil Nadu
13	Himalayan moist temperate forests	2.60	3.40	Himachal Pradesh, Jammu & Kashmir and U.P.
14	Himalayan dry temperate forests	0.20	0.20	Jammu & Kashmir and Himachal Pradesh
15	Sub-alpine forest			
16	Moist alpine-scrub	3.30	4.30	Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir and U.P
18	Alpine scrub			

Appendix 2.2

State wise Productivity and above ground biomass of forests

Sl.No	State	Current Annual Increment 000 cum/year 1993	Standing above ground biomass tons/ha
1	Andhra Pradesh	5929	473.6
2	Arunachal Pradesh	15243	1014.2
3	Assam	6061	382.5
4	Bihar	1715	184.7
5	Goa	231	17.1
6	Gujarat	1459	110.8
7	Haryana	27	2.8
8	Himachal Pradesh	1603	231.8
9	Jammu and Kashmir	6402	413.4
10	Karnataka	5574	384.8
11	Kerala	1983	141.6
12	Madhya Pradesh	14122	1271.8
13	Maharashtra	5008	383.4
14	Manipur	1889	150.4
15	Meghalaya	2150	134.3
16	Mizoram	1332	121.3
17	Nagaland	1903	149
18	Orissa	4432	425.7
19	Punjab	23	2.8
20	Rajasthan	292	39.2
21	Sikkim	767	48.1
22	Tamil Nadu	1394	132.9
23	Tripura	316	31.2
24	Uttar Pradesh	5818	414.7
25	West Bengal	433	80.3
	Total	87622	6865.1

Source: FSI, 1995, page 80; Table 5.3

Appendix 2.3.1

Distribution of Trees and Their Volume by Different Categories in Haryana

S. No.	Category	Total No.of Trees ('000 no.)	Total Volume ('000 cu.m.)
1	Farm Forestry	23644	4259.14
2	Road side	5541	1334.73
3	Village Woodlot	10748	2465.59
4	Block Plantation	10203	1095.06
5	Ponds	249	65.36
6	Railway Line	650	121.79
7	Canalside	4079	989.97
8	Others	28	5.31
	Total Stems	55141	
	Stem/ha	12.94	
	Total		10336.96

Appendix 2.3.2

Distribution of Trees by Different Categories in Karnataka

S. No.	Category	Total no. of Trees ('000 no.)
1	Farm Forestry	74977
2	Block Plantation	37025
3	Village Woodlot	10610
4	Roadside Plantation	2257
5	Others	9388
	Grand Total	**134257**
	No. of trees/ha	**15.77**

Appendix 2.3.3

Distribution of Trees by Different Categories in West Bengal

S. No.	Category	Total no.of Trees ('000 no.)	Estimated Trees/ha
1	Farm Forestry	5096	1.03
2	Road side	9594	1.94
3	Village Woodlot	16205	3.26
4	Block Plantation	21602	4.37
5	Ponds	20550	4.16
6	Railway Line	30	0.01
7	Canalside	7870	1.59
8	Others	44686	9.04
	Grand Total	**125634**	**25.41**

Appendix 2.3.4

Distribution of Trees by Different Categories in Western Uttar Pradesh

S. No.	Category	Total no. of Trees ('000' no.)	Stem/ha
1	Farm Forestry	175246	11.09
2	Road side	9747	0.62
3	Village Woodlot	8222	0.52
4	Block Plantation	115071	7.28
5	Ponds	125	0.01
6	Railway Line	1161	0.07
7	Canal side	1465	0.09
	Grand Total	**311037**	**19.68**

Appendix 2.3.5

Distribution of Important Trees and their Volume in Homesteads in Kerala

S.No.	Trees	Total no. of Trees ('000 no.)	Total Volume ('000 cu.m.)
1	Coconut	94920	34171
2	Murikku	45896	4061
3	Cashew	41124	12146
4	Mango	32214	11369
5	Jack	32106	15560
6	Vatta	26366	1997
7	Tamarind	6805	1735
8	Teak	18160	1986
9	Matty	18421	1290
10	Anjily	10083	4175
11	Other trees	116070	15758
	Grand Total	**442165**	**104248**

Source: FSI 1997, Panday and Kumar, 2000

Appendix 2.4

Total Number of Flowering Plants

Sl.No.	State	Total number of flowering plants in the wild	Endemism in flowering plants
1	Andhra Pradesh	NI	16
2	Arunachal Pradesh	8500	239
3	Assam	3010	102
4	Bihar	2650	11
5	Goa	1115	5
6	Gujarat	2102	16
7	Haryana	1227	NI
8	Himachal Pradesh	NI	NI
9	Jammu and Kashmir	4252	121
10	Karnataka	3947	82
11	Kerala	3535	108
12	Madhya Pradesh	2317	NI
13	Maharashtra	3225	80
14	Manipur	2376	74
15	Meghalaya	NI	65
16	Mizoram	2141	27
17	Nagaland	2431	14
18	Orissa	2630	29
19	Punjab	1843	4
20	Rajasthan	1910	22
21	Sikkim	4500	58
22	Tamil Nadu	5640	533
23	Tripura	1463	28
24	Uttar Pradesh	3000	7
25	West Bengal	3580	NI

Source: Mudgal V. et.al.(eds), 1999. Floristic Diversity and Conservation Strategies in India Vol. II, Vol.III, Calcutta, Botanical Survey Of India, Government of India, NI=No Information

Appendix 2.5

Mega and micro centers of endemic flowering plants in India

Sl.No.	Hotspots
1	Andaman Group of Islands
2	Nicobar Group of Islands
3	Agasthyamalai hills
4	Annamalai and high ranges
5	Palani Hills
6	Nilgris – Silent valley, Wynad, Kodagu
7	Shimoga – Kanara
8	Mahabaleshwar – Khandala Ranges
9	Konkan – Raigad
10	Marathwada – Satpura Ranges
11	Tirupati – Cudappa Nallamailai hills
12	Vizagapatnam – Ganjam – Jeypore hills
13	South Deccan – leeward side
14	Chottanagpur plateau
15	Kathiawar – Kutch
16	Rajasthan – Aravalli hills
17	Khasia – Jaintia hills
18	Patkoi – Manipur – Lushai hills
19	Assam
20	Arunachal Pradesh Himalaya
21	Sikkim Himalaya
22	Garhwal – Kumaon Himalaya
23	Kashmir – Ladakh Himalaya
24	Lahul – Himachal Pradesh Himalaya

Source: Nayar, M.P. 1996. Hot Spots of Endemic Plants of India, Nepal and Bhutan, Trivandrum Tropical Botanic Garden and Research Institute

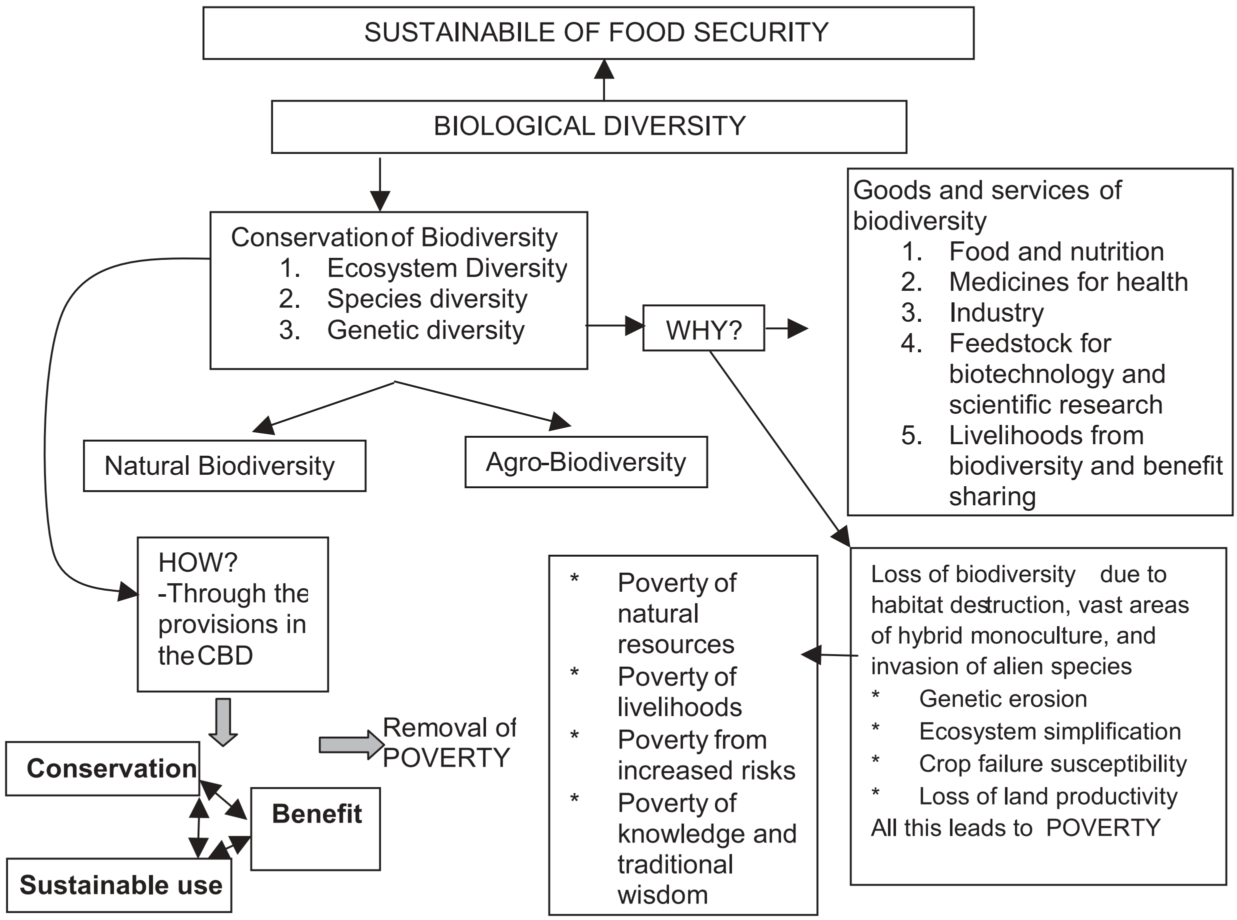
Appendix 2.6

Rare and endangered flora and fauna recorded in India till date

Sl.No.	State / UT	1 Total No. of Endangered Rare and Threatened Vertebrate Fauna	2 Total list of rare and endangered flowering plants
1	Andhra Pradesh	5	NI
2	Arunachal Pradesh	18	52
3	Assam	13	60
4	Bihar	4	250
5	Goa	1	5
6	Gujarat	10	57
7	Haryana	2	31
8	Himachal Pradesh	9	NI
9	Jammu and Kashmir	13	15
10	Karnataka	4	NI
11	Kerala	7	147
12	Madhya Pradesh	7	90
13	Maharashtra	4	153
14	Manipur	4	28
15	Meghalaya	3	69
16	Mizoram	3	22
17	Nagaland	1	22
18	Orissa	9	144
19	Punjab	3	10
20	Rajasthan	6	8
21	Sikkim	13	46
22	Tamil Nadu	7	217
23	Tripura	0	15
24	Uttar Pradesh	12	5
25	West Bengal	15	37

Source: Col.1, Red Data Book on Vertebrates, Zoological Survey Of India, Government of India
Col.2, Mudgal V. et.al. (Eds), 1999. Floristic Diversity and Conservation Strategies in India Vol. II, Vol.III, Calcutta Botanical Survey Of India, Government of India, No Information=NI

Appendix 2.7


SUSTAINABILE OF FOOD SECURITY
BIOLOGICAL DIVERSITY
Conservation of Biodiversity
1. Ecosystem Diversity
2. Species diversity
3. Genetic diversity
WHY?
Goods and services of biodiversity
1. Food and nutrition
2. Medicines for health
3. Industry
4. Feedstock for biotechnology and scientific research
5. Livelihoods from biodiversity and benefit sharing
Natural Biodiversity
Agro-Biodiversity
HOW?
-Through the provisions in the CBD
Loss of biodiversity due to habitat destruction, vast areas of hybrid monoculture, and invasion of alien species
* Genetic erosion
* Ecosystem simplification
* Crop failure susceptibility
* Loss of land productivity
All this leads to POVERTY
* Poverty of natural resources
* Poverty of livelihoods
* Poverty from increased risks
* Poverty of knowledge and traditional wisdom
Removal of POVERTY
Conservation
Benefit
Sustainable use

Appendix 3.1

Pollution Levels for Various Air Pollutants in Industrial & Residential Areas

Pollution Level	Annual Means Concentration Range (Microgram per cubic metre)			
	Industrial		Residential	
	SO_2 & NO_2	SPM	SO_2 & NO_2	SPM
Low (L)	0 - 40	0 - 180	0 - 30	0 - 70
Moderate (M)	40 - 80	180 - 360	30 - 60	70 - 140
High (H)	80 - 120	360 - 540	60 - 90	140 - 210
Critical (C)	> 210	> 540	> 90	> 210

Source: GOI, Central Statistical Organisation, "Compendium of Environment Statistics"-2000

Trends of Air Pollutants in major urban cities in India (1990 & 1998)

City / Location		Nitrogen Dioxide		Sulphur Dioxide		SPM	
		1990 AV	1998 AV	1990 AV	1998 AV	1990 AV	1998 AV
Mumbai	Residential (Average of 2 sites)	27.6	22.1 $	27.5	16.1 $	211	103 $
	Industrial (Average of 1 site)	30.8	24.9 *	56.7	21.7	180	226
Calcutta	Residential (Average of 2 sites)	30	30.9	29	31	205	275
	Industrial (Average of 1 site)	26	ID	32.5	ID	302	286
Chennai	Residential (Average of 2 sites)	20.0 *	22.3 $	9.7 *	10.5	109 *	116 *
	Industrial (Average of 3 sites)	24.9	15.7	31.8	13.1	129	126
Bangalore	Residential (Average of 1 sites)	11.2	28.4	17.1	41.6	68	239
	Industrial (Average of 2 sites)	11.4	23.2	19.8	35.3	109	134
Hyderabad	Residential (Average of 3 sites)	16.8 ~	33.3	6.6 ~	10.6	158 ~	167
	Industrial (Average of 3 sites)	10.9	28.3	12.4 #	13	77 #	259
Patna	Residential (Average of 2 sites)	NA	12.9	NA	17.1	NA	359
Bhopal	Residential (Average of 2 sites)	24.3	26.2	12	17.2	165	287
	Industrial (Average of 1 site)	26.0 *	26.3	20.9 *	17.5	396 *	384
Nagpur	Residential (Average of 3 sites)	8.3	17.1	8.3	6.1	204	149
	Industrial (Average of 2 sites)	9.8	13.8	9.8	8.3	206	138
Pune	Residential (Average of 3 sites)	33.5	56.6	12.1 ~	48.1	216 ~	247
	Industrial (Average of 2 site)	39.7 $	59.6	15.6 $	50.2	230 $	374
Jaipur	Residential (Average of 3 sites)	15.4	20.9	5.2	8.5	429	209
	Industrial (Average of 2 sites)	11.4	22.8	6.7	13.3	253	248
Kanpur	Residential (Average of 3 sites)	11.2	21.8	7.7	16.5	338	404
	Industrial (Average of 2 sites)	11.9	25.9	7.6	17.7	377	441
Chandigarh	Residential (Average of 3 sites)	12.2	9	3.4	4.8	222	229
	Industrial (Average of 2 sites)	10.4	9.8	13.2	5.8	252	331

Source: Central Pollution Control Board, Ministry of Environment & Forests,
Air Quality Status and Trends in India-2000

ID = Data inadequate AV = Annual average
NA = Data not available SPM = Suspended Particulate Matter
# = Average of 1 site $ = Average of 3 sites
~ = Average of 2 sites * = Average of 4 sites

Appendix 3.2

Air Pollution Control in India

National ambient air quality standards were adopted by the Central Pollution Control Board (CPCB) in 1982 and were revised in 1994. These air quality standards are prescribed according to land use for

1. Industrial areas – areas with intensive industrial activities
2. Sensitive areas – hill stations, hospitals, sanctuaries, national monuments, health resorts and national parks
3. Residential, urban and mixed use area – areas not covered in 1 and 2

Since the seventies there have been a spate of legislations providing for environmental protection. In India we largely follow the system of direct controls. However, these measures do not provide the polluters with necessary incentives to choose the least cost method of pollution control. No genuine attempt has been made to introduce fiscal instruments like pollution taxes or marketable pollution permits. Another problem with Government policy on environmental protection has been the provision of pollution subsidies to the industries. Pollution subsidies provide perverse incentives to industries for increasing their scale of production, and hence environmental pollution (Baumol and Oates, 1988).

Some of the ways in which pollution control subsidies are being provided are

- Accelerated depreciation of pollution control equipment for corporate tax computation.
- Investment allowance for corporate tax calculation for investments in pollution control equipment
- Exemption of capital gains tax, for the capital gains obtained through the relocation of the polluting factory
- Rebates of excise and customs duties for many types of pollution control equipment

These tax concessions or subsidies do not guarantee efficiency, as they do not provide polluters with incentives to choose the least cost pollution abatement technologies. They are not desirable from the equity point of view either as they cause an increase in the polluters profits, many of whom belong to the category of large factory owners. The one case where subsidies for industrial units may be justified is when the government assistance is being provided to small-scale enterprises.[1] The promotion of small-scale industry has been the conscious policy of the government in the past. To achieve this end, over 800 items were reserved for exclusive production by small-scale enterprises. These enterprises are also entitled to financial assistance, tax benefits and subsidized electricity and water charges. The industrial estates in the country are now dominated by small and medium enterprises. A number of environmental problems have been

[1] M.N Murty, Role of Government in Environmental Management in the MN Murthy, AJ James and Smita Mishra edited Economics of Pollution Control; Industrial Pollution in India, 1998, OUP, Delhi.

Murty, M.N.,1998. Role of Government in Environmental Management In the Economics of Pollution Control. eds M.N Murty, A.J James and Smita Mishra. Oxford University Press: New Delhi created because of inadequate understanding of the technology of waste energy and treatment, lack of required space for pollution control facilities, ineffective supervision and management of installations for pollution control and lack of technical assistance. Subsidies and financial incentives to these enterprises may be justified.

There are several ongoing strategies for air quality management.

Industrial Pollution Control: Seventeen highly polluting industries have been identified and their emissions are regularly monitored. These include aluminium, caustic soda, cement, copper, distillery, dyes and dye intermediate, fertilizer, iron and steel, leather, pesticides, petrochemicals, pharmaceuticals, pulp and paper, refinery, sugar, thermal power plant and zinc. Of the 1551 large and medium scale industrial units identified in 1992 in these 17 categories, 1349 units have installed the requisite pollution control equipment, 179 units have closed down and 23 units are yet to install the pollution control facilities as on June 30th 2002. Legal action has been taken against the defaulting units. Twenty-four problem areas in sixteen states have been identified and action plans are either already being implemented or are in the process of being finalized. Recommendations on improvement of fuel quality and beneficiation of coal at pithead have been made and notification has been issued under the Environment act, 1986. Industries are being encouraged to use cleaner technologies to reduce the emission of pollutants in the atmosphere. The use of waste minimization and waste utilization technologies is being promoted.

Vehicular Pollution Control: Emission norms for 2000 had been notified in August 1997 under the Motor Vehicles Rules. These norms akin to EURO 1 norms adopted in Europe in 1992 require modifications in engine design for new passenger cars and the fitment of catalytic converters in two stroke engines. The quality for diesel and gasoline fuel has been notified in April 1996 under the Environment act. There are specifications for low leaded gasoline, unleaded gasoline and low sulphur diesel. Financial incentives such as subsidies are being provided to promote the use of catalytic converters and Compressed Natural Gas (CNG). CNG is considered to be a clean fuel with emissions of toxic gases less than in other fuels. The CPCB has helped establish retail outlets for CNG. It has been made mandatory since December 1996 for all Government vehicles to fit either CNG kits or catalytic converters. Twenty-year-old vehicles were prohibited from plying from Dec 1998 in New Delhi. A phasing out of seventeen-year-old vehicles from Nov 1998 and fifteen year old vehicles from Dec 1998 followed this.

Appendix 3.3

Sources of global emissions of the main GHGs (percentages)

Gases	Greenhouse effect	Sources	
Carbon Dioxide	45 to 55	Coal	29
		Oil	29
		Gas	11
		Deforestation	20
		Other	10
Methane	10 to 20	Biomass burning	11 to 15
		Gas & Coal fields	14 to 25
		Rice paddies and Natural wetlands	16 to 44
		Rumination	16 to 26
		Tundra	15 to 20
		Other	5 to 10
Chlorofluorocarbons	10 to 16	Aerosols	19
		Refrigerants	30
		Cleaning agents	19
		Blowing agents	28
		Other	4
Nitrous oxide	7 to 11	Fossil fuels	12 to 34
		Biomass burning	8 to 20
		Fertilizers	5 to 15
		Other	30 to 75

Source: Global Environmental Negotiations I – Green Politics, 1999, edited by Agarwal A, Narain S and Sharma A, Centre for Science and Environment, New Delhi.

Appendix 3.4

Carbon sinks: some basic concepts

Global carbon is held in a variety of different stocks. Natural stocks include oceans (they store the largest pool of carbon, about 38-40,000 GtC-*giga tonnes of carbon*, predominantly in the form of dissolved inorganic carbon), fossil fuel deposits, the terrestrial system (store about 2,200 GtC) and the atmosphere (stores about 760 GtC).

In the terrestrial system carbon is sequestered in rocks and sediments in swamps, wetlands and forests and in the soils of forests, grasslands and agriculture. About two-thirds of the globe's terrestrial carbon, exclusive of that sequestered in rocks and sediments, is sequestered in the standing forests, forest understory plants, leaf and forest debris and in forest soils.

In addition, there are some non-natural stocks. For example, long-lived wood products and waste dumps constitute a separate human-created carbon stock. Given increased global timber harvests and manufactured wood products over the past several decades, these carbon stocks are likely to increase.

A stock that is taking up carbon is called a *'sink'* and one that is releasing carbon is called a *'source'*. Shifts or flows of carbon over time from one stock to another are viewed as carbon *'fluxes'*. Over time, carbon may be transferred from one stock to another. For example, fossil fuel burning shifts carbon from fossil fuel deposits to the atmospheric stock. Carbon cycles continuously among the three global reservoirs: atmosphere, the terrestrial biosphere and the oceans. Carbon exchanges between the atmosphere and the terrestrial biosphere total about 60 GtC annually, and between the atmosphere and the oceans total about 90 GtC.

The amount of carbon stored in any stock may be large, even as the fluxes are small or zero. An old-growth forest, experiencing little net growth, would have this property. Also, the stock may be small while the fluxes may be significant. Young fast-growing forests tend to be of this type. The potential for agricultural crops and grasses to act as a sink and sequester carbon appears to be limited, due to their short life and limited biomass accumulations. However, agricultural and grassland soils have substantial potential to sequester carbon. Their role in the human management of carbon could increase as we learn more about their characteristics.

The total amount of CO_2 absorbed annually - 120 GtC is known as gross primary productivity. Carbon losses from respiration halve the gross carbon uptake; the net primary productivity is about 60 GtC. This process can be observed in the atmosphere, where concentrations of CO_2 fall during the growing season (spring and summer) and rise again during the colder months, when plant growth largely ceases. At the same time, carbon losses from ecosystems occur continuously due to the decomposition of organic matter by soil biota. These losses further reduce the productivity of ecosystems to about 10 GtC globally. Finally, additional carbon losses occur as a result of various disturbances, such as storms, fires, harvest and deforestation. The final, net primary productivity stands at 0.7 GtC annually[1].

Appendix 3.5

Global efforts to counter CO_2 emissions - The Kyoto Protocol

Countries concerned with the rising concentration of greenhouse gases resulting in global warming, came together in 1992 to sign the United Nations Framework Convention on Climate Change (UNFCCC). It included a legally non-binding, voluntary pledge that the major developed nations would reduce their greenhouse gas emissions to 1990 levels by the year 2000. It did not happen. The first commitment period has since been extended to 2008 to 2012. Parties to the treaty decided in 1995 to negotiate a protocol to establish legally binding limitations or reductions in greenhouse gas emissions. The negotiations took place at a meeting from 1 to 11 December, 1997, at Kyoto Japan. Following completion of the Protocol in December 1997, details of several difficult issues remain to be negotiated and resolved. The protocol allows the Annex One countries (developed and industrialized countries) to trade emissions to a limited extent with the Annex Two countries (developing countries). Eight Conferences of the Parties (COP) have been held since 1992. The Kyoto meeting was the fourth of these conferences. COP 8 was held at Delhi in October 2002.

The declaration at Delhi emphasized that existing international commitments under UNFCCC should be implemented, and called for the early ratification of the Kyoto Protocol. It urged governments to promote technological advances through research and development, increase renewable energy resources and promote the transfer of technologies that can help reduce greenhouse gas emissions in major economic sectors. The Protocol's Clean Development Mechanism (CDM) was made fully operational. The CDM is a mechanism under the Kyoto Protocol that allows an industrialized country to invest in a clean energy project to replace a less efficient (more polluting) project in a developing country. In return, the industrialized country gets credit for the reduced emissions, which it can use to meet its Kyoto targets. The conference also concluded work on procedures for reporting and reviewing emission data from developed countries. The data on GHG emissions are now comparable and credible.

The Kyoto Protocol will enter into force 90 days after being ratified by 55 governments. Developed countries must account for at least 55% of that group's 1990 carbon dioxide emissions. The Kyoto Protocol recognizes land use, land use

[1] Mathews, E., Payne, R., Rohweder, M., Murray, S., 2000, Pilot Analysis of Global Ecosystems, Forest Ecosystems, WRI Washington D.C.

change and forestry activities (LULUCF[1]) and the associated net carbon sequestration flows estimated for the purpose of emission trading in terms of net removal units.[2]

The United States, which accounts for 36% of the industrialized countries' missions, has refused to sign the Kyoto Protocol. It has decided on a nationwide effort to reduce greenhouse gas emissions through the formation of seven partnerships across 33 of its States and two Canadian provinces. An 18% reduction in U.S greenhouse gas intensity is being aimed at.[3] But as the country continues to grow and increase its output, the total amount of greenhouse gas emissions are likely to rise. So an 18% reduction is not a large step forward. The compromises at Bonn and Marrakesh have greatly diluted the original protocol. The inclusion of carbon sinks has relaxed the abatement targets substantially while the dropping of supplementarity (limits on the extent to which a country's commitment to reduce GHGs can be met through various flexibility mechanisms) has reduced global demand for GHG abatement.

The UNFCC Convention will be effective only if both developed and developing countries fulfill their common but differentiated responsibilities. The Kyoto agreement, if it happens, would end by 2012. It is essential to look beyond Kyoto and take a long-term view on global climate change.

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[1] '*Land Use*' refers to the sum total of activities undertaken on a certain land area – including grazing and timber extraction, which releases carbon trapped in terrestrial sinks, and conservation efforts, which lead to increased CO2 sequestration. Clearing forests for agricultural purposes, conversion of grasslands to cropland and abandoning cropland or pastureland qualify as *'Land Use Change'*. From 1850 to 1998, land use and land use change led to emissions of about 134 billion tonnes of carbon (GtC) into the atmosphere. This represents a share of 33% of the total emissions in this period due to fossil fuel burning and cement production, and land use and land use change. *'Forestry'*, meanwhile includes a wide range of activities like planting and tending of growing trees, pest control, forest management, wildlife protection and production of non-timber products.

[2] Article 3.3 allows countries to get credits for reducing carbon dioxide concentrations through land-use change and forestry activities that are a result of human activities. Only afforestation, reforestation and deforestation (ARD) activities undertaken since 1990 will be accounted for in determining compliance with national commitments to reduce GHG emissions. Consequently, credits in the LULUCF sector are restricted not just to ARD, but also to those ARD activities that are directly human-induced, and then only to those activities that are initiated after January 1, 1990.

[3] U.S Partners to Explore Ways to Sequester Greenhouse Gases, 19 August 2003, International Information Programs, USINFO.STATE.GOV, Washington File

Appendix 4.1

Correlation Matrix of the Sustainability of Production Indicators#

		1	2	3	4	5	6	7	8
		WNSA	*CNSA*	*FDGRNPR*	*PFC*	*SWIUIP*	*GWATOTA*	*DEGTGA*	*AULCGSA*
1	*WNSA*	1							
2	*CNSA*	-0.299	1						
3	*FDGRNPR*	0.172	-0.115	1					
4	*PFC*	-0.313	0.510**	-0.093	1				
5	*SWIUIP*	-0.253	0.343	-0.331	0.191	1			
6	*GWATOTA*	-0.059	-0.409	-0.426*	0.128	0.207	1		
7	*DEGTGA*	-0.334	0.231	-0.291	0.077	0.191	-0.024	1	
8	*AULCGSA*	0.761**	-0.290	-0.027	-0.286	-0.250	-0.008	-0.203	1

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

The abbreviations correspond to that of the variables in the Table 9.1

WNSA – Weighted Net Sown Area

CNSA – Percentage Change in Net Sown Area

FDGRNPR – Food Production Per Capita

PFC – Per Capita Forest Cover

SWIUIP – Future Availability Surface Water

GWATOTA – Future Availability Ground Water

DEGTGA – Percentage of Degraded Area to Total Geographical Area

AULCGSA – Percentage of Leguminous Crops to Gross Cropped Area

Appendix 6.1

Correlation Matrix of the Sustainability of Food Access Indicators

		1	2	3	4	5	6	7
		BPL	*AGWT*	*INSTABIL*	*SIHOLD*	*LLLHH*	*PNFAEN*	*PCDEFOA*
1	*BPL*	1						
2	*AGWT*	-0.423*	1					
3	*INSTABIL*	0.011	-0.262	1				
4	*SIHOLD*	0.040	-0.319	0.171	1			
5	*LLLHH*	0.025	-0.115	0.186	-0.141	1		
6	*PNFAEN*	-0.287	0.149	0.573**	-0.083	0.438*	1	
7	*PCDEFOA*	0.179	-0.091	-0.057	0.258	-0.276	-0.214	1

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

The abbreviations correspond to that of the variables in the Table 9.1

BPL – Percentage of Population Below Poverty Line

AGWT – Percentage of Non- Agricultural Workers to Total Workers

INSTABIL – Instability of Cereal Production

SIHOLD – Average Size of Holding Hectare Per Household

LLLHH – Percentage of Landless Labour

PNFAEN – Percentage of Workers in Non crop Ag. Enpr. To Total Workers

PCDEFOA – Dense Forest Cover Per lakh Population

Appendix 7.1

Current Hotspots of pollution in groundwater

Pollutant	State	Place of occurrences
Salinity (Inland)	Maharashtra	Amravati, Akola
	Bihar	Begusarai
	Haryana	Karnal
	Rajasthan	Barmer, Jaisalmer, Bharatpur, Jaipur, Nagaur, Jalore & Sirohi
	U.P.	Mathura
Salinity (Coastal)	Andhra Pradesh	Vishakapatnam
	Orissa	Puri, Cuttak, Balasore
	West Bengal	Haldai & 24 Pargana
	Gujarat	Junagarh, Kachch, Varahi, Banskanta & Surat
Flouride	Kerala	Palaghat Krishna, Ananipur,.
	Andhra Pradesh	Cuddapah, Guntur and Nalgonda Nellor, Chittoor
	Gujarat	Banskanta, Kachch & Amreli
	Haryana	Hissar, Kaithal & Gurgaon
	Orissa	Bolangir, Bijapur, Bhubaneshwar and Kalahandi
	Punjab	Amritsar, Bhatinda, Faridkot, Ludhiana & Sangrur
	Rajasthan	Nagaur, Pali, Sirohi, Ajmer & Bikaner
	Tamil Nadu	Chengalput, Madurai
	U.P.	Unnao, Agra, Aligarh, Mathura, Ghaziabad, Meerut & Rai Baraili
Sulphide	Orissa	Balasore, Cuttak & Puri
Iron	U.P.	Mirjapur
	Assam	Darrang, Jorhat, Kamrup
	Orissa	Bhubaneshwar
	Bihar	E. Champaran, Muzaffarpur, Gaya, Manger, Deoghar & Madubani
	Rajasthan	Bikaner, Alwar, Bharatpur
	Tripura	Dharmnagar, Kailasanar, Ambasa, Amarpur & Agartala
	West Bengal	Madnipur, Howrah, Hoogly and Bankura
Manganese	Orissa	Bhubaneshwar, Athgaon
	U.P	Muradabad, Basti, Rampur & Unnao
Arsenic	West Bengal	Malda, Murshidabad, Nadia, 24 Pargana
Nitrate	Bihar	Patna, East Champaran, Palamu, Gaya, Nalanda, Nawada and Banka
	Andhra Pradesh	Vishakapatnam, East Godvari, Krishna, Prakasam, Nellor, Chittoor, Anantpur, Cuddapah, Kurnool, Khamam and Nalgonda
	Delhi	Naraina, Shehadr (Blocks)
	Haryana	Ambala, Sonepat, Jind, Gurgaon, Faridabad & Hissar
	Himachal Pradesh	Kulu, Solan, Una
	Karnataka	Bidar, Gulbarge and Bijapur
	Madhya Pradesh	Sehore, Bhopal & (West & Central Part of state)
	Maharashtra	Jalna, Beed Nanded, Latur, Osmanabad, Solapur Satara, Sangli & Kolhapur

Pollutant	State	Place of occurrences
	Punjab	Patiala, Faridkot, Firozpur, Sangrur & Bhatinda
	Rajasthan	Jaipur, Churu, Ganganagar, Bikaner, Jalore, Barmer, Bundi and Sawaimadhopur
	Tamil Nadu	Coimbatore, Penyar and Salem
	West Bengal	Uttar Dinajpur, Malda, Birbhum, Murshidabad, Nadia, Bankura & Purulia
Chloride	Karnataka	Dharwad, Belgaum
	Madhya Pradesh	Bhind, Shagapur and Sehore
	Maharashtra	Solapur, Satara, Amravati, Akola & Buldana
	Rajasthan	Barmer, Jaisalmer, Jodhpur & Jalore
	West Bengal	Contai, Digha, Haldia
Zinc	Andhra Pradesh	Hyderabad, Osmania University campus
	Delhi	R.K. Puram
	Rajasthan	Udaipur
Chromium	Punjab	Ludhiana

Appendix 7.2
Current Hotspots of pollution in surfacewaters

River	Polluted Stretch	Critical Parameters
I. Grossly Polluted	i) Immediately upstream of Ahmedabad city up to Sabarmati Ashram	DO, BOD, Coliforms
Sabarmati	ii) Sabarmati Ashram to Vautha	DO, BOD, Coliforms
Indus (Industries)	i) Downstream of Ludhiana to Harike	DO, BOD
	ii) Downstream of Nangal	Ammonia
Yamuna	i) Delhi to confluence with Chambal	DO, BOD, Coliforms
	ii) In city limits of Delhi, Mathura and Agra	DO, BOD, Coliforms
Subarnarekha	Hathidam to Bahragora	DO, BOD, Coliforms
Godavari	i) Downstream of Nasik to Nanded	BOD
	ii) City limits of Nasik and Nanded	BOD
Krishna	Karad to Sangli	BOD
Chambal	i) Downstream of Nangal	BOD, DO
	ii) Downstream of Kota	
Damodar	Downstream of Dhanbad to Haldia	BOD, Toxic
Gomti	Lucknow to confluence with Ganga	DO, BOD, Coliforms
Kali	Downstream of Modinagar to confluence with Ganga	DO, BOD, Coliforms
Khan	i) In the city limits of Indore	DO, BOD, Coliforms
	ii) Downstream of Indore	
Kshipra	i) In the city limits of Ujjain	DO, BOD, Coliforms
	ii) Downstream of Ujjain	
Hindon	Sharanpur to confluence with Yamuna	BOD, Toxic
II. Less Polluted		
Baiterni	Upstream of Chandbali	DO, BOD, Coliforms
Krishna	i) Dham dam to Narso Babari (Maharashtra)	DO, BOD, Coliforms
	ii) Tributary Streams	
	iii) Up to Nagarjanasagar dam, and from that dam to upstream of Repella (Andhra Pradesh)	DO, BOD, Coliforms DO, BOD, Coliforms
Bhadra	Origin to downstream of KICCL of Bhadra dam (Karnataka)	Coliforms
Brahmini	Upstream of Dharamshala	DO, BOD, Coliforms
Tunga	Thirthahalli to confluence with Bhadra	Coliforms
Cauvery	i) From Talakaveri to 5km of Mysore district border, Yagani (Karnataka)	-
	ii) From K R Sagar dam to Hogennekal (Karnataka)	
	iii) From Pugalur to Anicut (Tamil Nadu)	
	iv) From Grand Anicut to Kumbakonam (Tamil Nadu)	
Tapi	From city limits of Nepanagar to the city limits of Bhrhanpur (Madhya Pradesh)	-
Narmada	Along the city limits of Jabalpur (Madhya Pradesh)	-
Betwa	Between Vidisha, Manideep and Bhopal (Madhya Pradesh)	-

Appendix 7.3

Types of Pollution

Physical pollution: Industrial untreated effluents are discharged into the public sewers and these are usually of higher temperatures. The water becomes hot and this is detrimental to the fish. Trout die if water temperature rises above 25^0C. No fresh water fish survive above 40^0C. The pollutants emit a bad odor. Some industries have colored effluents, which impart color to the water. Besides the pollutants are responsible for aesthetic problems. In high temperatures, oxygen depletion takesplace. Hence the water-borne living things die. Besides organic matter decomposition extract O_2. Also certain chemicals are more toxic at higher temperatures.

Chemical pollution: Water gets heavily polluted by certain chemicals, which may be harmful to the animals & humans. The hardness of water may increase & certain chemicals may reach a concentration, which can harm the lives consuming this water. Pesticides like DDT may prove toxic to the animals and fish and humans consuming this water. Fertilizers if present in the water give rise to excessive growth in the fish. (Eutrophication). Also chemicals consumed by fish may reach the humans when they eat this fish.

Biological pollution: Disease - causing bacteria may reach the water bodies when the sewage water is thrown into places where drinking water areas are nearby. Pipelines carrying drinking water may also leak & get infected.

Oil pollution: Ship tankers carrying oils, rigs etc. may pollute the seas with oil. This occurs either by leaks or during accidents. Also when wastes from garages enter water bodies there may be oil pollution. Oil forms a thin film on the water surface. Hence marine life, which has to come to surface to breathe, may die. Also the birds may have decreased buoyancy & their feather insulation may reduce.

Radioactive pollution - This though rare is dangerous. If the half-life of a radio active substance is more, it continues to emit harmful rays (alpha, beta) for longer duration of time. If this contaminated water were consumed, the rays would harm the person concerned. Also photographic films & X-rays are made useless by such substances in the water.

Appendix 7.4

Major Air Pollutants

Tobacco smoke: Tobacco smoke generates a wide range of harmful chemicals and is a major cause of ill health, as it is known to cause cancer, not only to the smoker but affecting passive smokers too. It is well-known that smoking affects the passive smoker (the person who is in the vicinity of a smoker and is not himself/herself a smoker) ranging from burning sensation in the eyes or nose, and throat irritation, to cancer, bronchitis, severe asthma, and a decrease in lung function.

Biological pollutants: These are mostly allergens that can cause asthma, hay fever, and other allergic diseases.

Volatile organic compounds: Volatile compounds can cause irritation of the eye, nose and throat. In severe cases there may be headaches, nausea, and loss of coordination. In the longer run, some of them are suspected to cause damage to the liver and other parts of the body.

Formaldehyde: Exposure causes irritation to the eyes, nose and may cause allergies in some people.

Lead: Prolonged exposure can cause damage to the nervous system, digestive problems, and in some cases cause cancer. It is especially hazardous to small children.

Radon: A radioactive gas that can accumulate inside the house, it originates from the rocks and soil under the house and its level is dominated by the outdoor air and also to some extent the other gases being emitted indoors. Exposure to this gas increases the risk of lung cancer.

Ozone: Exposure to this gas makes our eyes itch, burn, and water and it has also been associated with increase in respiratory disorders such as asthma. It lowers our resistance to colds and pneumonia.

Oxides of nitrogen: This gas can make children susceptible to respiratory diseases in the winters.

Carbon monoxide: CO (carbon monoxide) combines with haemoglobin to lessen the amount of oxygen that enters our blood through our lungs. The binding with other haeme proteins causes changes in the function of the affected organs such as the brain and the cardiovascular system, and also the developing foetus. It can impair our concentration, slow our reflexes, and make us confused and sleepy.

Sulphur dioxide: SO_2 (sulphur dioxide) in the air is caused due to the rise in combustion of fossil fuels. It can oxidize and form sulphuric acid mist. SO_2 in the air leads to diseases of the lung and other lung disorders such as wheezing and shortness of breath. Long-term effects are more difficult to ascertain as SO2 exposure is often combined with that of SPM.

SPM (suspended particulate matter): Suspended matter consists of dust, fumes, mist and smoke. The main chemical component of SPM that is of major concern is lead, others being nickel, arsenic, and those present in diesel exhaust. These particles when breathed in, lodge in our lung tissues and cause lung damage and respiratory problems. The importance of SPM as a major pollutant needs special emphasis as a) it affects more people globally than any other pollutant on a continuing basis; b) there is more monitoring data available on this than any other pollutant; and c) more epidemiological evidence has been collected on the exposure to this than to any other pollutant.

Appendix 7.5

Statewise Reported Cases and Deaths due to Communicable Diseases, 1994

		Japanese Encephalitis		Malaria		Cholera		Diarrhoea	
Sl.No	States	No. of cases	No. of deaths	No. of cases	No. of deaths	No. of cases	No. of deaths	No. of cases	No. of deaths
1	Andhra Pradesh	1175	467	77340	7	82	4	1294737	568
2	Arunachal Pradesh	0	0	17372	0	0	0	31454	6
3	Assam	96	30	127910	58	NA	NA	NA	NA
4	Bihar	106	49	23358	0	0	0	NA	NA
5	Goa	37	10	3061	0	3	0	11425	28
6	Gujarat	0	0	216019	14	578	8	234193	195
7	Haryana	19	13	28286	0	49	0	317383	101
8	Himachal Pradesh	0	0	3091	0	25	0	348642	115
9	Jammu and Kashmir	0	0	2705	0	0	0	537745	112
10	Karnataka	99	22	145559	0	103	2	594890	276
11	Kerala	0	0	7438	0	36	0	610914	0.65
12	Madhya Pradesh	0	0	284137	23	289	9	720013	670
13	Maharashtra	0	0	237628	1	76	5	448823	330
14	Manipur	11	1	2297	45	2	0	15041	3
15	Meghalaya	0	0	6224	34	NA	NA	97083	18
16	Mizoram	0	0	11805	37	0	0	14338	21
17	Nagaland	0	0	2098	253	0	0	4700	12
18	Orissa	0	0	250559	64	2	0	785792	377
19	Punjab	0	0	15217	0	84	1	214482	118
20	Rajasthan	0	0	212136	452	3	0	210063	104
21	Sikkim	0	0	51	0	0	0	NA	NA
22	Tamil Nadu	278	176	96731	3	728	0	95526	89
23	Tripura	0	0	11680	16	0	0	92653	71
24	Uttar Pradesh	104	32	87148	0	485	3	377273	198
25	West Bengal	366	123	62270	45	125	0	NA	NA
	India	**2291**	**923**	**1953637**	**1052**	**4958**	**32**	**7262755**	**3609**

Source: Anon 1994, Health Information of India, Central Bureau of Health Intelligence, Directorate General of Health Services, Ministry of Health and Family Welfare, Government of India, New Delhi.

Appendix 7.6
Correlation Matrix of the Sustainability Indicators#

		16	17
		HHASDW	*IMR*
16	*HHASDW*	1	
17	*IMR*	0.342	1

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

The abbreviations correspond to that of the variables in the Table 9.1

HHASDW – Percentage of Household with Access to Safe Drinking Water

IMR – Infant Mortality Rate

Appendix 8.1
Projected Cereal Requirements For India For 2020 (million tons)

	Source/ Year	Food	Feed	Total	kg per capita per day
I	**2020 G.S . Bhalla's projection**				
	2 per cent growth	231.51	25.75	257.26	0.53
	3.7 per cent growth	246.08	50.11	296.19	0.61
	6 per cent growth	267.21	107.52	374.73	0.77
II	**2020 IMPACT* projection**				
	3 per cent growth	223.60	13.30	237.30	0.51
III	**2020 Kumar** projection**	237.60	16.90	254.50	0.55

Source: G.S Bhalla, 2001. Demand and Supply of Food and Feed grains by 2020. In Towards hunger free India. Agenda and Imperatives. (eds) M.D Asthana and Pedro Medrano. Manohar Publishers.New Delhi

Notes:* IMPACT model baseline results (Rosegrant et al.1995), ** Kumar's projections (Kumar 1998)

Appendix 9.1

Correlation Matrix of the Sustainability Indicators#

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	*WNSA*	1																
2	*CNSA*	-0.299	1															
3	*FDGRNPR*	0.172	-0.115	1														
4	*PFC*	-0.313	0.510**	-0.093	1													
5	*SWIUIP*	-0.253	0.343	-0.331	0.191	1												
6	*GWATOTA*	-0.059	-0.409	-0.426*	0.128	0.207	1											
7	*DEGTGA*	-0.334	0.231	-0.291	0.077	0.191	-0.024	1										
8	*AULCGSA*	0.761**	-0.290	-0.027	-0.286	-0.250	-0.008	-0.203	1									
9	*BPL*	0.099	0.016	-0.287	0.187	0.326	0.121	0.290	-0.013	1								
10	*AGWT*	-0.445*	-0.206	0.025	-0.140	0.033	0.161	-0.258	-0.460*	-0.423*	1							
11	*INSTABIL*	0.289	-0.102	-0.293	-0.065	-0.129	0.017	0.145	0.484*	0.011	-0.262	1						
12	*SIHOLD*	0.062	0.341	0.281	0.266	-0.322	-0.495*	0.335	0.107	0.040	-0.319	0.171	1					
13	*LLLHH*	0.447*	-0.426*	0.196	-0.359	-0.270	-0.006	-0.339	0.558**	0.025	-0.115	0.186	-0.141	1				
14	*PNFAEN*	0.265	-0.223	-0.298	-0.262	-0.038	0.115	-0.170	0.554**	-0.287	0.149	0.573**	-0.083	0.438*	1			
15	*PCDEFOA*	-0.238	0.322	-0.054	0.973**	0.093	0.200	-0.026	-0.218	0.179	-0.091	-0.057	0.258	-0.276	-0.214	1		
16	*HHASDW*	0.282	-0.408*	0.550**	-0.035	-0.566**	-0.254	-0.242	0.230	-0.192	-0.175	-0.096	0.300	0.368	-0.001	0.101	1	
17	*IMR*	0.644**	-0.485*	0.234	-0.258	-0.110	0.130	-0.274	0.556**	0.305	-0.482*	0.100	-0.028	0.333	-0.005	-0.153	0.342	1

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

The abbreviations correspond to that of the variables in the Table 9.1

WNSA – Weighted Net Sown Area

CNSA – Percentage Change in Net Sown Area

FDGRNPR – Food Production Per Capita

PFC – Per Capita Forest Cover

SWIUIP – Future Availability Surface Water

GWATOTA – Future Availability Ground Water

DEGTGA – Percentage of Degraded Area to Total Geographical Area

AULCGSA – Percentage of Leguminous Crops to Gross Cropped Area

BPL – Percentage of Population Below Poverty Line

AGWT – Percentage of Non- Agricultural Workers to Total Workers

INSTABIL – Instability of Cereal Production

SIHOLD – Average Size of Holding Hectare Per Household

LLLHH – Percentage of Landless Labour

PNFAEN – Percentage of Workers in Non crop Ag. Enpr. To Total Workers

PCDEFOA – Dense Forest Cover Per lakh Population

HHASDW – Percentage of Household with Access to Safe Drinking Water

IMR – Infant Mortality Rate

Appendix 9.2

Principal Component Analysis

Communalities are measures of the amount of variance in each variable that the factors explain. They describe the relative importance of each variable by providing a measure of the percent of variance in a variable using the factors as predictors. A good factor has much common variance thus accounting for a large part of the inter-correlations between several variables.

Communalities

	Initial	Extraction
WNSA	1.000	.793
CNSA	1.000	.941
FDGRNPR	1.000	.777
PFC	1.000	.988
SWIUIP	1.000	.732
GWATOTA	1.000	.848
DEGTGA	1.000	.868
AULCGSA	1.000	.875
BPL	1.000	.734
AGWT	1.000	.825
INSTABIL	1.000	.759
SIHOLD	1.000	.820
LLLHH	1.000	.561
PNFAEN	1.000	.865
PCDEFOA	1.000	.987
HHASDW	1.000	.813
IMR	1.000	.833

Extraction Method: Principal Component Analysis.

The total variance shows the initial eigen values describing the proportion of variance in all variables described the factor, (e.g. 2.756/ 17=16.211%). The factors are ordered based on their importance with respect to the variables; eigen values below one often used as a practical cutoff. The extraction sums of squared loading lists only the two factors that have been extracted for analysis. The rotation sums of squared loadings lists the eigen values after varimax rotation. Although the total variance explained is still the same (82.46), the eigen values have changed as has the factor variance.

The factor matrix is heart of the analysis as it described the factor loadings. This matrix shows the loadings prior to rotation and is typically more difficult to interpret than the rotated matrix that follows. The factor transformation matix shows the correlation of factors before and after rotations. The rotated factor matrix shows the variable groupings. We attempt to name the factors based on existing research and the names of the variables included in the grouping.

Principal Component Analysis extracts as many factors as there are variables. The relative importance of these variables declines (as measured by the % of variance explained and their eigen values). We have extracted factors with an eigen value of > 1.0. There are six factors.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.349	25.580	25.580	4.349	25.580	25.580	2.756	16.211	16.211
2	2.670	15.706	41.285	2.670	15.706	41.285	2.553	15.020	31.231
3	2.470	14.528	55.814	2.470	14.528	55.814	2.483	14.607	45.839
4	1.835	10.795	66.609	1.835	10.795	66.609	2.399	14.114	59.953
5	1.617	9.509	76.118	1.617	9.509	76.118	1.988	11.696	71.649
6	1.079	6.346	82.463	1.079	6.346	82.463	1.838	10.815	82.463
7	.692	4.070	86.533						
8	.512	3.012	89.545						
9	.470	2.762	92.308						
10	.381	2.241	94.549						
11	.349	2.055	96.605						
12	.232	1.362	97.967						
13	.142	.834	98.801						
14	9.580E-02	.564	99.365						
15	7.584E-02	.446	99.811						
16	3.177E-02	.187	99.998						
17	3.826E-04	2.250E-03	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix

	Component					
	1	2	3	4	5	6
WNSA	.702			.331		.332
CNSA		-.478	.396		.717	
FDGRNPR		.594		-.404	.351	.350
PFC			.977			
SWIUIP		-.831				
GWATOTA					-.872	
DEGTGA						-.915
AULCGSA	.586			.651		
BPL	.617	-.318				-.378
AGWT	-.800					
INSTABIL				.823		
SIHOLD		.427			.604	-.402
LLLHH	.328			.352		.389
PNFAEN				.875		
PCDEFOA			.988			
HHASDW		.856				
IMR	.817					

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser

Normalization. a Rotation converged in 13 iterations.

First Component	Second Component	Third Component	Fourth Component	Fifth Component	Sixth Component
WNSA	FDGRNPR	PFC	AULCGSA	CNSA	DEGTGA
BPL	SWIUP	PCDEFOA	INSTABIL	SIHOLD	(-ve)
AGWT	(-ve)		PNFAEN	GWATOTA	LLLHH
a(-ve)	HHASDW			(-ve)	
IMR					

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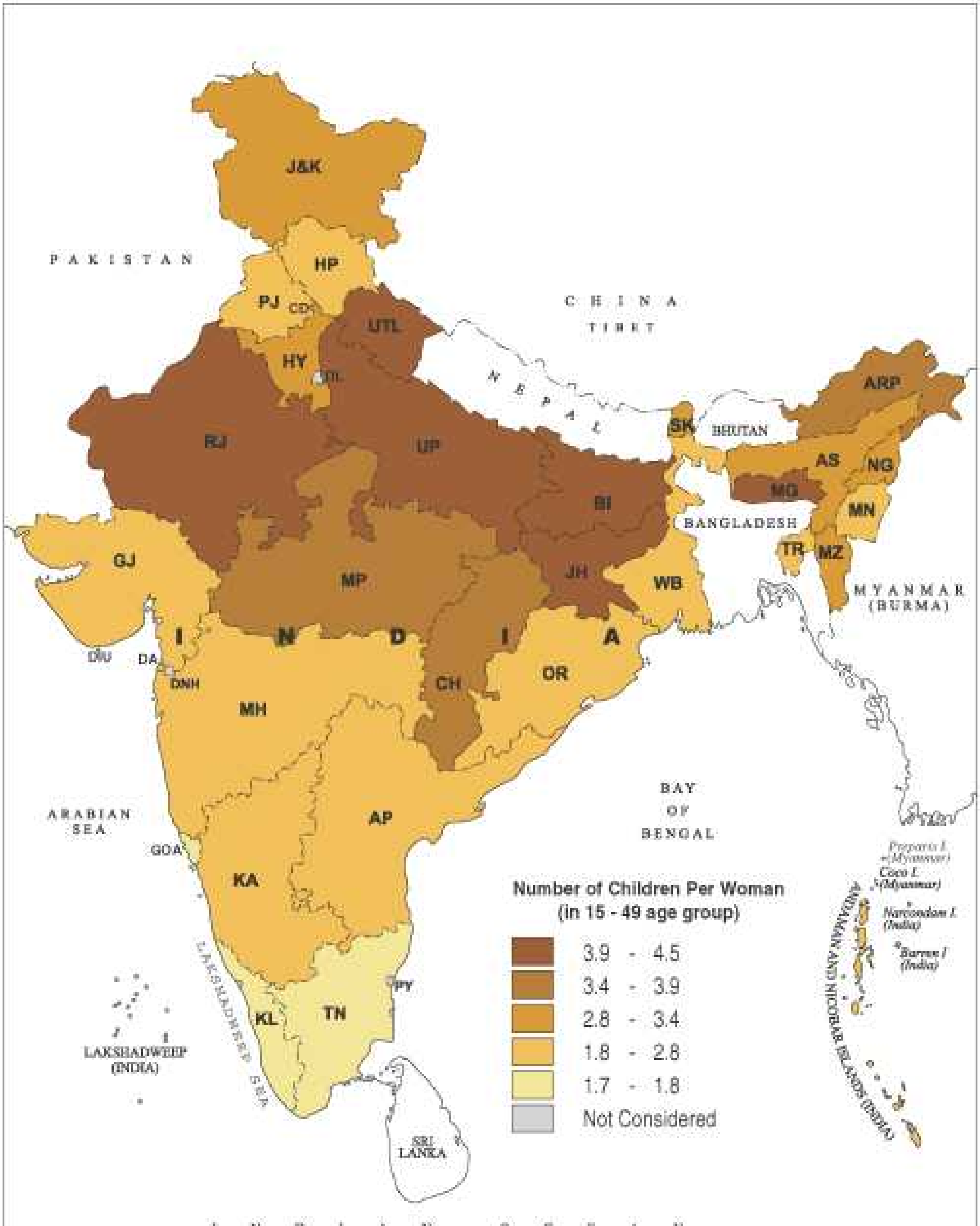
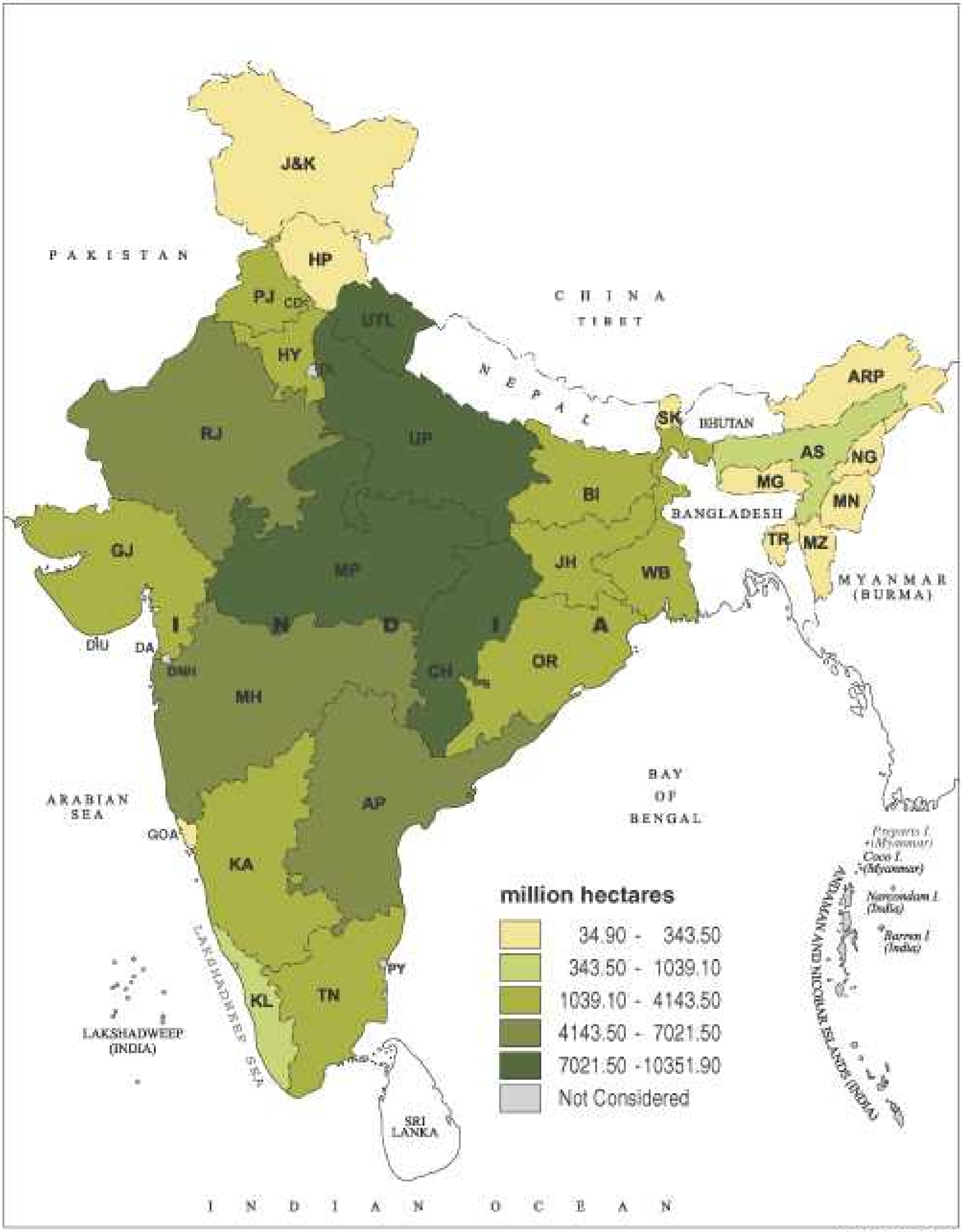
TOTAL FERTILITY RATE



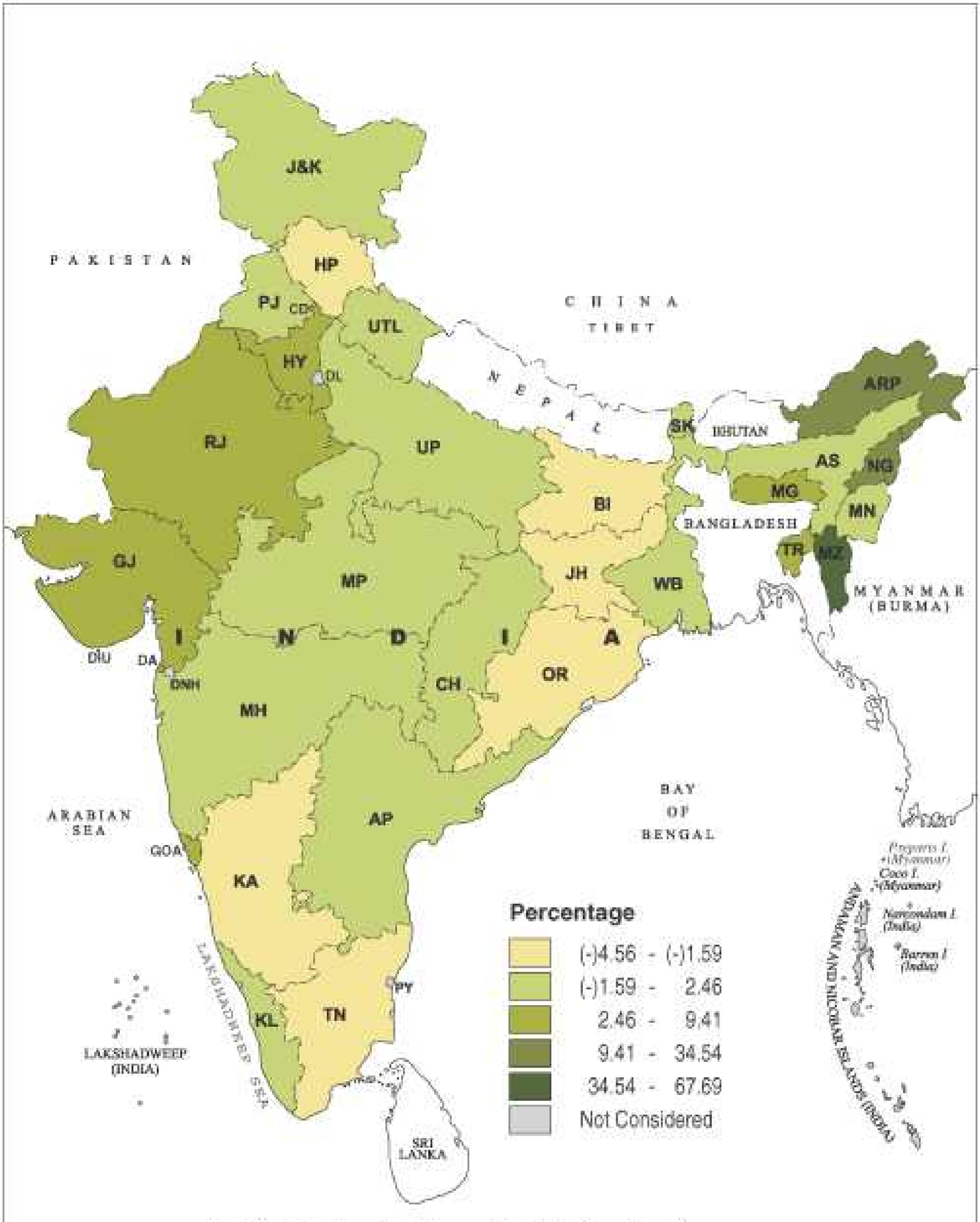
Map No. 1.1

NET SOWN AREA (WEIGHTED)



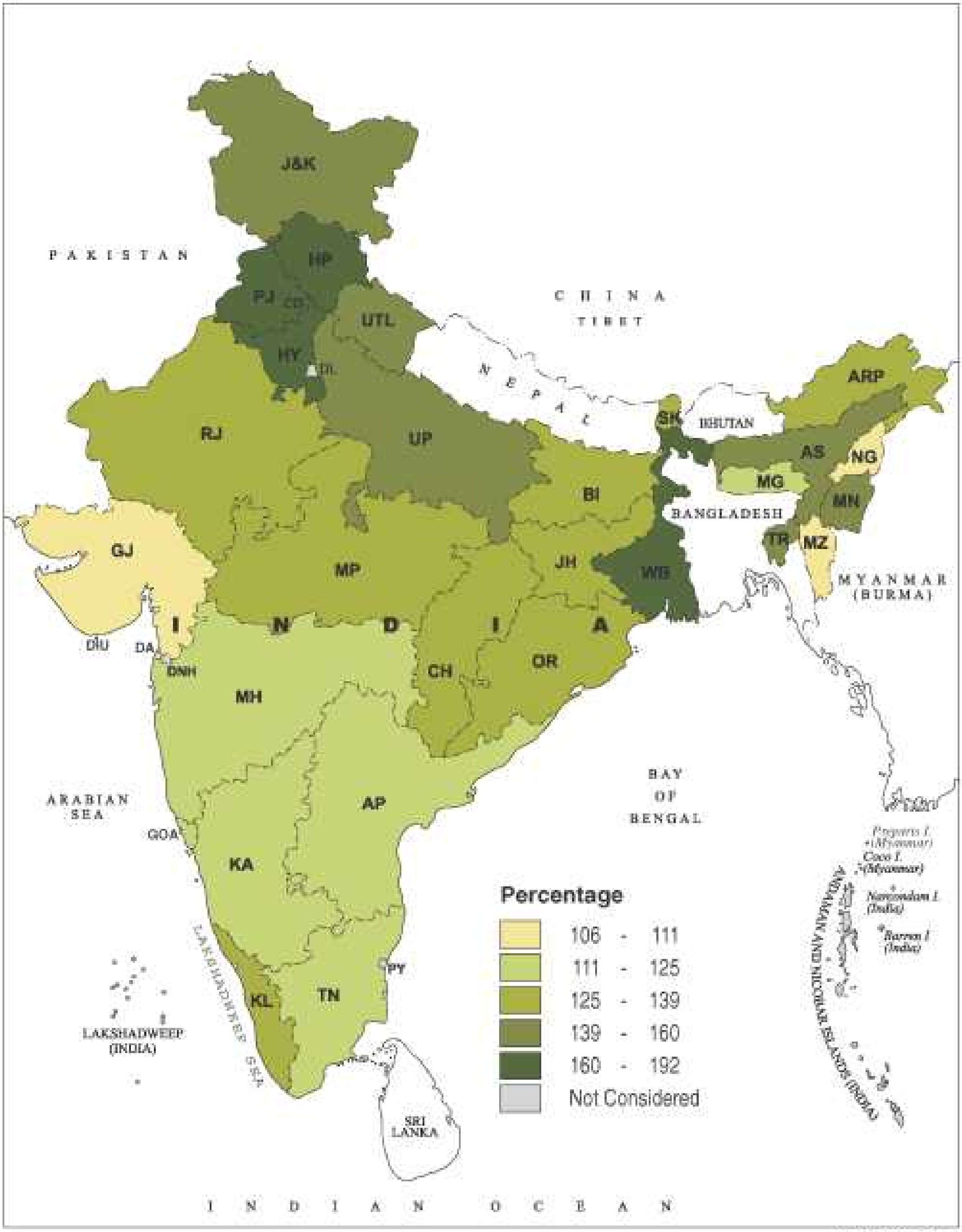
Map No. 1.2

CHANGE IN NET SOWN AREA (1991-92 TO 1998-99)



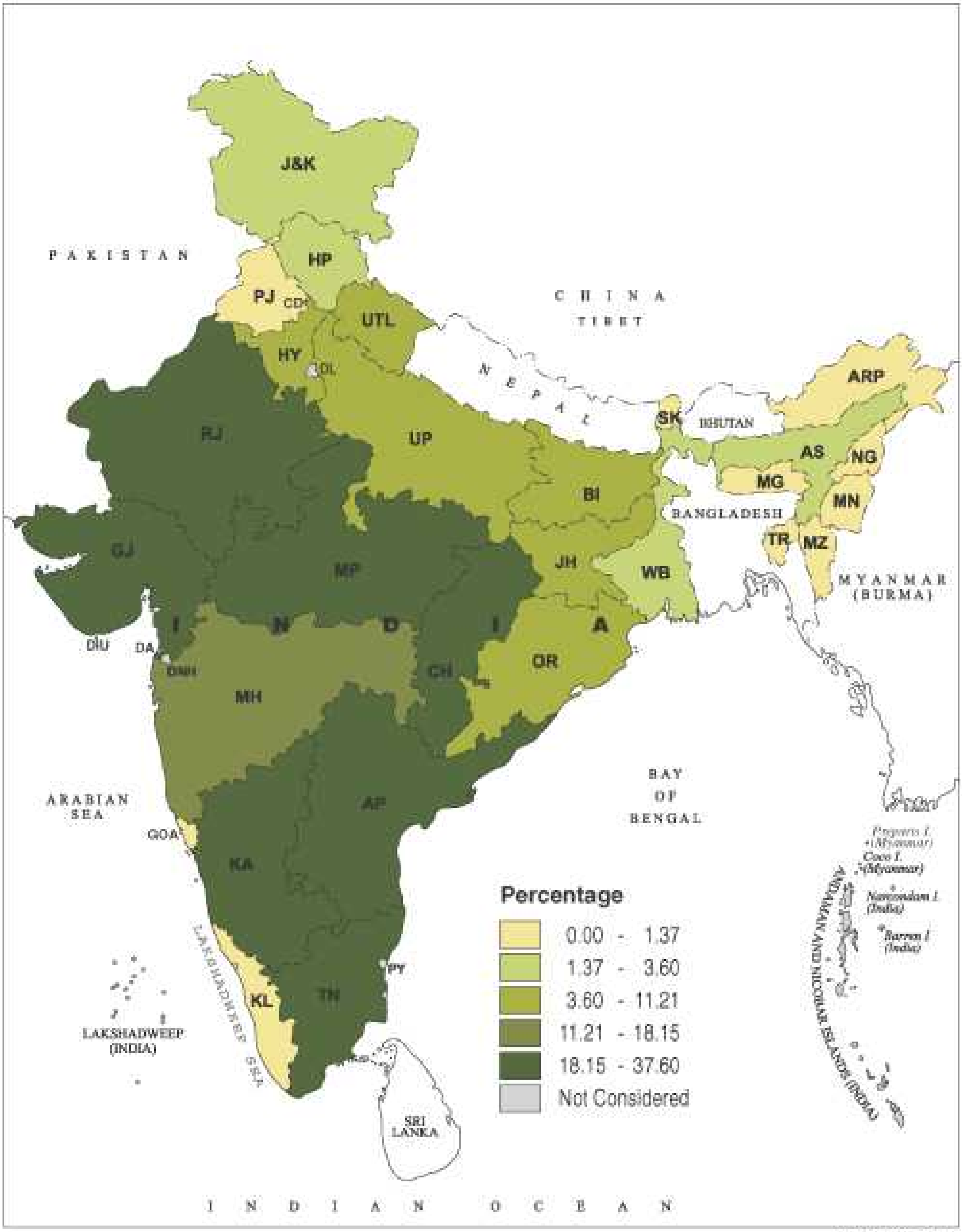
Map No. 1.3

CROPPING INTENSITY



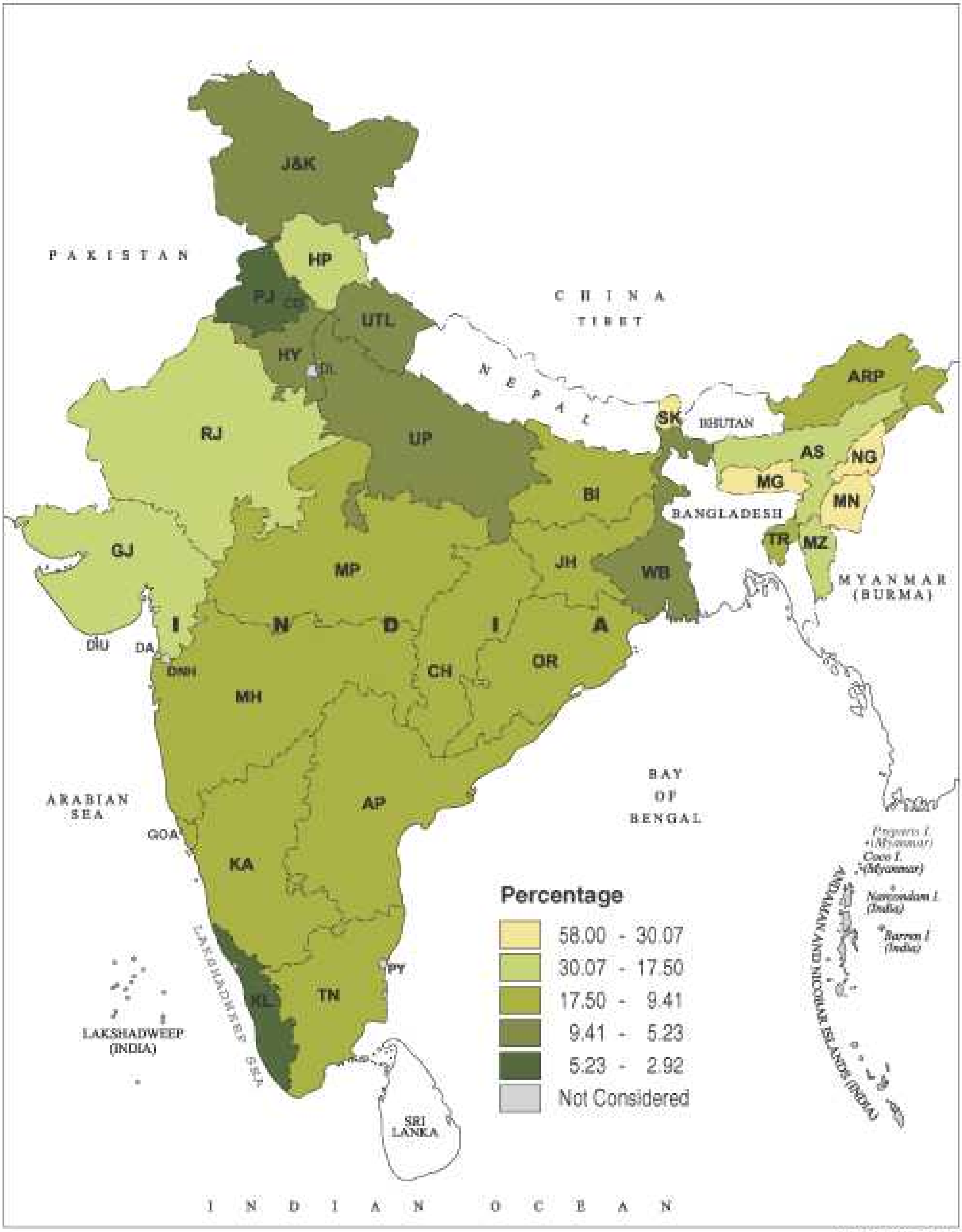
Map No. 1.4

AREA UNDER LEGUMES TO GROSS CROPPED AREA



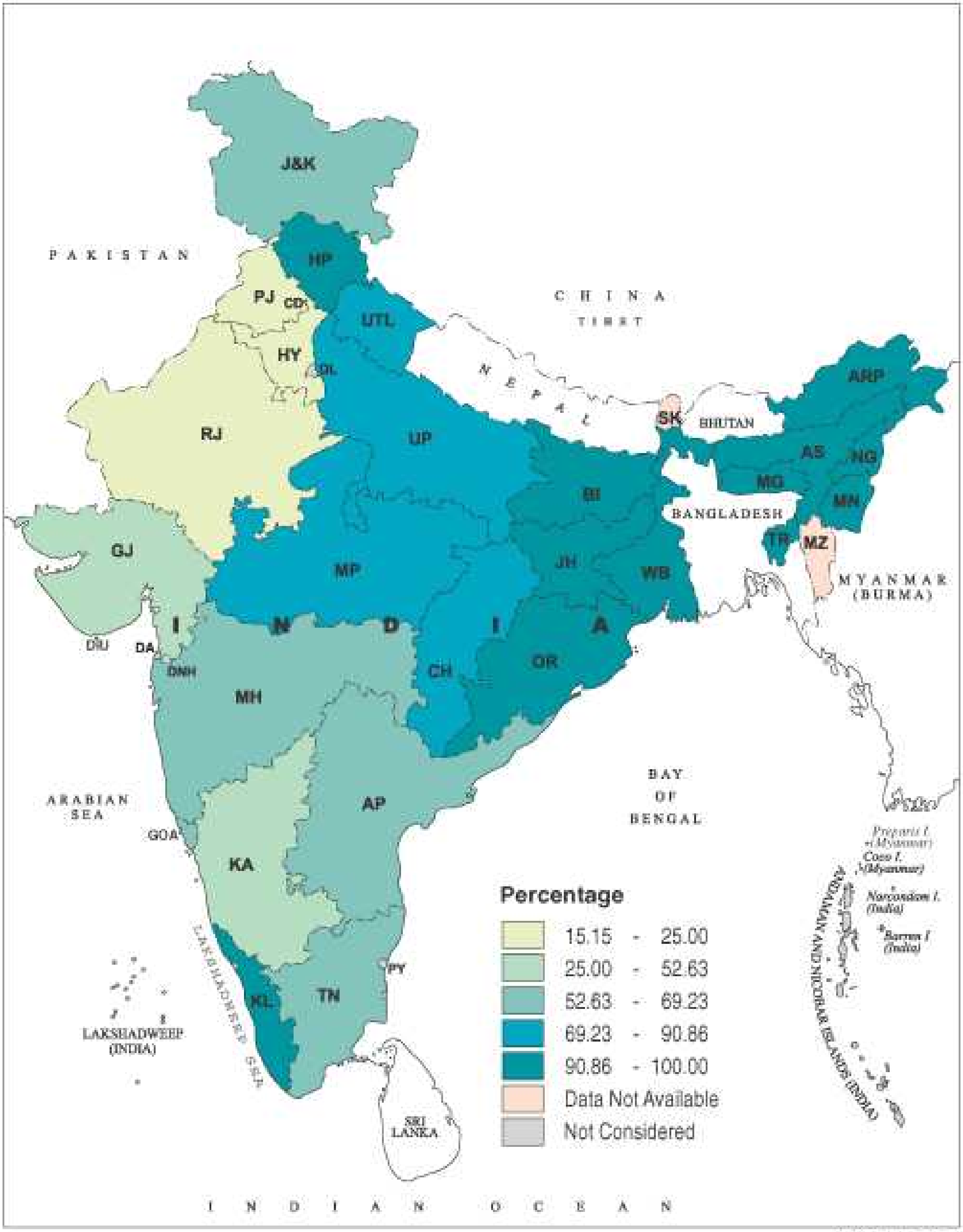
Map No. 1.5

DEGRADED LANDS TO TOTAL GEOGRAPHICAL AREA



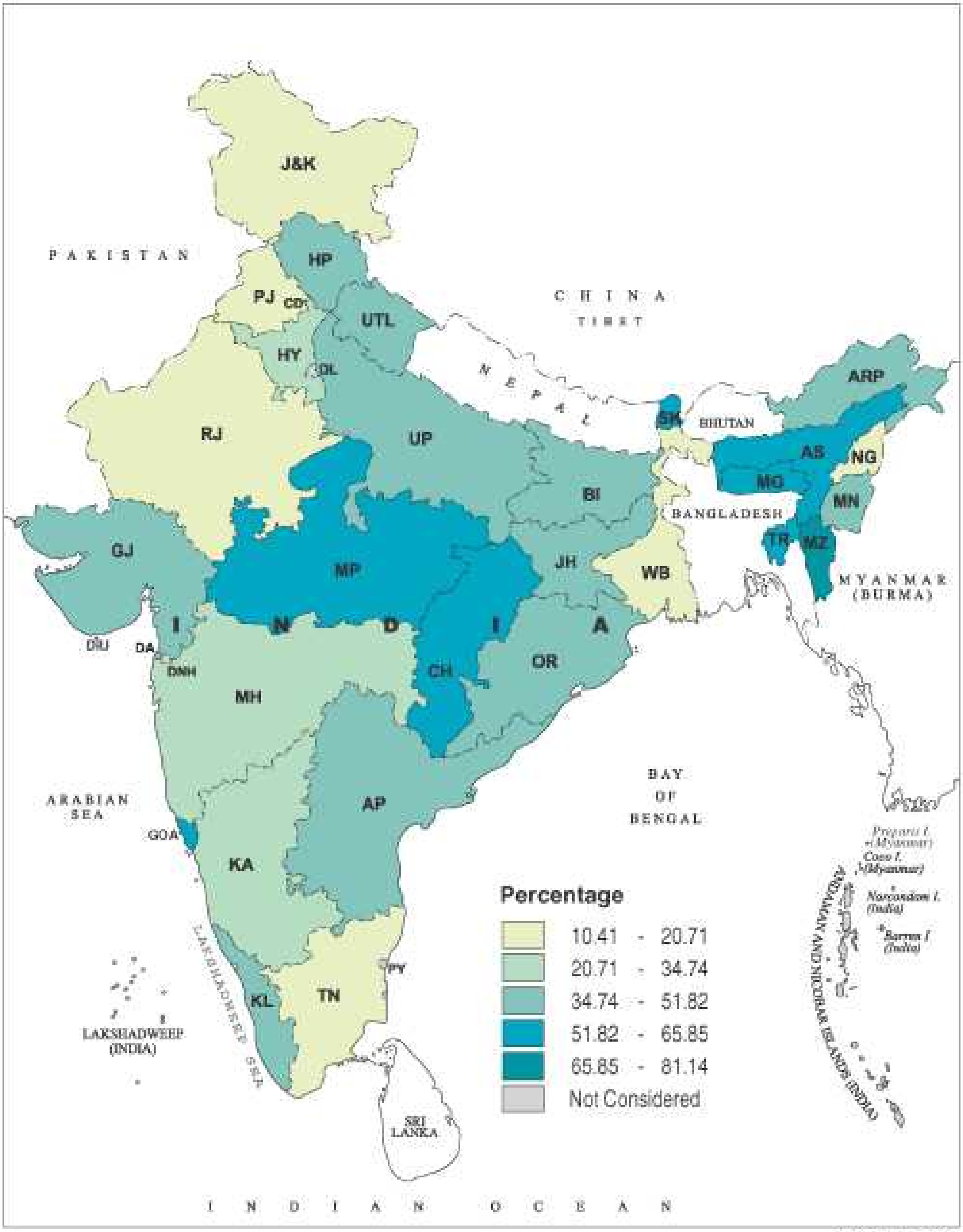
Map No. 1.6

PERCENTAGE OF IMD STATIONS HAVING RAINFALL HIGHER THAN HALF THE POTENTIAL EVAPOTRANSPIRATION



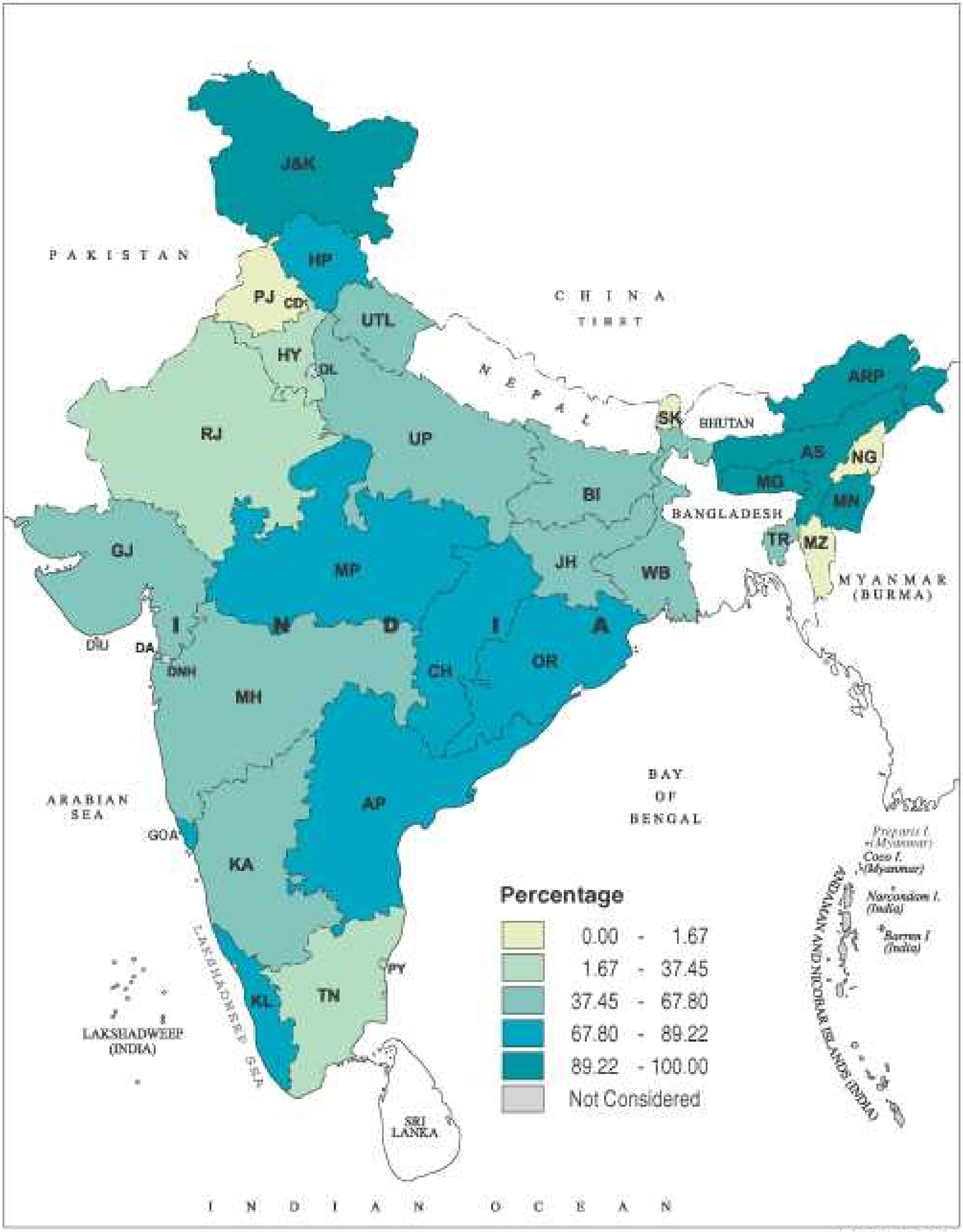
Map No. 1.7

UTILISABLE SURFACE WATER



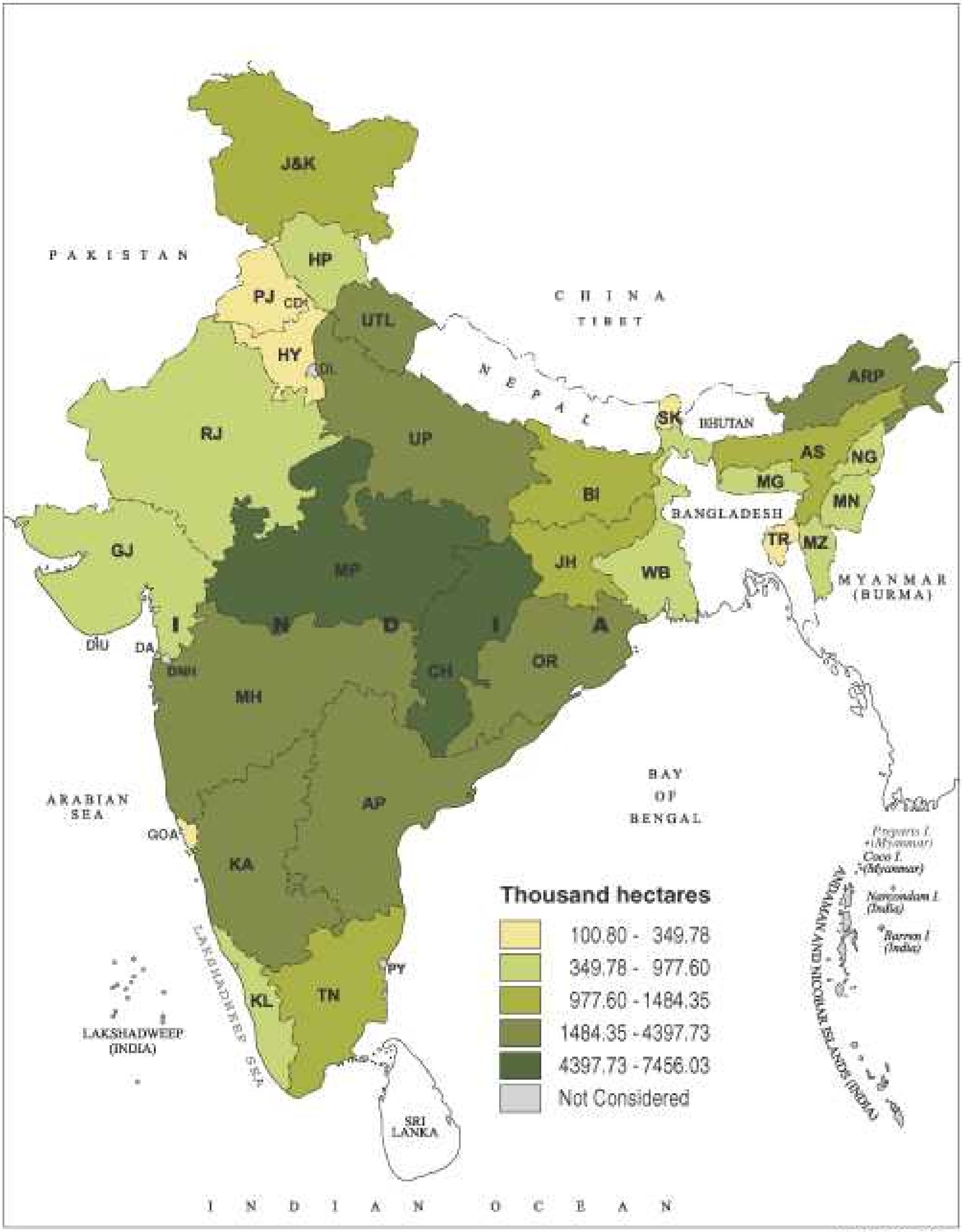
Map No. 1.8

UTILISABLE GROUND WATER



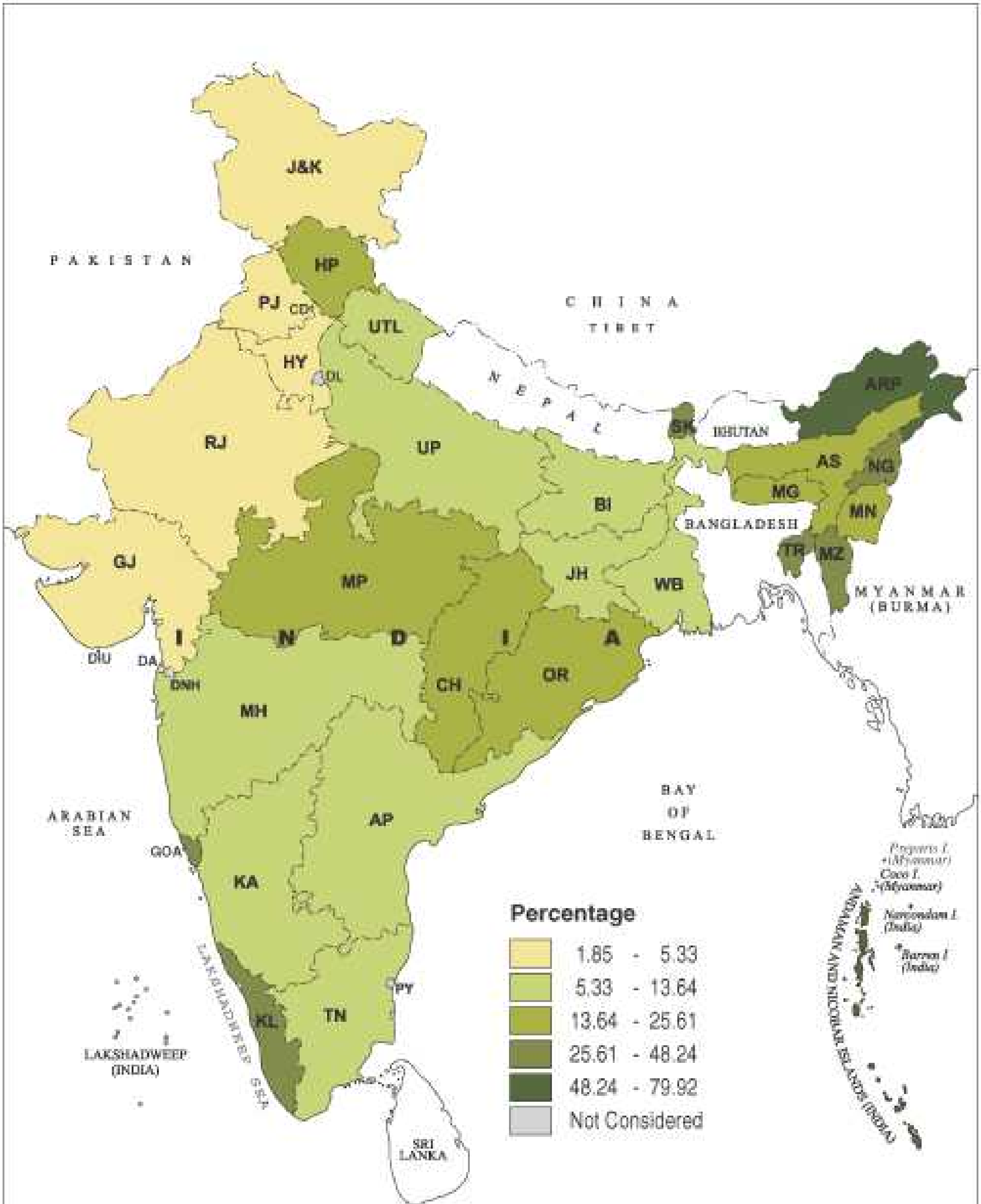
Map No. 1.9

FOREST COVER (WEIGHTED)



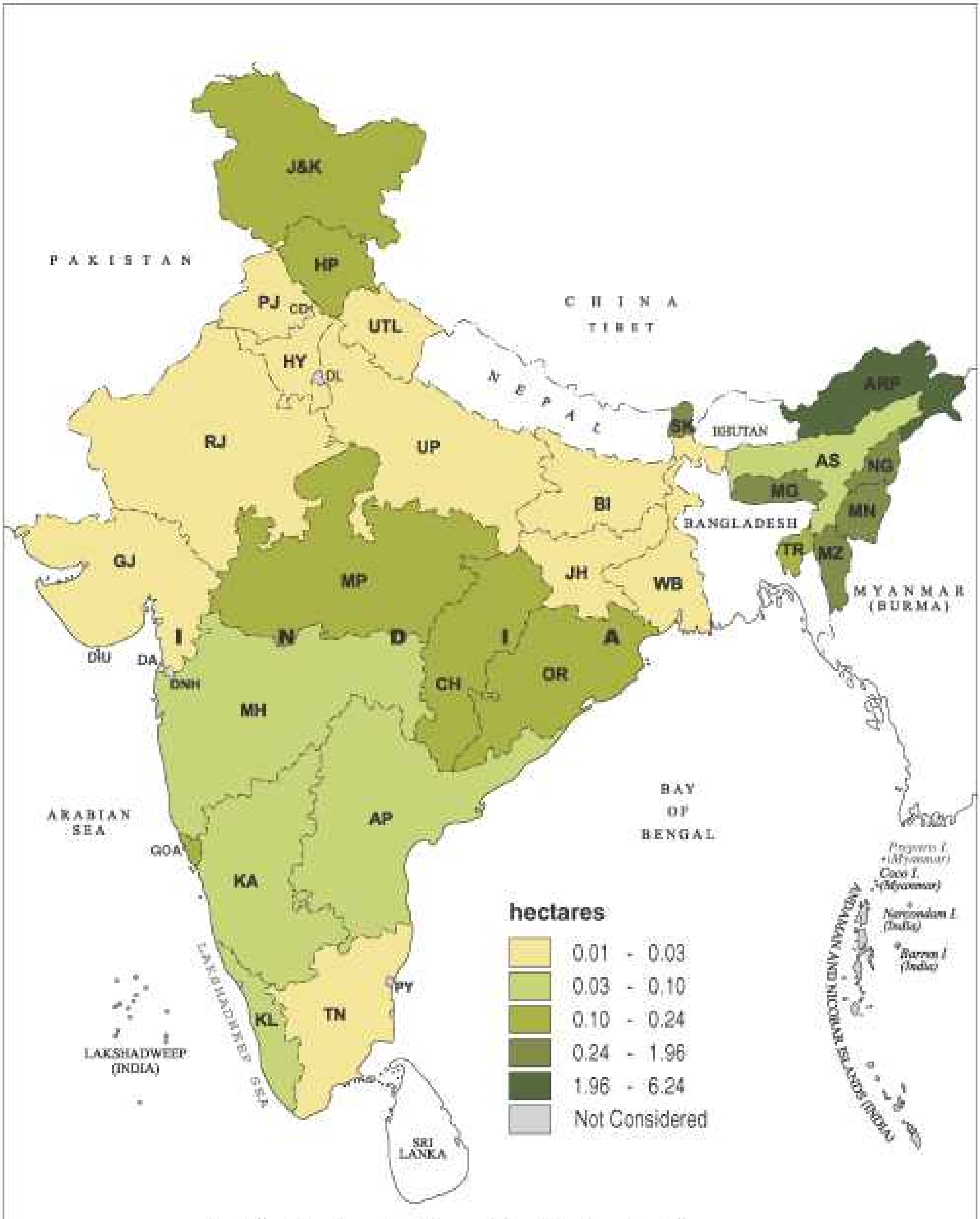
Map No. 2.1

DENSE FOREST COVER TO TOTAL GEOGRAPHICAL AREA



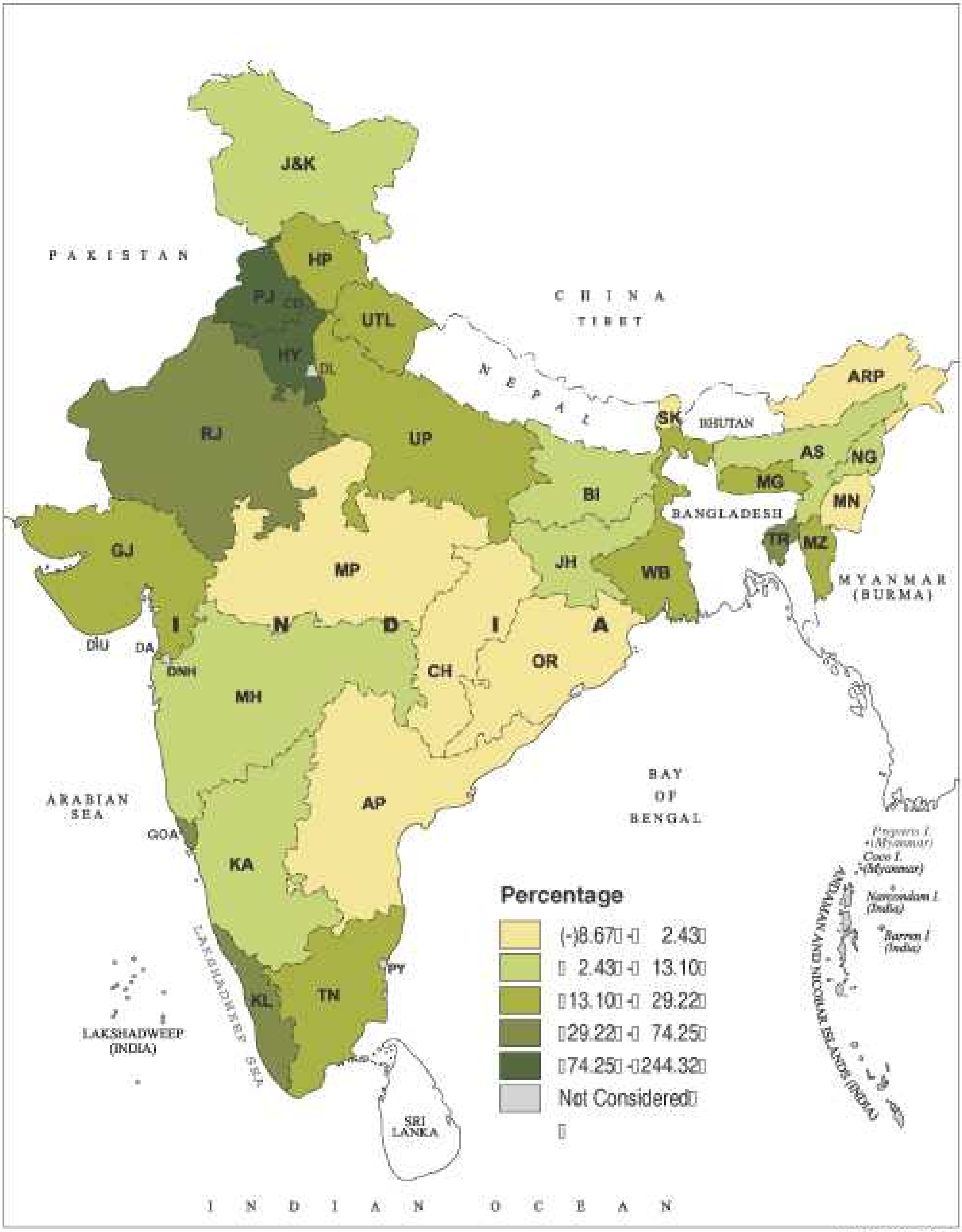
Map No. 2.2

PER CAPITA FOREST



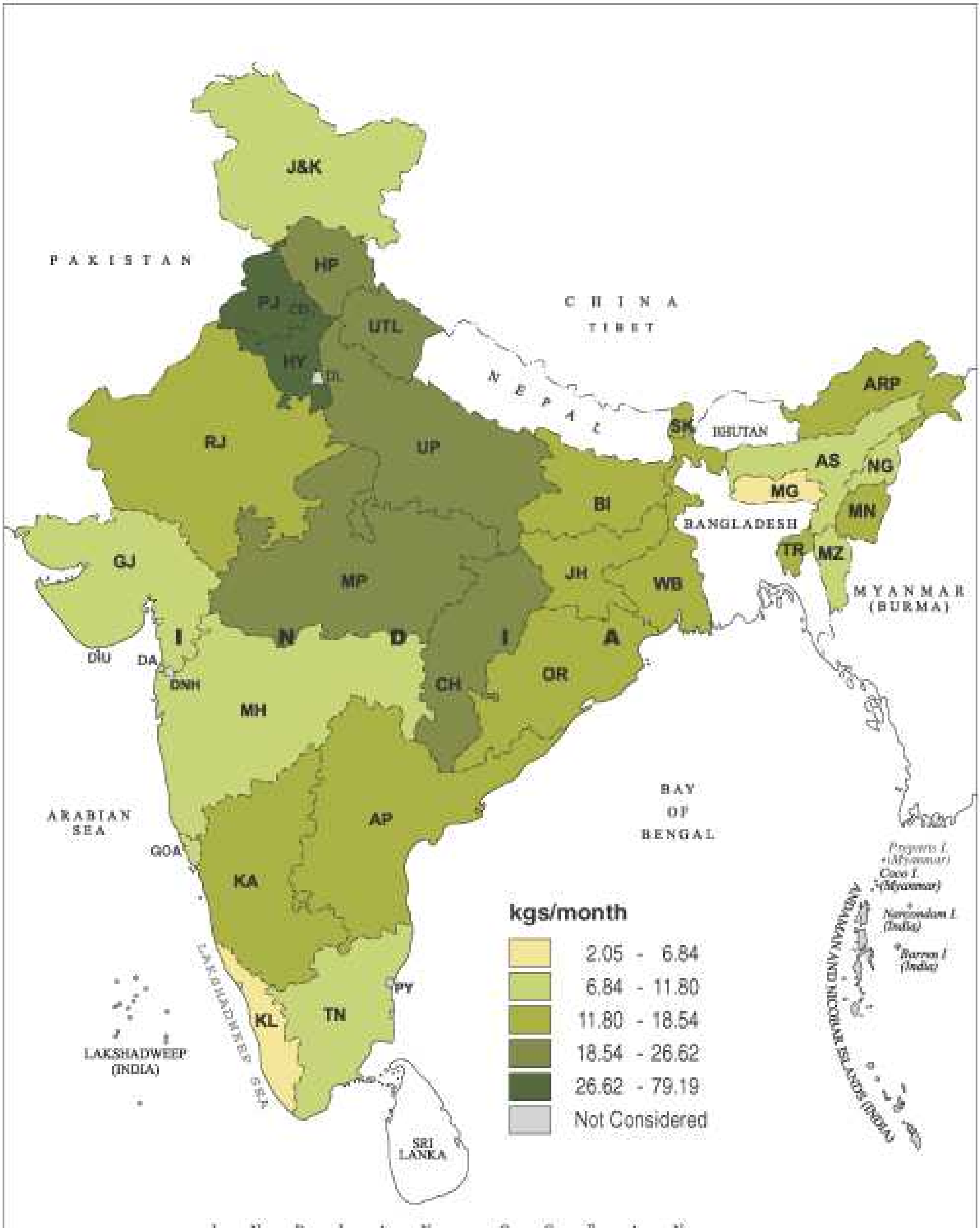
Map No. 2.3

CHANGE IN WEIGHTED FOREST COVER (1987-89 TO 2000)



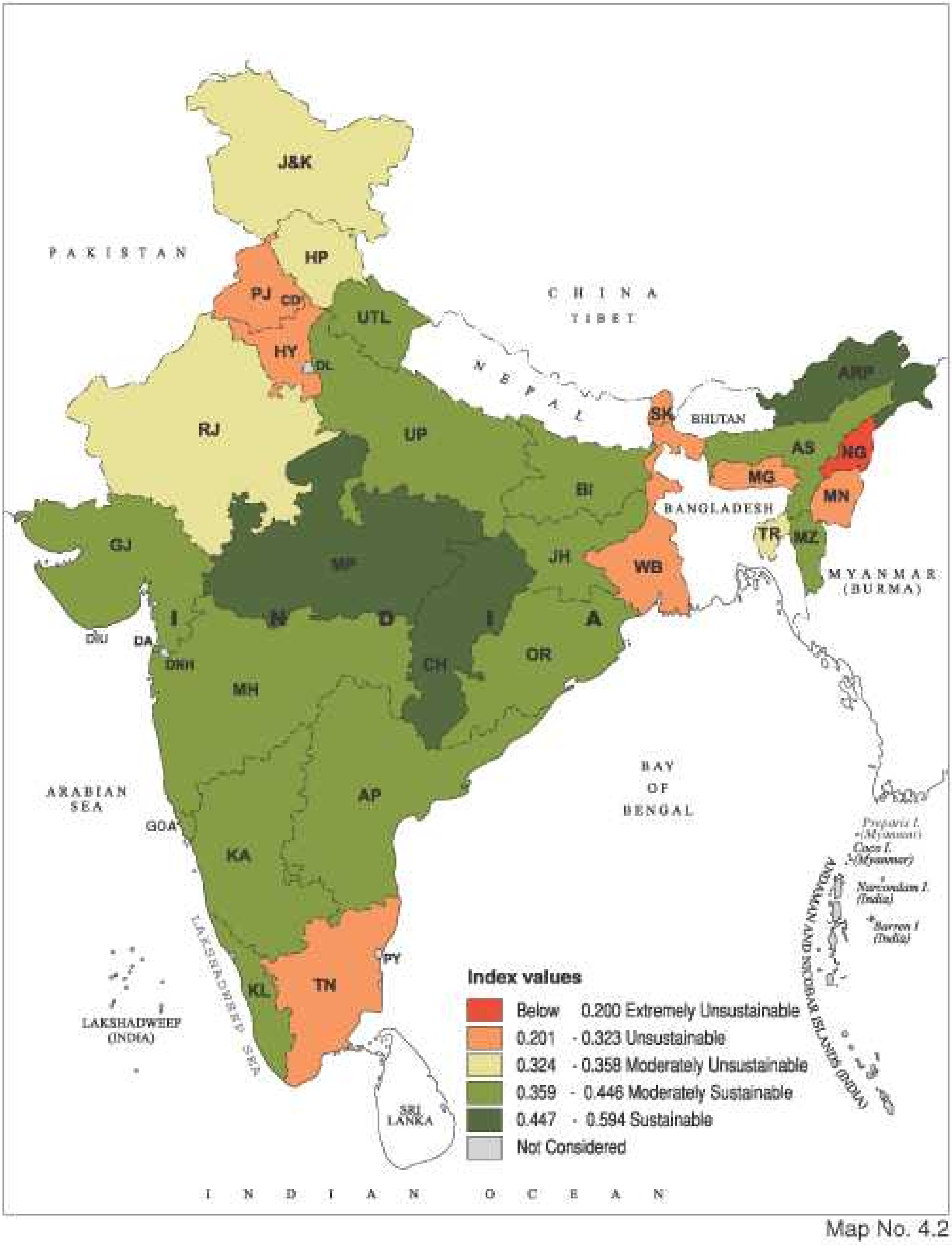
Map No. 2.4

PER CAPITA FOODGRAIN PRODUCTION



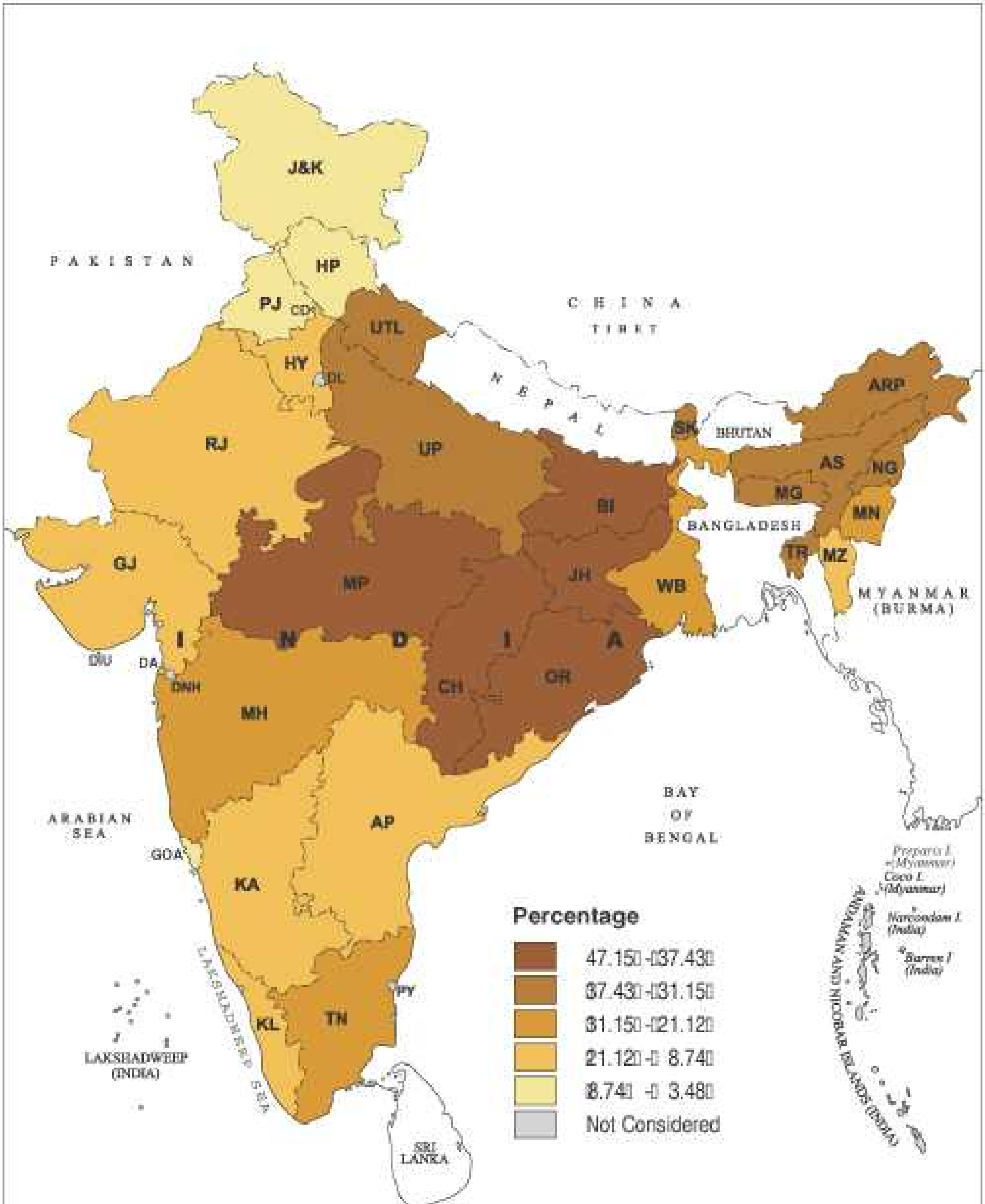
Map No. 4.1

SUSTAINABILITY OF FOOD AVAILABILITY



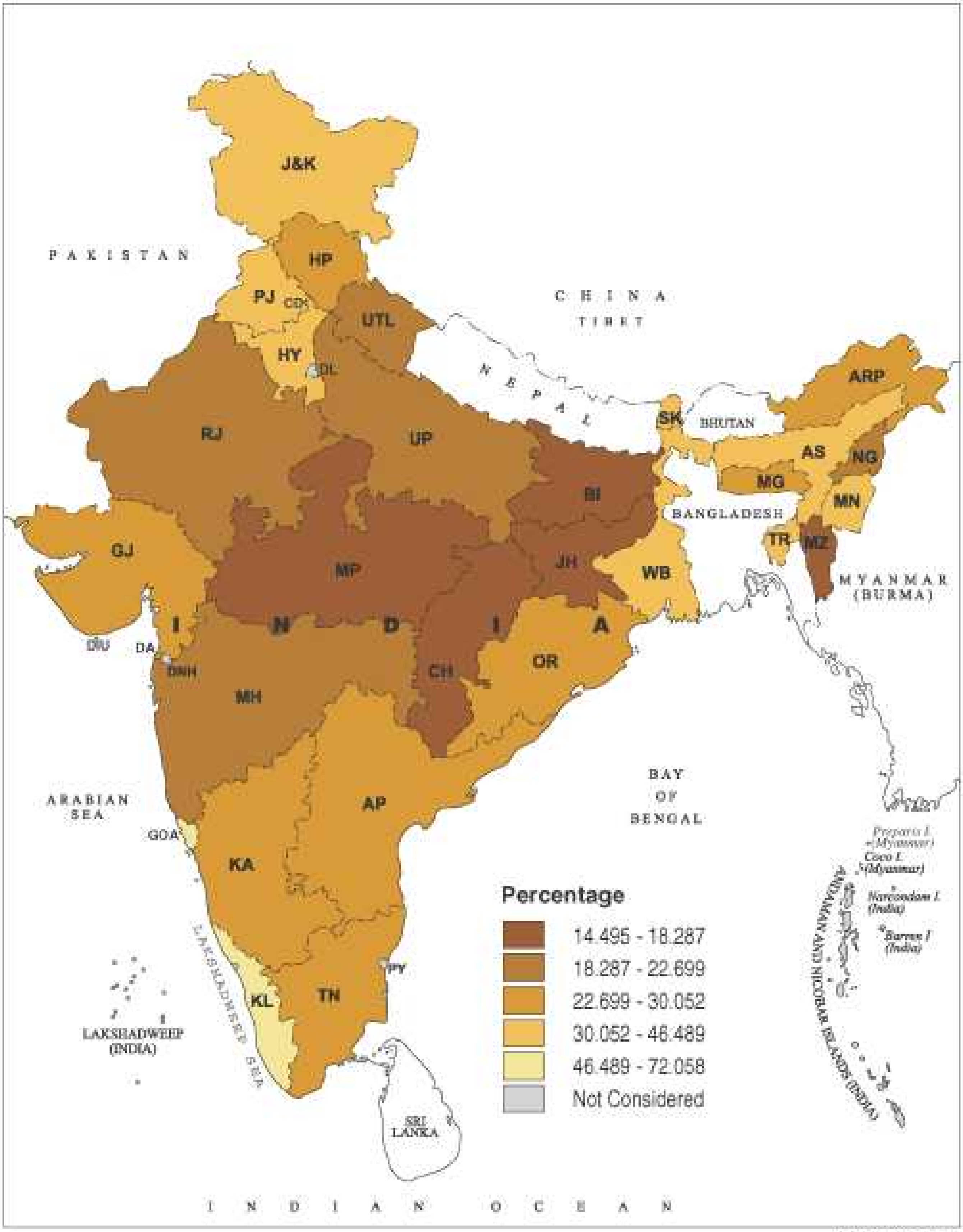
Map No. 4.2

POPULATION BELOW POVERTY LINE



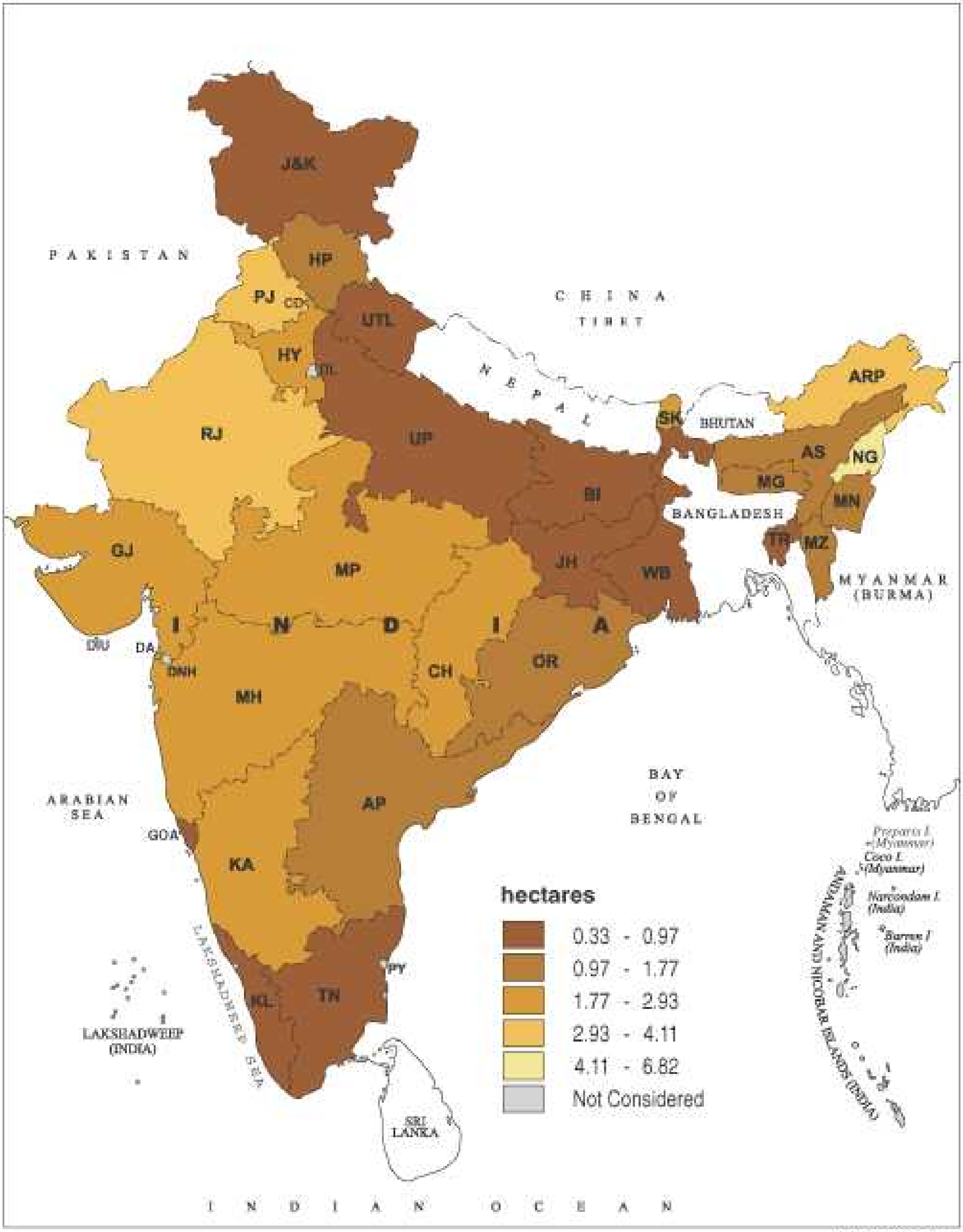
Map No. 5.1

NON-AGRICULTURAL WORKERS TO TOTAL WORKERS



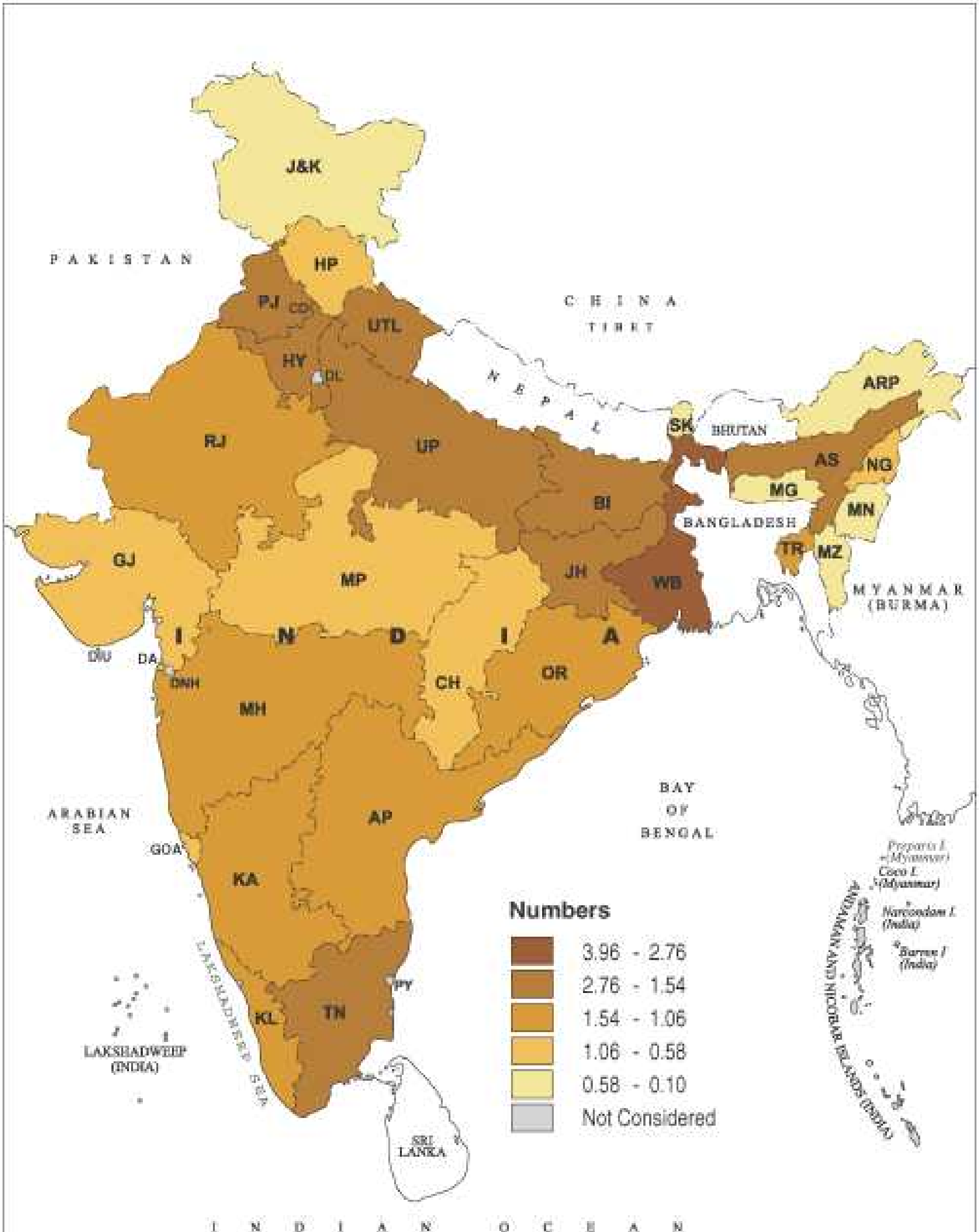
Map No. 5.2

AVERAGE SIZE OF THE LAND HOLDINGS



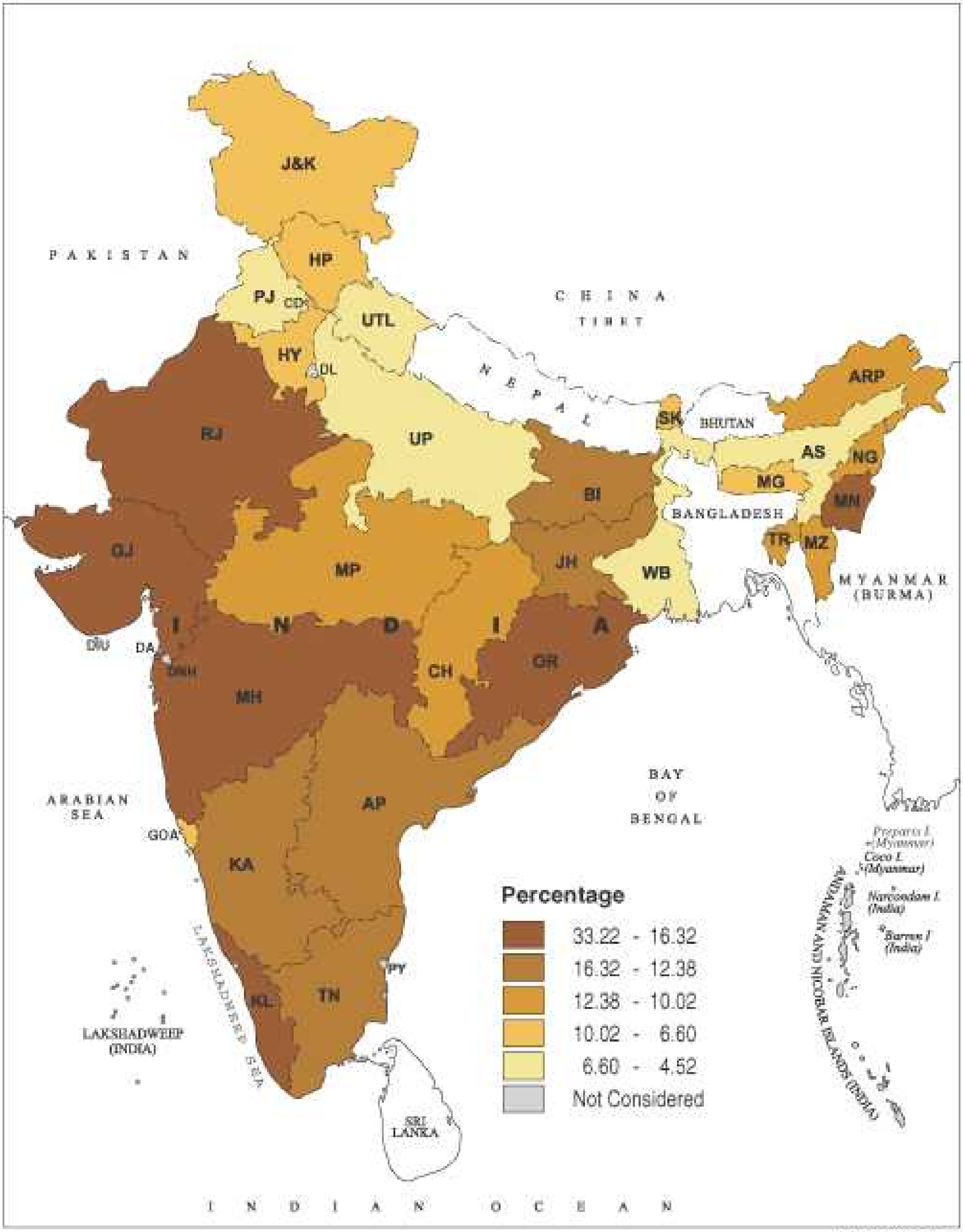
Map No. 5.3

LIVESTOCK POPULATION PER HECTARE



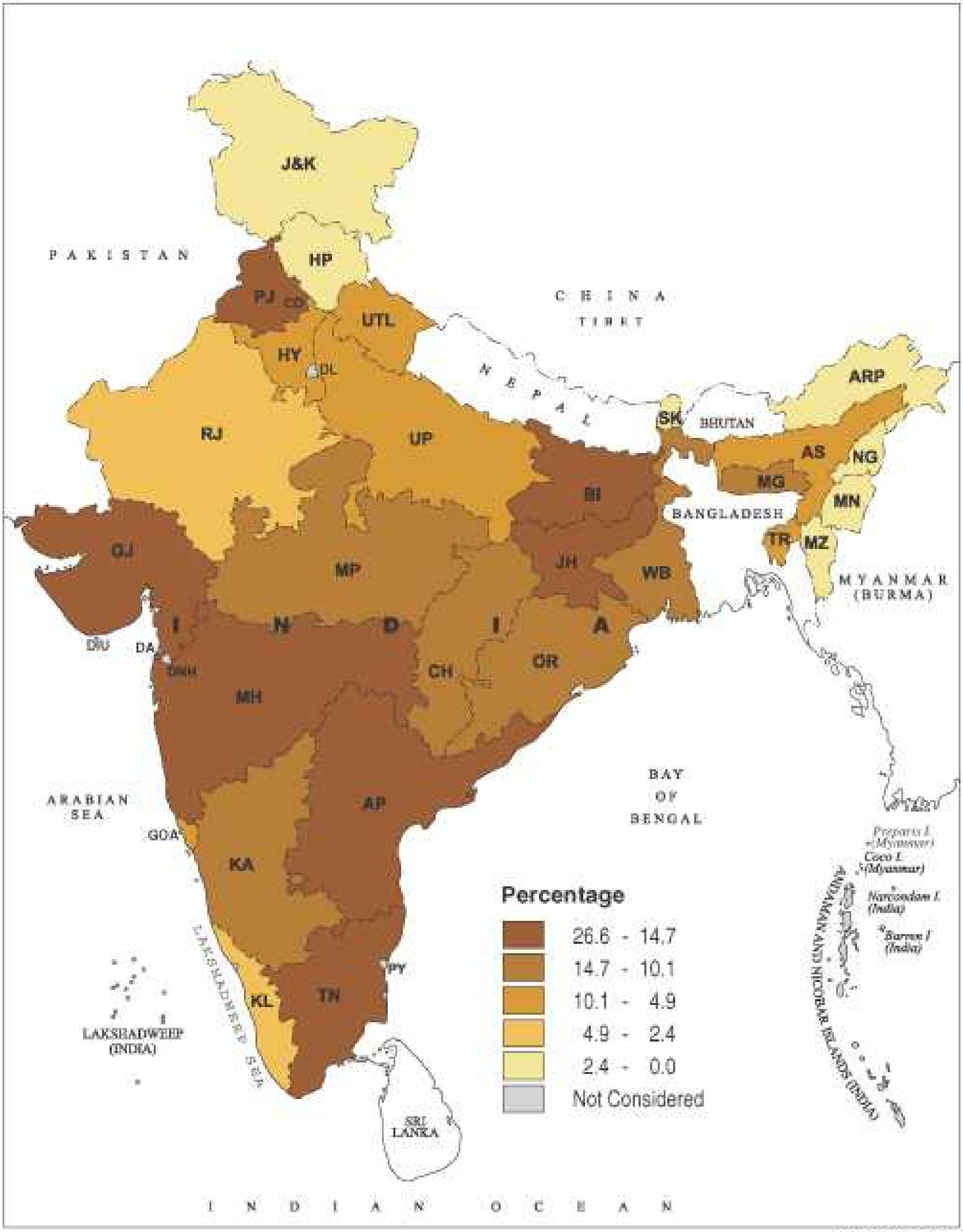
Map No. 5.4

INSTABILITY IN CEREAL PRODUCTION



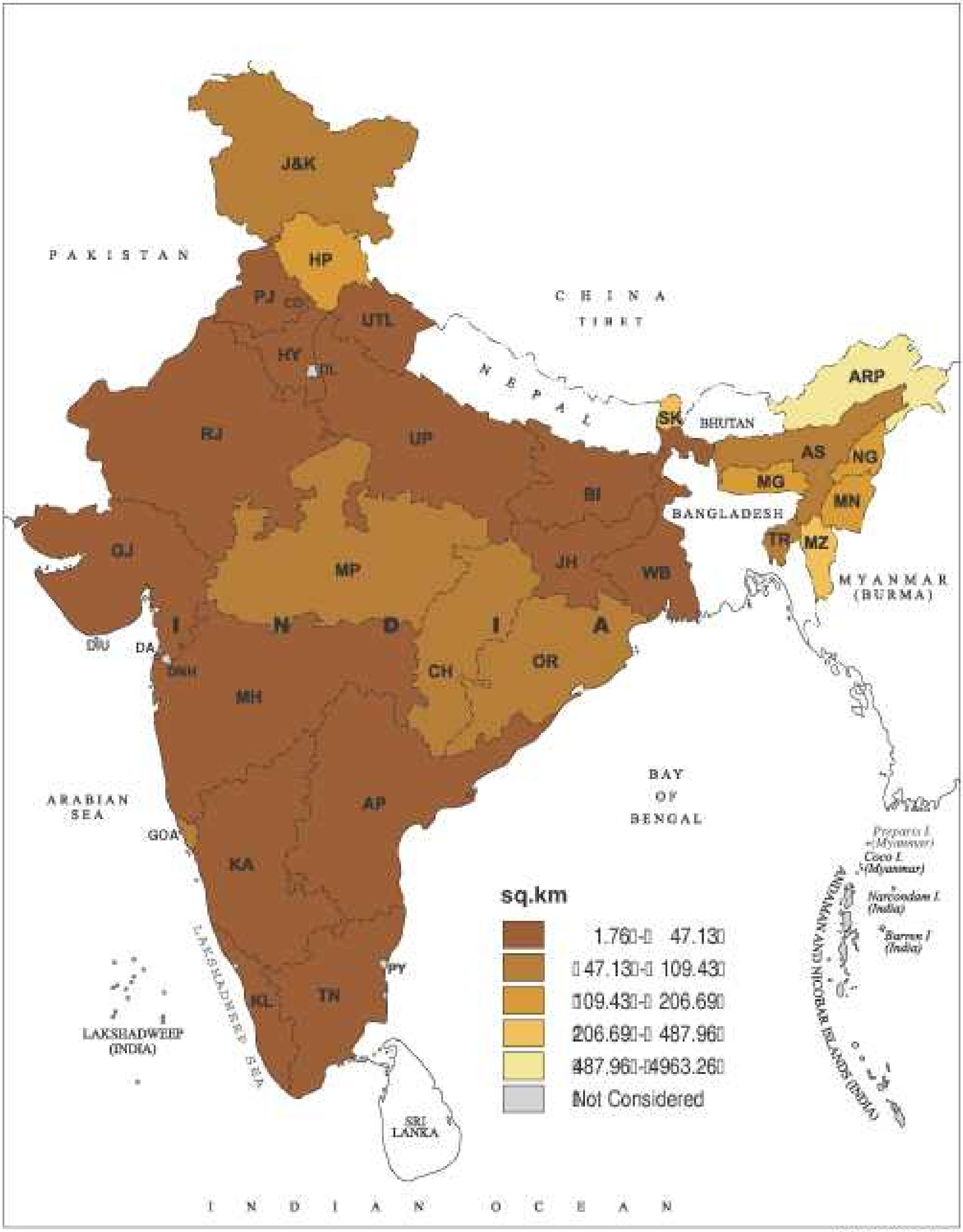
Map No. 5.5

LANDLESS LABOUR HOUSEHOLDS



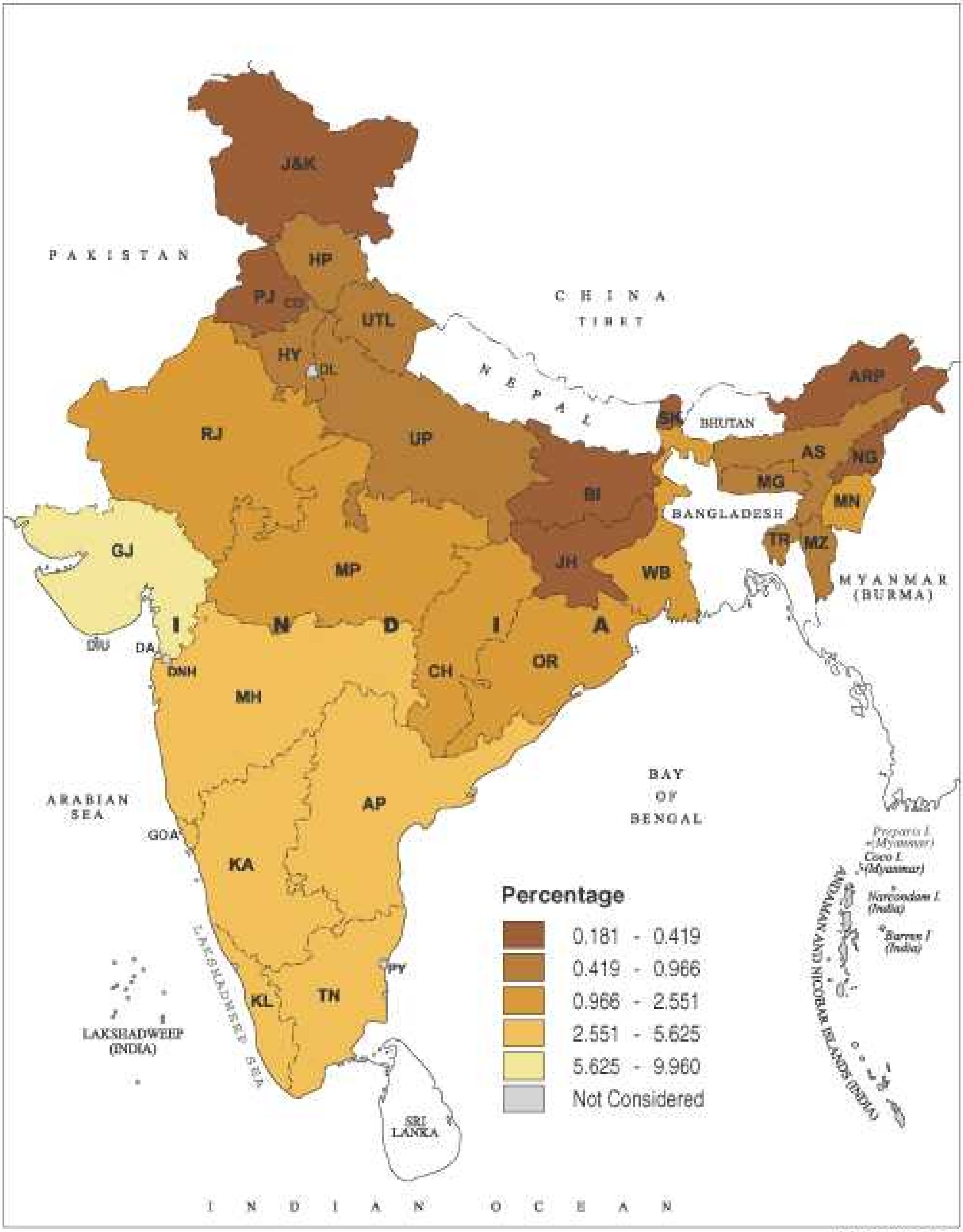
Map No. 5.6

DENSE FOREST AREA PER LAKH PERSONS



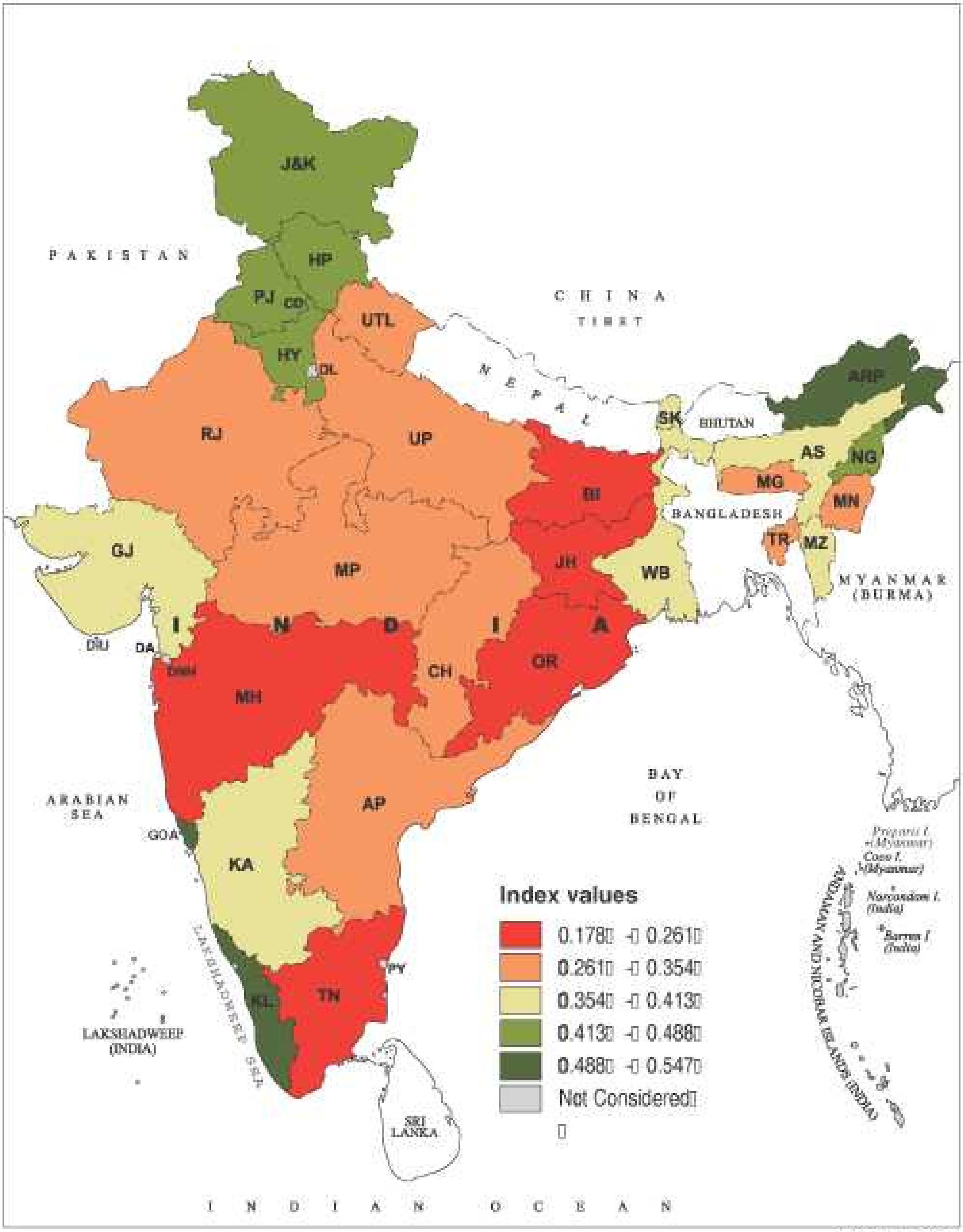
Map No. 5.7

RURAL WORKERS DEPENDENT ON NON-CROP AGRICULTURE ENTERPRISES



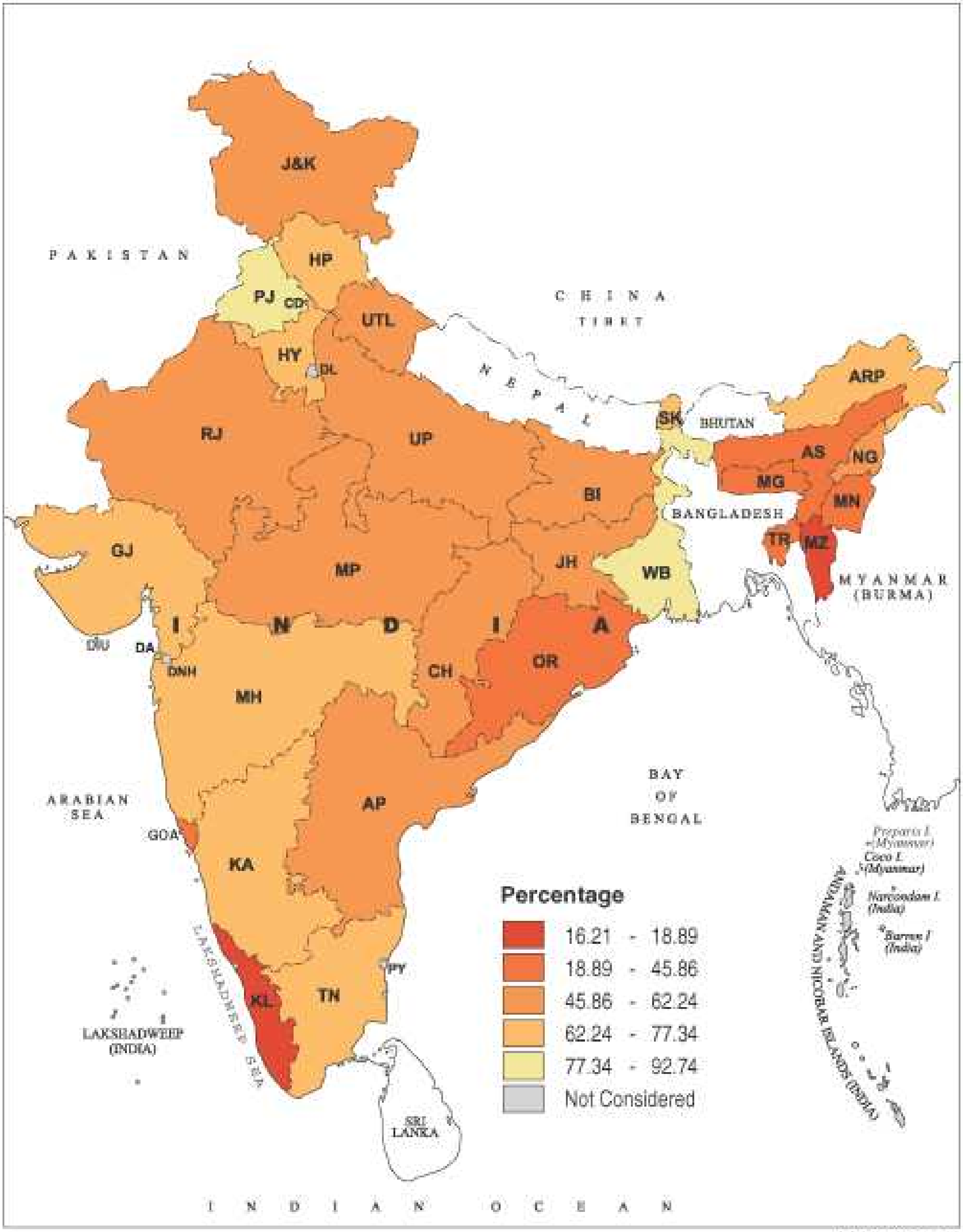
Map No. 5.8

SUSTAINABILITY OF FOOD ACCESS



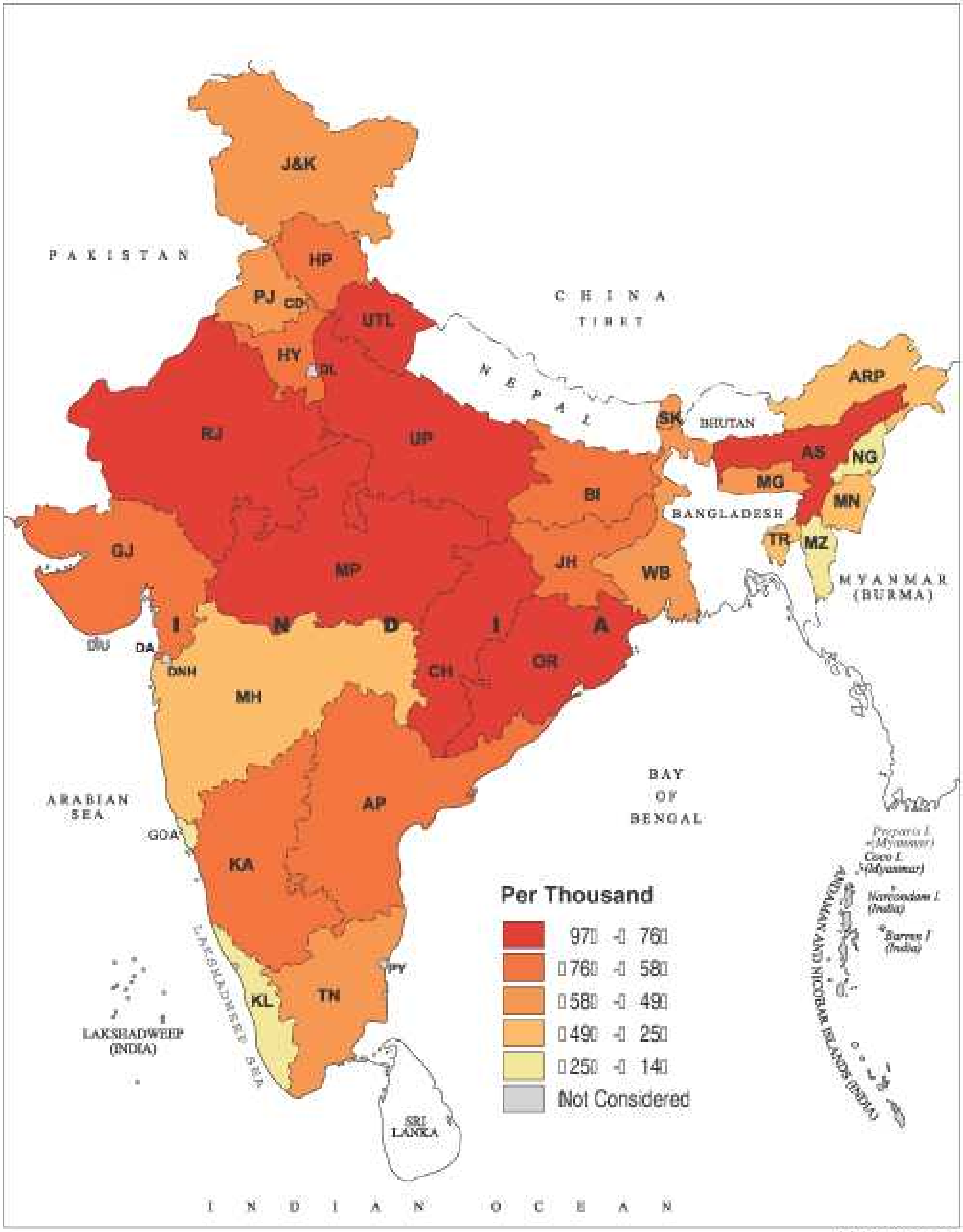
Map No. 6.1

HOUSEHOLDS HAVING ACCESS TO SAFE DRINKING WATER



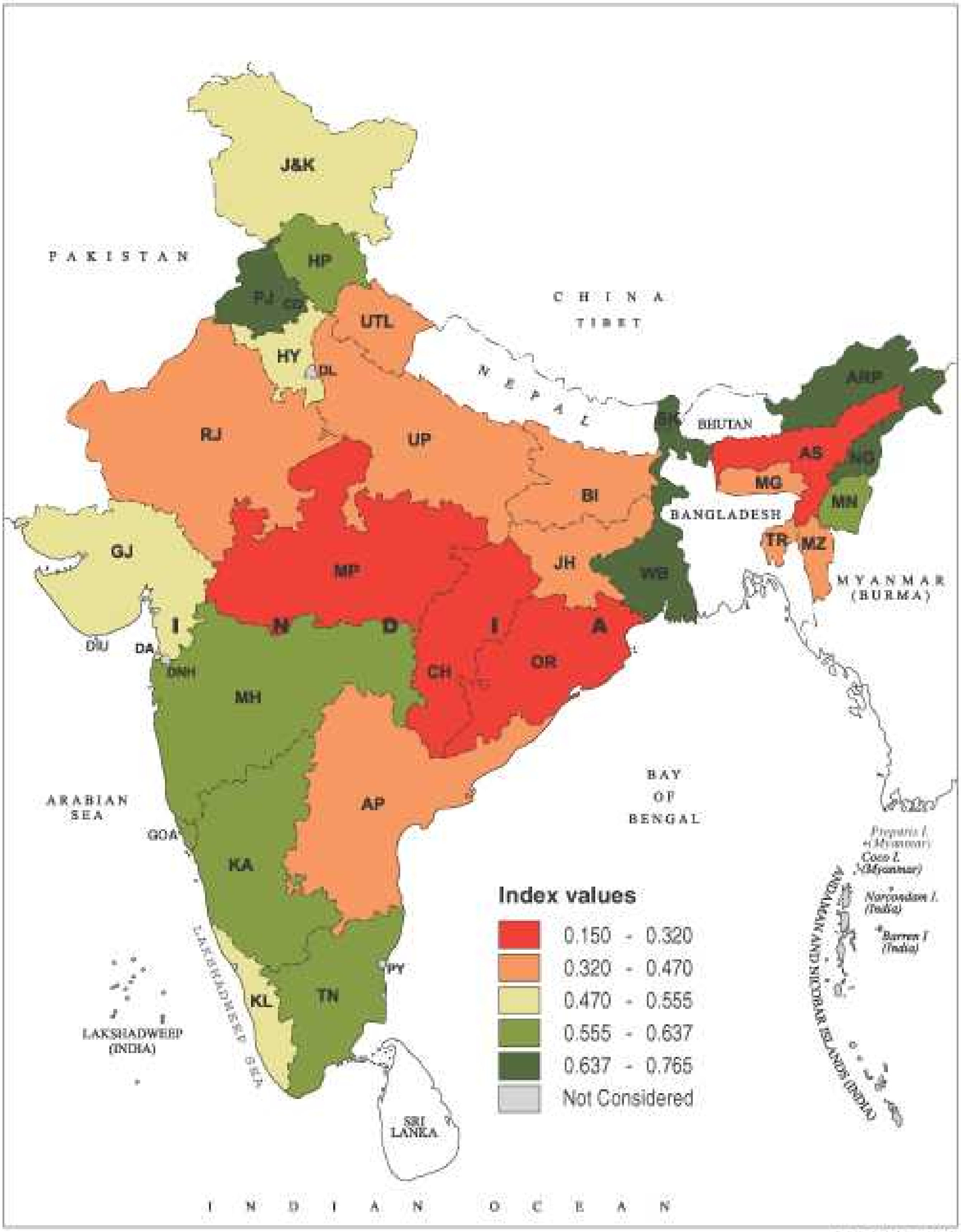
Map No. 7.1

INFANT MORTALITY RATE



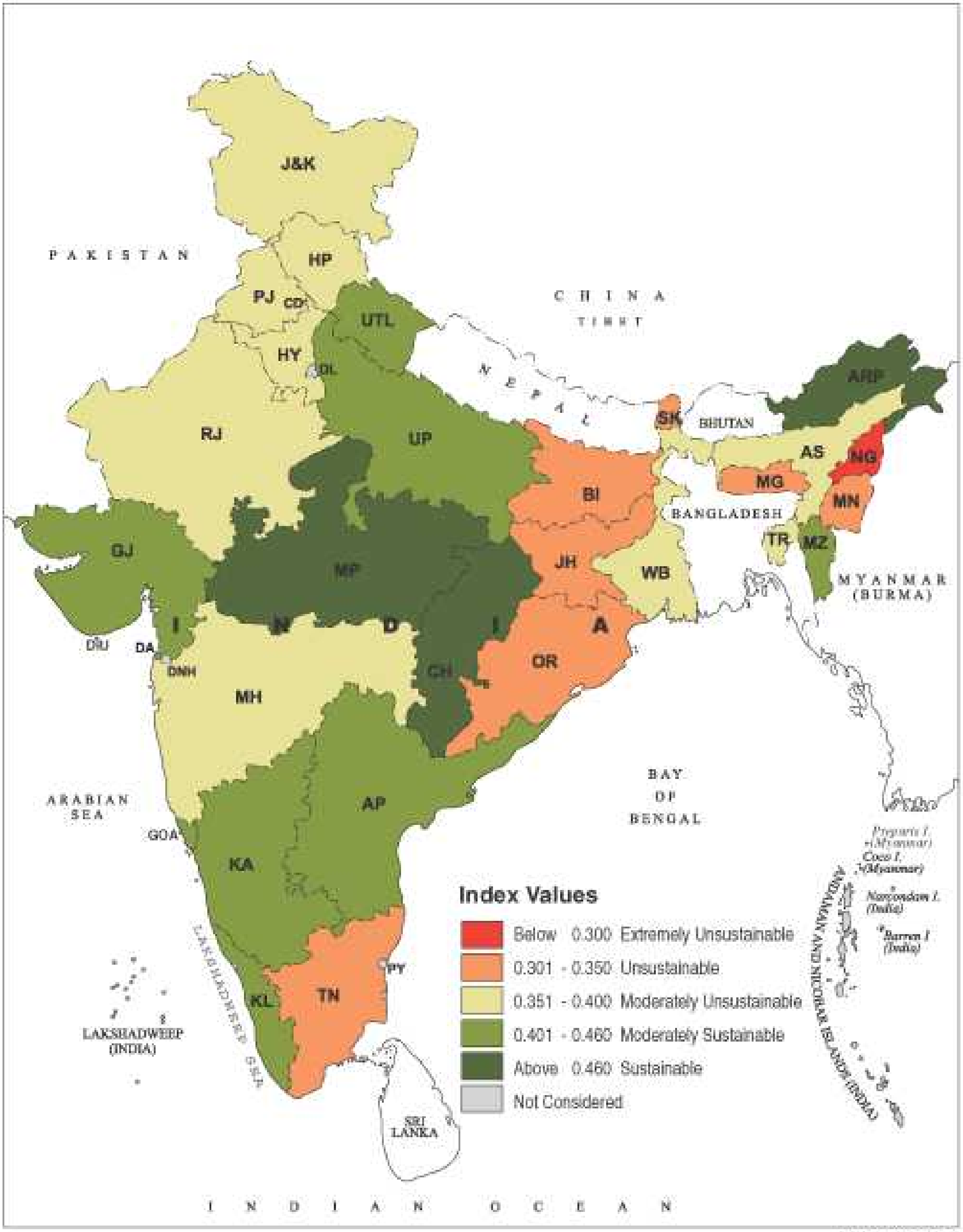
Map No. 7.2

FOOD ABSORPTION



Map No. 7.3

SUSTAINABILITY OF FOOD SECURITY



Map No. 9.1