MONOGRAPH 23/2012

Green Economy – Indian Perspective

K.S. Kavi Kumar
Ramprasad Sengupta
Maria Saleth
K.R. Ashok
R. Balasubramanian

With inputs from
Brinda Viswanathan and Sukanya Das

MSE
Mentoring Excellence

MADRAS SCHOOL OF ECONOMICS
Gandhi Mandapam Road
Chennai 600 025
India

September 2012

Green Economy – Indian Perspective

K.S. Kavi Kumar[1], Ramprasad Sengupta[2], Maria Saleth[3], K.R. Ashok[4], and R. Balasubramanian[4]

With inputs from
Brinda Viswanathan[1] and Sukanya Das[1]

[1] Madras School of Economics, Chennai; [2] Jawaharlal Nehru University, New Delhi; [3] Madras Institute of Development Research, Chennai; [4] Tamil Nadu Agricultural University, Coimbatore

MADRAS SCHOOL OF ECONOMICS
Gandhi Mandapam Road
Chennai 600 025
India

MONOGRAPH 23/2012

September 2012

Rs.200/-

MADRAS SCHOOL OF ECONOMICS
Gandhi Mandapam Road
Chennai 600 025
India

Phone: 2230 0304/ 2230 0307/2235 2157
Fax : 2235 4847 /2235 2155
Email : info@mse.ac.in
Website: www.mse.ac.in

Preface

This study has been commissioned by the Ministry of Environment and Forests, Government of India. The main objective of the study is to assess the scope and relevance of the concept of 'Green Economy' in the Indian context and identify various green economy initiatives in the priority sectors such as Agriculture, Water and Energy. The study was coordinated by Dr. K.S. Kavi Kumar, Professor, Madras School of Economics and included Dr. Brinda Viswanathan, Associated Professor and Dr. Sukanya Das, Assistant Professor as team members. The team also benefited from the advice of Dr. D.K. Srivastava, Director, MSE and Dr. U. Sankar, Honorary Professor, MSE. In addition, three external consultants provided technical inputs to the study, and they are:

- *Dr. K.R. Ashok and Dr. R. Balasubramanian, Tamil Nadu Agricultural University – on green issues related to Agriculture (principal authors of Chapter 5 of this report)*

- *Dr. R. Maria Saleth, Madras Institute of Development Studies – on green issues related to Water (principal author of Chapter 6 of this report)*

- *Dr. Ramprasad Sengupta, Jawaharlal Nehru University – on green issues related to Energy (principal author of Chapter 7 of this report)*

The team members would like express their sincere thanks to Shri Rajneesh Dube, Joint Secretary, MoEF and Shri Vivek Wadekar, Director, MoEF for their support and encouragement throughout the course of this study. The project team would also like to acknowledge the help extended by Shri R.S. Ahlawat, Economic Advisor, MoEF and his colleagues.

The project team would like to acknowledge the Director and Administrative Officer of MSE in facilitating smooth conduct of the project. The secretarial help provided by Ms. Saraswathi is gratefully acknowledged.

K.S. Kavi Kumar
Professor, MSE

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Chapter 1

INTRODUCTION AND CONTEXT

In the run-up to the Rio+20 conference of the United Nations on Sustainable Development 2012, a lot of attention has been being paid to the notion of 'Green Economy'. One of the conference themes was on, 'Green Economy in the context of Sustainable Development and Poverty Eradication' (GESDPE). The UNEP has recently brought out 'The Green Economy Report' (GER) that attempted to synthesize the research done as part of the Green Economy Initiative. The GER defines a green economy as, "one in which the vital links between economy, society, and environment are taken into account and in which the transformation of production processes, production and consumption patterns, while contributing to a reduction per unit in reduced waste, pollution, and the user of resources, materials, and energy, waste and pollution emission will revitalize and diversify economies, create decent employment opportunities, promote sustainable trade, reduce poverty, and improve equity and income distribution".

Despite being a multi-country initiative, there are apprehensions that the UNEP report still reflects the 'carbon-centric' approach to green economy and hence may not clearly articulate the perspectives of developing countries like India. It is in this context it is important to reflect on what should be India's perspective on green economy. Given the urgent development priorities it is important that the Indian perspectives on green economy must integrate the social and equity issues with the environmental issues.

While the green economy concept could in general be connected with almost all sectors of the economy, for the purpose of this study the focus has been on three crucial sectors of importance, (a) agriculture, (b) water, and (c) energy. In addition the report also discusses the issues related to interventions in the context of environmental management in India and ushering green construction practices as India prepares to meet its rapidly growing construction demands.

The report is structured as follows: The second chapter attempts to provide a comprehensive perspective on defining green economy and connects it with other similar concepts. The following chapter discusses India's national circumstances and policy priorities. The issues related to growth and development implications of green economy and integration of green economy with poverty eradication are discussed in the fourth chapter. The fifth to eighth chapters provides sector-wise discussion on scope and potential for green economy initiatives with focus on agriculture, water, energy, and other sectors (including environment and construction sectors), respectively. In an attempt to summarize the main issues associated with green economy the ninth chapter presents a SWOT analysis of green economy and discusses India's position in the international negotiations on green economy.

Chapter 2

DEFINING 'GREEN ECONOMY'

For a variety of global concerns like the problems faced in the climate change negotiations, need for creation of 500 million more jobs by 2020, or even responses to financial collapse, green economy is increasingly seen as an effective answer. It is important however to ensure that the green economy debate does not lead to, (i) gains for elite only (e.g. rich countries and/or large corporates), (ii) green protectionism and anti-growth, and (iii) sidelining of useful sustainable development concepts and strategies. It is against this backdrop this section outlines the definitions of 'green economy' that currently dominate the global discourse along with potential criticisms. At the outset it must also be noted that some have argued against spending further effort on defining green economy (Khor, 2011), suggesting instead to focus on understanding what is not green economy. Nevertheless it will be worthwhile to trace the historical developments in the conceptualization of green economy and highlight the current understanding.

2.1 Historical Background and Conceptual Evolution

While the concept of sustainable development has been interpreted in varied ways in a wide range of contexts of development policies and forums world-wide, most of these interpretations have taken their starting point as the definition which was arrived by consensus at the World Commission on Environment and Development (WCED) in 1987. This definition states that sustainable development process is one which meets the needs of the present generation without compromising the ability of future generations to meet their own needs. This definition is rather broad, but its prime focus was on intergenerational equity. Its obvious implication in terms of resource use has been that the development process has to ensure such use of resources of man made capital, human capital, and natural capital in the current period that the present generation leaves behind in quantity and composition such an endowment of resources for the next generation that the latter could have access to the same opportunities and amenities of the level of living.

So far as the content of development is concerned the development economists have elaborated the concept in different ways depending on the priorities among issues of the concerned area in such context of sustainability. However, it has also been agreed that the sustainability of a development process would require three basic conditions to be fulfilled:

(a) Macro-economic growth process should be strong and sustainable and policies based on sound macro-economic fundamentals.

(b) The growth process should be socially sustainable, that is based on the principle of social inclusiveness and participation of all sections of people in the development process so that poverty, unemployment, illiteracy, hunger and diseases can be eradicated and certain norms of social equity and for a just society can be achieved.

(c) The process of economic growth should involve such use of natural resources and capacity of the ecosystem to provide eco-services and natural resource supply that there is no net erosion of eco-capacity.

However, the above three kinds of consideration of economic efficiency in macro-economic allocation of resources, social equity and environmental sustainability are very likely to be conflicting with each other whenever an actual agenda of development comes up for implementation. For example, as the geographical and geological map of coal and mineral resources and that of forests overlap to a large extent in India, the environmental clearance becomes a conflicting issue for mineral and energy development. It would be ideal if there exists such a strategy and a path of development which find the fulfillment of the above three objectives not to be competing or conflicting with each other, but have relations of complementarities. It is, however, not so easy for a country to find out such a strategy of development. It is therefore important to find a balance of considerations of the above objectives of macroeconomic growth, social equity and environmental sustainability of the development process while making a choice for the development strategy and policies. Such balancing is in fact a challenging task. The concept of Green Economy and green development has emerged out of such efforts of balancing alternative sustainability considerations for development.

In spite of the fact that considerations of social equity and environmental sustainability and the complementarity between the two figured importantly in the debates and discussions of the earth summits at Rio de Janerio in 1992 and the Johannesburg in 2002, it remains the fact that the global economy based on the current patterns of consumption and production and use of natural resources in both the developed and the developing world have imposed heavy strain on the ecosystems of the different parts of the world resulting in the erosion of the bio-capacities and environmental degradation. On the other hand, extreme poverty still persists in many parts of the world in spite of the fact that the world GDP increased by more than 60% since 1992 and the process of globalization benefited some, but not all in the global development process. It should be noticed in this connection that the dominant ideology of the world as replicated in actions reveal the following:

1. The sustainability as defined by the world commission has been interpreted to be placing much greater emphasis on inter-generational equity than on intra-generational equity.
2. As a consequence of (1), in all discussions on global change, the climate change issue has dominated over other social cum environmental issues of national level importance having important global economic implications and policy ramifications.
3. The discussions on climate change related policy issues have been mostly carbon centric having serious constraining implications on the growth process of the developing world and social equity.
4. The sustainability as defined by the world commission has also been interpreted more in the spirit of weak sustainability than strong sustainability, presuming that effects of erosion of natural capital can be offset by the development of new kind of knowledge and man made capital and discovery of alternative resources so that the development of human well-being can be sustained over time. The tremendous technological progress of the twentieth century and the emergence of new (endogenous) growth economics has provided the basis for such optimistic faith.
5. The presumption of substitutability between man made and natural capital is valid only over a limited range of erosion of natural capital. While natural capital has been abundant in some of the developing economies, the man made capital machinery, buildings and structure as well as human capital need often to be developed in most of the developing countries. However, this often has involved conversion of natural capital into these other forms of capital although there has remained substantive scope of conservation of natural resources through increasing efficiency gains due to technical progress. There is also at the same time now a growing recognition of the existence of environmental threshold which would constrain such conversion of natural capital as these are also needed for the development of human welfare for their critical role of life support.

6. It may further be noted in this connection that while ecosystems may be conceived like capital assets which depreciate if they are overused or misused, but unlike the reproducible assets, their depreciation beyond a level is irreversible or it may take a long time for the ecosystem to recover. It may even not be possible to replace a degraded ecosystem by a new one even with some human investment of energy and capital. Besides, there are risks for an ecosystem to collapse without giving any warning if the erosion of bio-capacity has exceeded some threshold which may not always be known prior its exact happening.

7. As the eco-capacity of ecosystems get eroded and irreversibly lost the eco-services in the forms of supply of fresh water, soil conservation, water purification and waste treatment by nature, pollination and control of pests and natural hazards, genetic and other biochemical resource supply etc. most of which are non-marketed eco-services, become scarcer. As a result of such growing scarcity it is the poor and economically under-privileged class who would often suffer most from the deprivation of benefit from such eco-services. As many of such eco-services are accessed by the poorer sections of the population through the common resources of the marginal or degraded land and forests, dry land or upland, land with water stress and vulnerable to climatic or ecological disruption, the growing eco-scarcity results in their erosion of income and affect their livelihood security. The poor then tend to overuse their already degraded common resources and further aggravate the problem of scarcity of eco-services resulting in serious problems for ensuring their sustainable livelihood in a highly populated country like India.

It is thus in the background of the relative neglect of the considerations of social equity and irreversibility of the loss in eco-capacity beyond a threshold level, that the concept of green economy has emerged further qualifying the concept of sustainable development to characterize an economy. The UNEP has defined green economy as one that results in an improved human well-being and social equity while significantly reducing environmental risks and ecological scarcities (see below for more details on the UNEP definition of the green economy). This would imply the development process to be low carbon, resource efficient and socially inclusive. Such development process would be driven by investment on both public and private account that would reduce carbon and other pollution emissions, improve efficiency of resource use or resource conservation in production and consumption and significantly abate loss of bio-diversity and ecosystem services. These investment funds should be so deployed as to generate at the same time income and employment in the economy as to ensure eradication of poverty and an equitable sharing of the benefits of growth. A green growth process is thus to target such transition of an economy which will eliminate as far as possible the trade-offs between economic growth and gains in environmental quality or social inclusiveness so as to strike a balance among all these three aspects of the development process.

So far as the issue of greening the development process is concerned, it is the emphasis on the conservation of eco-capacity which is determined by the primary productivity of the ecosystems that deserves special attention here. The pressure that is created by the human economy on the environment for the supply of the resources of food, fiber, timber and non-timber forest products, supply of minerals, etc. and absorption of carbon dioxide and other types of wastes, can be measured by what is called Ecological Footprint which is the requirement of biologically productive area in terms of crop land, pasture, forests, fisheries land for built up construction and finally carbon up take land. The carbon uptake land represents in a given year the forest area required for the balance of CO_2 emissions not absorbed by forests, ocean and soil but accumulating in the atmosphere. If the totality of requirement of land use exceeds bio-capacity of land area of a country then the gap between the two called ecological deficit – would represent the measure of ecological degradation of the earth.

However, a country can import or export commodities or resources from or to another country. The bio-capacity in terms of land use area required for the net import of a country would have to be added to obtain the ecological footprint of the total consumption of an economy. However, it has to be noted that bio-productivity varies both across land use and across countries. The methodology of calculation of such footprint involves use of yield factors for normalizing the bio-productivity of a particular land use in terms of world average for that particular use and also an equivalent factor which brings in alternative land uses in terms of equivalent primary crop land requirement at global average productivity of crop land. The total ecological footprint per capita and the bio-capacity of such different types of land as estimated shows that the world as a whole had an ecological deficit of 0.9 global hectare per capita in 2007. Besides, out of the total ecological footprint of 2.7 hectares per capita in that year the share of carbon uptake footprint had been more than half i.e., 1.41 hectare per capita. It may be noted that India had faced an ecological deficit of 0.5 global hectares per capita and out of her total ecological footprint of 0.9 hectare, the share of carbon footprint has been about one third i.e., 0.33 hectares. Even the total carbon footprint of the world has been very unevenly distributed across the countries. The per capita carbon footprint of USA had been 6.51 global hectares while that of India and China had been 0.33 hectare and 0.13 hectares respectively (see Table 2.1).

The total per capita ecological footprint of the world increased in global hectare from 7.0 in 1971 to 17.4 in 2005, while the bio-capacity increased from 13.0 in 1961 to only 13.4 in 2005, causing the ratio of per capita ecological footprint to bio-capacity ratio to increase from 0.54 in 1971 to 1.31 in 2005, the overshoot taking place sometime around 1990. However, the dominant share of carbon footprint in the total ecological footprint has drawn much greater attention to the issue of carbon emission due to the burning of fossil fuel and was projected it to be the central concern for the stress on the eco-capacity of the world. However, this gives a biased carbon centric impression of ecosystem's degradation. Table 2.1 shows apparently no deficit of bio-capacity to meet the human requirement of cropland, pasture land, fishing ground, built up area and even forest area for all purposes other than that of carbon uptake. This however does not mean that the product markets of goods and services produced out of the supplies from such land use have all been in equilibrium. As there exists dualism in the development process with growing disparities between the rich and the poor in spite of the process of globalization, it remains a fact that millions of the poor are marginalized in some of the product markets of essential commodities. It is the deficiencies in the supply and distribution of many of the life support requirements like those of food, fodder, fiber and shelter for the poor which result in the existence of malnutrition, illiteracy, homelessness, etc. just as global warming is an expression of non-availability of bio-capacity of land for sufficient carbon uptake.

Table 2.1: Ecological Footprint and Biocapacity of Various World Regions, 2007

Regions/ Countries	Population (million)	ECOLOGICAL FOOTPRINT (global hectares per capita)							BIOCAPACITY (global hectares per capita)						Ecological (Deficit) or Reserve
		Total Ecological	Cropland Footprint	Grazing Footprint	Forest Footprint	Fishing Ground	Carbon Footprint	Built-up Land	Total Biocapacity	Cropland	Grazing Land	Forest	Fishing Ground	Built Land	
World	6.476	2.7	0.64	0.26	0.23	0.09	1.41	0.07	2.1	0.64	0.37	0.81	0.17	0.07	(0.6)
High Income Countries	972	6.4	1.15	0.28	0.61	0.17	4.04	0.13	3.7	1.42	0.33	1.20	0.58	0.13	(2.7)
Middle Income Countries	3.098	2.2	0.62	0.22	0.16	0.09	1.00	0.08	2.2	0.62	0.40	0.83	0.23	0.08	0.0
Low Income Countries	2.371	1.0	0.44	0.09	0.15	0.02	0.26	0.05	0.9	0.35	0.28	0.13	0.07	0.05	(0.1)
China	1323.3	2.1	0.56	0.15	0.12	0.07	0.13	0.07	0.9	0.39	0.15	0.16	0.06	0.07	(1.2)
India	1103.4	0.9	0.40	0.01	0.10	0.01	0.33	0.04	0.4	0.31	0.01	0.02	0.04	0.04	(0.5)
Japan	126.1	4.9	0.58	0.04	0.24	0.28	3.58	0.08	0.6	0.16	0	0.27	0.06	0.06	4.3
North America	330.5	9.2	1.42	0.32	1.02	0.11	6.21	0.10	6.5	2.55	0.43	2.51	0.88	0.10	2.7
Canada	32.3	7.1	1.83	0.50	1.00	0.21	3.44	0.09	20	4.89	1.80	9.30	3.96	0.09	13.0
USA	298.2	9.4	1.38	0.30	1.02	0.10	6.51	0.10	5.0	2.30	0.29	1.78	0.55	0.10	(4.4)
Europe (EU)	487.3	4.7	1.17	0.19	0.48	0.11	2.58	0.17	2.3	1.00	0.21	0.64	0.29	0.17	(2.4)

Source: Global Footprint Network 2008, www.footprintnetwork.org.

The data on ecological footprint would therefore be of limited significance for assessing resource adequacy for a green development process. While prevention of erosion of eco-capacity would require reduction in the size of the different types of footprint, the process of inclusive development and eradication of poverty would give rise to growing competing demand for land use for the various purposes like agriculture, watershed development, and pasture or land for growing fodder for livestock raising which constitutes the main capital stock of the rural poor. As industrialization and development of infrastructure are of crucial importance for raising labour productivity, employment and income for removing poverty the demand for built up use of land is also likely to grow at the cost of other land uses. While large carbon footprint may immediately warrant the high priority of expansion of forest area for stepping up the rate of carbon sequestration from the atmosphere, the other competing demand for land use for inclusive growth process would deserve attention for a proper strategy of balanced land use for green growth. Such green growth has to combine the conservation or development of eco-capacity with eradication of poverty and ensure social equity in the development process.

2.2 UNEP Green Economy Initiative

A green economy is typically understood as an economic system that is compatible with the natural environment, is environmentally and ecologically friendly and perhaps is also socially just. These attributes are the conditions that must be imposed on an economy from the perspective of many green economy advocates. This *conventional* concept of a green economy may be alternatively described as "the greening of an economy". Some fundamental criteria for meeting these conditions have been established since Rio, such as using renewable resources within their regenerative capacity, making up for the loss of non-renewable resources by creating their renewable substitutes, limiting pollution within the sink functions of nature, and maintaining ecosystem stability and resilience. Conditions for social justice may include: 1) not compromising on future generations' capability to meet their needs; 2) the rights of poor countries and poor people to development and the obligations of rich countries and rich people to changing their excessive consumption levels; 3) equal treatment of women in access to resources and opportunities; and 4) ensuring decent labour conditions. Additionally, issues of good governance and democracy are also seen as critical for ensuring social justice and equity.

Less understood but should be of a much greater interest is that green economy as an economic system is dominated by investing in, production, trade, distribution and consumption of not only environmentally friendly but also environmentally enhancing products and services. In this sense, many green conditions such as those listed above should no longer be seen as constraints on an economy; instead, they should be regarded as forces that generate new economic opportunities.

This is about expanding and reshaping, not reducing, the space for economic development and poverty reduction. The way this *modern* concept of a green economy is described above seems consistent with the way in which other major types of an economy are described: 1) an agrarian economy ("an economy which relies on farming."); 2) an industrial economy ("an economy dominated by manufactured goods"); 3) a service economy ("an economy dominated by services rather than products"); and 4) a knowledge economy (an economy "based on the production, distribution, and use of Knowledge as the main driver of growth, wealth creation, and employment across all industries"). Similarly, a green economy is one dominated and driven by the demand for, and supply of, environmentally friendly and environmentally enhancing products and services, which in turn safeguard and enhance human well-being. A defining indicator of a green economy, accordingly, is the share of environmentally friendly and environmentally enhancing products and services as a whole in total output and employment. The Green Economy Initiative launched by the United Nations Environment Programme in October 2008 was aimed at seizing the opportunities this modern concept of a green economy has to offer. It seeks to accomplish two tasks. First, it tries to make a "beyond-anecdotal" macroeconomic case for investing in sectors that produce environmentally friendly or environmentally enhancing products and services ("green investment"). By a "macroeconomic case", it mainly refers to the contribution of green investment to output and job growth. Second, the initiative tries to provide guidance on how to boost pro-poor green investment. The goal is to encourage and enable policymakers to support increased green investment from both the public and private sectors. The initiative consists of a range of research and advisory products and services to be delivered in partnership with organisations within and beyond the United Nations System.

This modern concept of a green economy complements and expands the other, more familiar concept of a green economy which subjects an economy to green requirements. Subjecting an economy to green requirements with various policy tools such as environmental pricing and standards is no longer pursued only as a punishment for environmentally negative behaviors; importantly it also serves to incentivize economic agents to produce, trade and consume environmentally friendly or environmentally enhancing products and services. The income and jobs generated through a green economy, in return, are expected to further motivate economic agents to subject their activities to environmental requirements. This instrumental perspective of the modern concept recognizes that it is through investments, both public and private, in innovation, technology, infrastructure and institutions that economies shift their course or achieve fundamental structural change.

The UNEP initiative states that 'A green economy implies the decoupling of resource use and environmental impacts from economic growth. It is characterized by substantially increased investment in green sectors, supported by enabling policy reforms'. The first sentence may not be valid for some developing countries in a few situations. For example, in case of India with 8-9 % GDP growth and the goal of providing clean cooking fuel to all households and access to electricity to all households will increase energy demand. What is feasible is to reduce the energy intensity of GDP and greenhouse emission intensity of GDP via policies such as energy conservation and transition to low carbon growth path. Reduction of resource/material intensity especially by micro, small and medium enterprises is feasible if India can get access to cleaner, environment-friendly and material savings technologies from developed countries on concessional terms. Further, some important infrastructural projects like irrigation, mining and roads may be needed even when they cause some damage to the ecosystem. What is needed is a conscious analysis of the trade-offs between economic growth and environment based on social cost benefit analysis with built-in provisions for rehabilitation and creation of livelihoods opportunities for the affected population and compensation for afforestation/ offset provisions. If the damage is of irreversible nature or the particular ecosystem has incommensurable values then its preservation is the only option.

Similarly the policy suggestion of "getting prices right" can be a long-term policy objective. In the short run, achievement of goals such as providing access to clean energy for all and providing food security for the poor necessitate provision of these goods at low cost. The challenges are targeting the subsidies only to the poor through unique identification cards and phasing out the subsidies over time. The point is that the trade-offs and synergies among policies are country-specific and design of such policies need to be made by the countries based on their national circumstances and policy goals.

Furthering this framework, the UNEP Paper notes that 'it is counter-productive to develop generic green economy indicators applicable to all countries given differences in natural, human and economic resources. Rather, focusing on the process of making the transition to a green economy acknowledges that countries will take many diverse paths in achieving this objective, and that a green economy in one country may look quite dissimilar to a green economy in another country'. Such position should be agreeable to countries like India.

2.3 How Does 'Green Economy' Relate to Other Similar Concepts?

Despite a widespread use of the term 'green economy' in the ongoing debate in the run-up to the Rio+20 conference, a number of other similar terms are used alongside and often lead to confusion. Some of these related concepts are linked with the 'green economy' concept here.

Low Carbon Economy: A low carbon economy is one that emits a minimal amount of carbon dioxide and other Greenhouse Gases, although what constitutes the minimum has yet to be agreed upon. What is important, however, is that economies are reducing the carbon intensity of their economies overtime, in both unitary terms (CO_2 per unit of GDP) and absolute terms. A low carbon economy can be seen as one of the outcomes from operationalising a particular dimension of a green economy. Investing in renewable energy and energy efficiency is expected to not only generate new sources of income and jobs but also reduce carbon emissions amongst other environmental gains.

Green Growth: According to the United Nations Economic Commission for Asia and Pacific (ESCAP), green growth is one that "emphasizes environmentally sustainable economic progress to foster low-carbon, socially inclusive development". There are three things to note here. First, "growth" as used in this concept is not the same as output growth, which is the standard meaning of growth in economics; it is elevated to cover "economic progress". Second, "green" appears to be equal to "environmentally sustainable", which typically refers to using natural resources and nature's sink functions within their carrying capacity (similar to the concepts of a circular economy and sustainable consumption and production). Third, low-carbon and social inclusion are the objectives of "green growth". In essence, this concept is similar to the familiar concept of a green economy discussed earlier. The definition of green growth adopted by the Organisation for Economic Co-operation and Development (OECD) also appears to have covered both the conventional and new understandings of a green economy: "Green growth means promoting economic growth while reducing pollution and greenhouse gas emissions, minimising waste and inefficient use of natural resources, and maintaining biodiversity. Green growth means improving health prospects for populations and strengthening energy security through less dependence on (imported) fossil fuels. It also means making investment in the environment a driver for economic growth." Thus, for practical purposes, one may consider green growth (with growth meaning economic development as in ESCAP's definition) and green economies to have similar meanings.

Sustainable Development: A green economy (or green growth) is often seen as an approach to achieving sustainable development. A major challenge in moving towards sustainable development is to balance and coordinate different interests: between economic growth/job creation and environmental integrity, between the rich and the poor, and between the present and future generations. A green economy, by turning environmental imperatives into viable economic activities, helps reconcile the need for economic growth (especially in developing countries with a growing population and legitimately rising aspirations for better life) and the need to ensure the environmental basis for continued growth into the future. A green economy can also contribute to social equity if it is conditioned with specific public policies. In selecting the sectors for green investment, for example, priority can be given to those sectors that could potentially benefit the poor most.

A crucial issue to note here is that while sustainable development lays emphasis on inter-generation equity aspects, the green economy and green growth make attempt to integrate intra-generational equity aspects also into the debate.

Millennium Development Goals: These are specific international development goals that national governments and international organizations have agreed to achieve by 2015. Although there are 8 goals and 21 targets, the focus is on poverty eradication. Goal 1, for example, is to eradicate extreme poverty and hunger and Target 1A is to halve the proportion of people living on less than $1 a day. A green economy should and could contribute to the achievement of poverty eradication. First, poverty issue is a priority not only for many developing countries but also for development assistance of many developed countries. Pursuing a green economy without addressing poverty concerns is unlikely to get traction with these countries. Second, a number of sectors with green economic potential are particularly important for the poor, such as agriculture, forestry, fishery, and water management. Investing in these sectors is likely to benefit the poor, in terms of not only jobs for the poor, but also secure livelihoods that are dominantly based on ecosystem services.

It must be emphasized, however, that a green economy with its focus on green investments will not automatically address poverty issues; a pro-poor orientation must be pursued in any green economy initiatives. Investment in renewable energy, for example, will have to pay special attention to the issue of the poor's access to energy; payments for forests' carbon sequestration services should have the poor forest communities as the primary beneficiaries and should not adversely affect their rights to use forest resources; and the promotion of organic agriculture should open up opportunities particularly for poor small farmers who typically make up the majority of the agricultural labour force in most low income countries.

2.4 Potential Criticisms

2.4.1 Would Green Economy and/or Sustainable Development Lead to Poverty Eradication?

Some argue that it is incorrect to ask the question, "How can a green economy contribute to sustainable development" and prefer to leave green economy undefined. The better question (after defining sustainable development) they argue would be: how can we achieve sustainable development? Since economic activity is causing the problems one is trying to fix, then altering the economy is the only way to achieve sustainable development.

This doesn't yet capture the entire theme of the Green Economy in the Context of Sustainable Development and Poverty Eradication (GESDPE). The question of this theme is not just "how can a green economy contribute to sustainable development?" Rather, it also asks about its contribution to poverty eradication. There is a built in assumption behind this theme. The assumption is that a lack of sustainable development is contributing to the existence of poverty. This may be true, but making development sustainable does not inherently decrease poverty. In order to do that, one needs to focus on poverty eradicating development not just sustainable development – even if they are closely related, more precise questions can only produce better solutions.

This then leads to a more specific question: <u>How can one achieve sustainable development in a way that it leads to the eradication of poverty?</u> Comparing this with the green economy related question, "How can a green economy contribute to sustainable development and poverty eradication?" The difference is that the second question uses the term green economy while the first one does not. If one accepts the premise that sustainable development can only occur if the economy is green, then these two questions are basically the same. If one tries to answer the modified question, it can be seen that there are many different ways to achieve desired results. Therefore, there are many different economies that are both green and that also lead toward the eradication of poverty. It doesn't really matter which economy one uses, anything that works could do.

Furthermore, as the world's population changes, the green economy that one will need to use to meet objectives will also need to change. In the mean time, anything the world adopts that moves it further from the current unsustainable, poverty enabling economy is better than nothing. It is unrealistic to think that the world will be able to solve everything by Rio Summit in 2012. This conference should therefore be aimed at simply moving the ball forward both on putting into place the proper incentives to redirect the economy toward our new goals as well as taking the first steps toward institutional reform.

2.4.2 Would Focus on Green Economy Shift Focus to Lower Productivity?

Most green-economy proposals predict huge benefits at low cost, making them politically appealing. Some argue that these benefits are largely due to inappropriate economic forecasting methods. In particular, the criticism is towards using "input-output analysis" for such forecasting. In an input-output analysis a vast matrix is calculated from economic data as they exist *today*, tracing connections between firms in different industries. For example, an automobile plant uses steel, aluminum, plastic, batteries, paint, tyres, and other materials to produce cars with a particular amount of labor per car under current technology. If we think that the plant would begin producing more cars, the input-output matrix could be used to calculate how much more steel, aluminum, and other inputs would be demanded by the car industry and how many more workers would be hired to work in it.

There is a role for such calculations in industry forecasts (for example, predicting steel demand from auto production helps steel plants decide about investing in new capacity). But using them to predict the impact of government programs to green the economy is problematic because the method rests on two assumptions that green proposals violate: constant prices and constant technology.

By definition, efforts to change energy technology are going to change production technology and prices. The relationships in an input-output matrix based on using coal to generate electricity and gasoline to fuel cars simply aren't applicable to an economy where substantial amounts of energy come from high-cost sources like wind and solar and the cars are hybrids or run on ethanol. Even more questionably, the green-economy predictions rest on extremely optimistic estimates of the impact of spending on new technologies. Almost no advocates of these policies deduct the jobs lost from replacing existing technologies with the new, green ones. Refinery workers, coal miners, fossil-fuel power plant workers, and many others will all lose their jobs if the proposed shift to non-fossil fuels takes place. Because all that public spending to produce these new technologies comes from taxes (whether today or in the future), it reduces private spending and so eliminates the jobs that would have been created by the higher private spending displaced by the taxes.

Any estimates of major changes are likely to be imprecise even if all these factors are taken into account because of the considerable uncertainty surrounding these relationships. Ignoring all the downsides could lead to the criticisms that the green economy movement may be politically motivated.

Even if we set aside these technical issues, there could still be some serious problems with green-economy plans. Perhaps most important is related to highlighting low-productivity jobs on grounds that more employment is better. For example, the UN Environment Programme criticizes modern agriculture because "labor is extruded from all points in the system," argues wind and solar are better technologies because producing each BTU of energy requires more labor than in fossil-fuel industries, and argues that the steel industry has evolved to use too little labor. To see why this is a problem, let's consider ethanol. Corn-based ethanol requires more labor to produce than gasoline does, largely because growing and processing corn is more labor-intensive than pumping and refining oil. As a result, green-economy advocates score ethanol higher than gasoline since each BTU of energy in ethanol takes more labor to make than a BTU of gasoline. But lower labor productivity is a bad thing not a benefit. Not only does more labor mean higher costs, but higher-productivity jobs can pay higher wages precisely because they are more productive. Low-productivity jobs are low-paying jobs because employers cannot afford to pay their employees more than the employees generate.

Since the switching over from high paying jobs to low paying jobs is not feasible, the low-productivity jobs being advocated by the green economy proponents could at best be considered appropriate for the labor force that is currently not in employment or in very low productivity jobs. This perhaps is more true for economies in transition and low income countries where surplus labor force is often a major concern. In sum, green economy could facilitate transition in short and medium term towards environmentally benign development in economies that currently need to provide livelihood options for a large majority of its work force. Even this could only happen if these economies bring about appropriate institutional reforms.

Chapter 3

INDIA'S NATIONAL CIRCUMSTANCES AND POLICY PRIORITIES

3.1 Macroeconomic Performance

According to the World Bank, India's per capita gross national product (GNP), (based on the Atlas Methodology) was only US$ 1410 in 2011, compared with US$ 48,450 for the United States and US$ 9488 for the world. Thus India's per capita GNP was only 2.9 % of the U.S average and 14.86 % of the world average. In terms of purchasing power parity, India's per capita GNP was US$ 3488, which was 8.10 percent of the U.S average and 34.59 percent of the world average. As per UNDP Human Development Report (2011) India ranks 134 in the ranking of 187 countries. The Human Poverty Index which focuses on the proportion of people below certain threshold levels in each of the three areas, namely life expectancy, adult literacy and gross enrolment in schools gives a rank of 88 in the list of 135 countries. India has to sustain its high GDP growth rate of 8 -9% per annum at least for another two decades to achieve about 5.5-6.5% compound annual growth rate in per capita income and provide resources for inclusive growth. The Eleventh Five Year Plan envisages inclusive growth to ensure that growth is widely spread so that its benefits, in terms of income, employment and quality of life, are adequately shared by the poor and weaker sections of society. The Plan also includes a commitment to pursue a development process which is environmentally sustainable.

India perceives strong linkages among agricultural growth, job creation and reduction in rural poverty. During the first decade of the Millennium the rate of growth of agricultural output was lower than the planned output. The Planning Commission fixed a target growth rate of 4 per cent per annum for the 11th plan. The target of 4% growth in GDP from agriculture and allied sectors was felt necessary to achieve overall GDP growth target of 9% per annum without undue inflation and generate exportable surplus. Also global experience reveals that growth originating in agricultural sector is at least twice effective in reducing poverty as GDP growth originating in other sectors. There are forward and backward linkages with the non-agricultural sector.

The pace of economic growth is usually regarded as the primary indicator of a country's macroeconomic health. By this measure India has done very well in this decade, especially in the most recent five years, with GDP growth averaging an unprecedented 8.8 percent a year over 2003-04 to 2007-08. The previous best five-year period for growth was in 1992-93 to 1996-97 (at 6.6 percent a year), triggered by the initial burst of economic reforms following the balance of payments crisis of 1991 (Table

3.1). That earlier spurt in investment, productivity and growth had faltered after 1996 because of several factors, including: the headwinds from the East Asian financial crisis; the initial uncertainties of coalitional governance; and a sustained deterioration in the fiscal deficit caused primarily by the large public pay increases following the Fifth Pay Commission. As a consequence, growth had slowed to an average of 5.5 percent during the Ninth Five Year Plan period, 1997-98 to 2001-02. It dropped even lower to 3.8 percent in 2002-03 because of a sharp, drought-induced fall in agricultural output.

Since then the country has witnessed an extraordinary boom, with the aggregate investment rate surging above 37 percent of GDP by 2007/8 and economic growth soaring to 9 percent or higher in the preceding three years, 2005-06 to 2007-08. Though the growth rate had dipped a bit to 6.7 percent in 2008-09, it picked-up again to about 8.5 percent in 2009-10 and 2010-11. The proximate drivers of this growth spurt included the sustained investment boom, cumulative productivity enhancing effects of reforms, an unusually buoyant international economic environment and a demand-and-technology driven acceleration of modern services output. Inspection of the sectoral composition of growth shows that the Ninth Plan slowdown was confined to agriculture and industry; services continued to grow fast and even accelerated (Table 3.1). Moreover, the expansion of services accelerated further in the years after 2002-03, propelled by high rates of growth in communications (especially telecom), business services (especially information technology) and finance. Industry picked up steam from 2002-03 and continued to grow robustly right through to 2007-08. During 2004-05 to 2007-08, industrial sector has been unusually buoyant in the last three years, contributing significantly to the 9 percent plus rate of overall economic growth. In the recent past it has slowed down somewhat to 7.2 percent in 2010-11. Agricultural growth remained variable, substantially dependent on weather conditions. The growth rate in agriculture has been significant in 2010-11 at seven percent.

The exceptionally rapid growth in India's services sector is reflected in the contribution of this sector to overall economic growth since 1991-92 (see Figure 3.1). In the five years between 1991-92 and 1996-97 services contributed just about half of total growth in GDP. In the subsequent five years to 2001-02 the sector's contribution rose sharply to 68 percent and has remained at a high 64 percent in the six years since 2001-02. These shares would be even higher if the construction sub-sector were included under services instead of industry. Perhaps equally noteworthy but more disquieting is the low and declining contribution of agriculture to GDP growth after 1996-97, even though over half of India's labour force is still employed in this sector. In the six years after 2001-02 agriculture contributed only 7 percent of total growth of GDP. The CAGR of the services sector at 10.2 percent for the period 2004-5 to 2010-11 has been higher than the 8.6 per cent CAGR of GDP during the same period, clearly indicating that the services sector has outgrown both the industry and agriculture sectors.

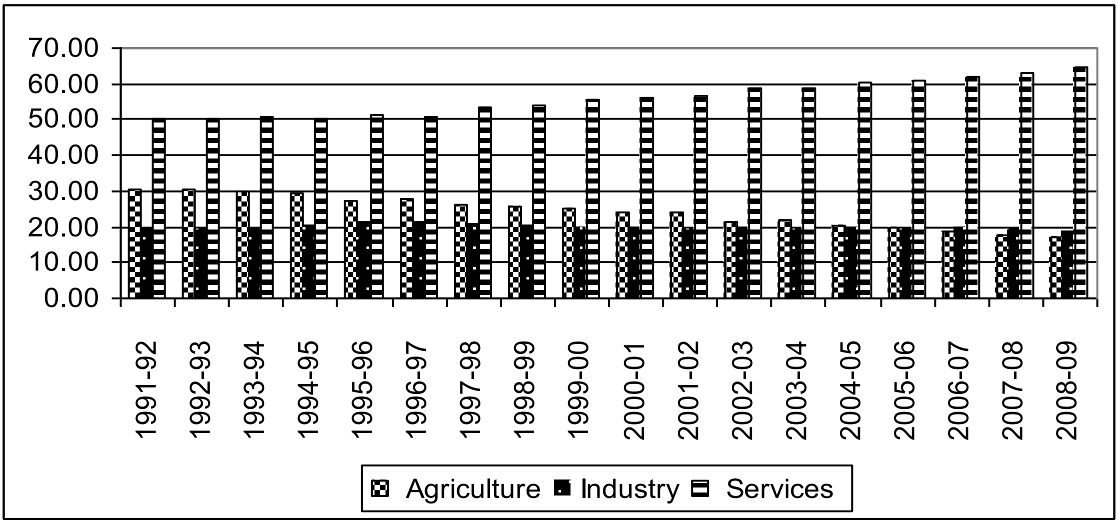
Table 3.1: Growth Rate of Real GDP

(in percent per year)

Sectors (or) Details	1992-93 to 1996-97	1997-98 to 2001-02	2002-03 to 2006-07	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
GDP	6.6	5.5	7.8	3.8	8.5	7.5	9.4	9.6	9.0
Agriculture	4.8	2.5	2.5	-7.2	10.0	0.0	5.9	3.8	4.5
Industry	7.3	4.3	9.2	7.1	7.4	10.3	10.1	11.0	8.5
Services	7.3	7.9	9.3	7.5	8.5	9.1	10.3	11.1	10.8
Per-capita	4.4	3.5	6.1	2.3	6.9	5.8	7.7	8.1	7.5

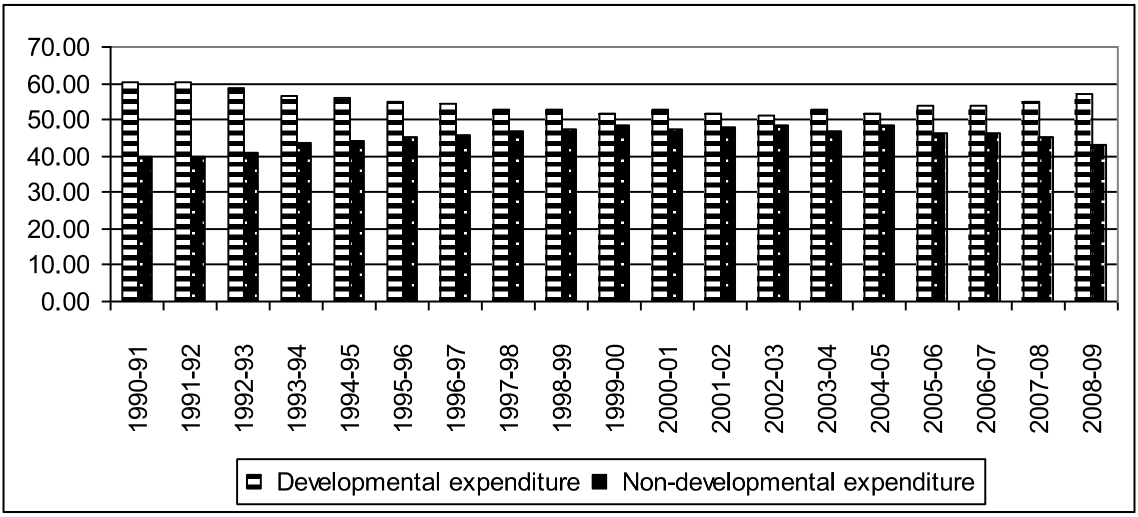
Source: CSO.

Figure 3.1: Sectoral Composition of GDP in India



Source: CSO.

Figure 3.2: Share of Development and Non-Development Expenditure in Total Expenditure



Source: RBI, 2009.

Figure 3.2 shows trend in the shares of development and non-development expenditure in the total expenditure of the centre and states. The development expenditure declined from its high share of about 60 percent in 1990-91 to 51 percent by mid 2000s. Recent years however witnessed increase in the development expenditure, propelled largely by the development expenditure in the states. In 2010-11, the development expenditure by the Centre and States together stands at about 57 percent of the total expenditure.

3.2 Employment and Poverty Pattern

As per the 61st Round National Sample Survey (for the year 2004-05) the employment grew by 1.97 percent per annum in rural India during the period 1999-2000 to 2004-05, while it grew by 3.22 percent per annum in urban India during the same period. While aggregate employment growth (calculated at compound annual rates) in both rural and urban India was still slightly below the rates recorded in the period 1987-88 to 1993-94, it clearly recovered sharply from the deceleration of the 1993-94-1999-00 period. The recovery was most marked in rural areas, where the earlier slowdown had been sharper. This in turn reflects an increase in labour force participation rates for both men and women, as evident from Table 3.2. This includes both those who are actively engaged in work and those who are unemployed and looking for work. The 66th Round of NSS (for the year 2009-10) suggests that the labor participation rates of females in recent years have declined sharply in both rural and urban areas, whereas the labor participation of male members remained stable compared to 2004-05.

Table 3.2: Labor Force Participation Rates

Details	Usual Status				Current Daily Status			
	1993-94	1999-2000	2004-05	2009-10	1993-94	1999-2000	2004-05	2009-10
Rural Males	56.1	54.0	55.5	54.8	53.4	51.5	53.1	53.6
Rural Females	33.0	30.2	33.3	20.8	23.2	22.0	23.7	19.7
Urban Males	54.3	54.2	57.0	55.6	53.2	52.8	56.1	55.0
Urban Females	16.5	14.7	17.8	12.8	13.2	12.3	15.0	12.9

Source: Various reports of employment and unemployment surveys in India by NSSO.

The employment details in each sector can also be assessed through NSS data. While as expected there has been a significant decline in agriculture as a share of rural employment, the share of manufacturing employment has not gone up commensurately for rural male workers. Instead, the more noteworthy shift for rural males has been to construction, with some increase in the share of trade, hotels and restaurants. For urban males, on the other hand, the share of trade, hotels and restaurants has actually declined, as it has for other services. Manufacturing is back to the shares of a decade ago, still accounting for less than a quarter of the urban male work force. The only consistent increases in shares have been in construction, and to a lesser extent transport and related activities. Interestingly, the big shift for urban women workers has been to manufacturing, the share of which has increased by more than 4 percentage points. A substantial part of this is in the form of self-employment. Other services continue to account for the largest proportion of women workers, but the share of trade hotels and restaurants has actually fallen compared to 1999-2000.

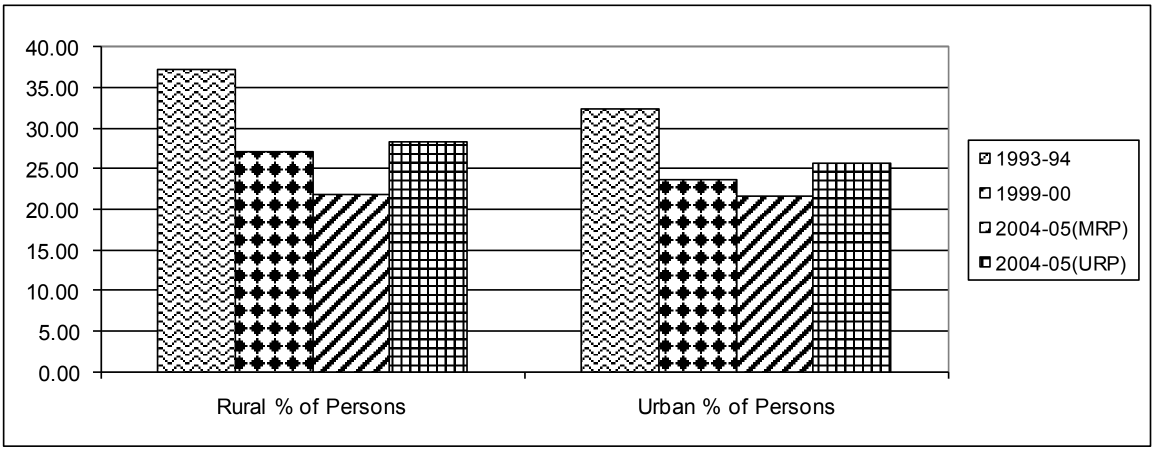
These activity rates, combined with projections of population growth from the Registrar General based on Census 2001, allow one to estimate the growth of employment by broad category over the period 1999-2000 to 2004-05 and compare it with the earlier period. While there has been a slight recovery in the rate of growth of agricultural employment, this is essentially because of a significant increase in self-employment on farms (dominantly by women workers) as wage employment in agriculture has actually fallen quite sharply. However, urban non-agricultural employment certainly appears to have accelerated in the latest period. In rural areas, this is the case for both self and wage employment, although the rate of increase has been more rapid for self-employment. In urban areas, the increase has been dominantly in self-employment. Such expansion would indeed be a sign of a positive and dynamic process if it is also associated with rising real wages, or at least not falling real wages. Therefore, in order to appreciate the nature of this new employment, it is important to examine the trends in real wages and remuneration for self-employment over this period. Analysis of real wages suggests that for most categories of regular workers, the recent period has not been one of rising real wages. While real wages have increased slightly for rural male regular employees, the rate of increase has certainly decelerated compared to the previous period. The economy has therefore experienced a peculiar tendency of falling real wages along with relatively less regular employment for most workers.

It is often held that the rapid growth of modern IT-driven services in India offers an opportunity to exploit the demographic dividend. In fact there is an increasingly popular perception that India would be able to encash the demographic dividend through the growth of its IT and IT-enabled services sector. Of course, there is no doubt that both in absolute and relative terms the size of the IT sector in India is now impressive. The National Association of Software and Services Companies (NASSCOM) estimated the size of the software and IT enabled services industry in 2004-05 at $22.6 billion, comprising of $4.8 billion of domestic revenues, $13.1 billion of software and services export revenues and $4.6 billion of revenues from exports of IT-enabled services and business process outsourcing (BPO). Placed in the context of the economy as a whole, the sector's revenues now amount to around 4.5 per cent of GDP. This makes it an important segment of the non-agricultural sector.

However, the sector's contribution to employment does not compare with its role in the generation of income and foreign exchange. The only available estimates here are those from NASSCOM, which indicate that employment rose from around 285,000 in 1999-2000 to just 1,287,000 in 2004-05, or at a compound rate of about 35 per cent per annum. This is indeed remarkable given the fact that rate of growth of employment during 1999-2000 to 2004-05 as per NSS statistics amounted to just 1.97 per cent in rural areas and 3.22 per cent in urban areas. However, these growth rate figures conceal the low base from which employment has grown, making the absolute contribution of the sector to employment minimal. The total IT industry, including both hardware and software elements, as well as IT-enabled services, still employs only slightly more than 1 million workers, out of an estimated total work force in India of more than 415 million, and urban work force of around 110 million. Total employment in this sector is far short of even the annual increment in the youth workforce. This mismatch between the sector's contribution to GDP and its contribution to employment does suggest that, despite its high growth, this sector can make only a marginal difference to employment even of the more educated groups in urban areas.

The declining share of agricultural sector is consistent with the development experiences of developed countries. However, as discussed above what is disconcerting is the very slow shift of employment from agricultural sector to non-agricultural sector. Assuming the share of rural population in total population at 70 per cent (72.2 per cent in 2001 census) and using an estimate of agricultural employment of 749 persons per 1000 persons employed from 61th Round of National Sample Survey, the share of agricultural employment in total employment is estimated at 52.43 per cent. This means that the average value added per employee in the non-agricultural sector is about 6.4 times higher than the value added per employee in the agricultural sector. This order of magnitude widens income inequality between agricultural and non-agricultural sectors and suggests the need for policy changes to achieve the goal of inclusive growth.

Figure 3.3: Poverty in Rural and Urban India: 1993-94 to 2004-05



Source: RBI, 2009.

Fifty years after the independence, a vast number of people still live below the poverty line in India, making poverty eradication one of the most challenging problems. As shown in figure 3.3, percentage of population below poverty line declined from about 37 percent in 1993-94 to 22 percent in 2004-05 in rural India. In urban India the poverty decline over the same period was from 32 percent to 22 percent. The poverty decline is more modest if estimates are made on the basis of uniform recall period as against the mixed recall period in the expenditure survey. The poverty rate in 2009-10 however was higher in both rural (33.8 percent) and urban (29.8 percent) India. This was attributed to change of methodology (Tendulkar methodology) adopted in the 66^{th} Round of NSS survey.

The Mahatma Gandhi National Rural Employment Programme, which began in the first year of the 11th Plan, is expected to further reduce the percentage of people below the poverty line, especially in rural areas. In addition through the green economy initiatives fresh attempt could be made to give boost to agriculture sector and provide viable livelihood opportunities for vast rural population. The drive towards organic agriculture could be seen as one such green economy initiative and same is discussed in the subsequent sections of this paper.

3.3 Housing, Transport and Energy

A large number of people are homeless in India. Besides, a great portion of population live in non-livable houses, and that a major portion cannot even afford a formal house. Economic condition forces them to live in an inferior housing environment. The mainstream formal housing needs a faster production system of housing maintaining quality of houses and economy to overcome the huge shortage. Appropriate solution to provide affordable, socio-culturally acceptable and environment friendly housing continues to be a serious challenge to public as well as private housing providers. There is around 24.7 million-house shortage in India on an average (National Building Organization, NBO & NHHP 2007, as quoted in Roy et al., 2008). Most of the shortage (99%) is for the lower income group and economically weaker section as per NBO and NHHP.

Table 3.3: Housing Shortage in India

Details	Rural/ Urban	1981	1991	2001
Population (in cr.)	Rural	52.38	62.87	74.25
	Urban	15.95	21.76	28.61
	Total	68.33	84.63	102.86
Housing Shortage in Cr.	Rural	1.63	1.47	1.41
	Urban	0.7	0.82	1.06
	Total	2.33	2.29	2.47

Source: Adopted from Roy *et al.*, 2008.

Table 3.3 shows housing shortage in India in rural and urban areas. Given the high emission intensity of the construction sector, meeting the challenge of housing shortage would result in large-scale emissions of pollutants, unless measures are taken to develop green building practices. The eighth chapter highlights further issues associated with the green buildings.

Another source of environmental pollution is increasing trend observed in the use of vehicles for transportation. Table 3.4 shows the total number of registered motor vehicles in India during 1991 and 2006. As could be seen the growth rate of private vehicles is significantly higher than that of public vehicles such as buses and mini-vans. Transport provides yet another opportunity for green economy intervention through the possible introduction of hybrid cars etc.

Table 3.4: Trend in Total Number of Registered Motor Vehicles in India

(in thousands)

Year	Two Wheelers	Cars, Jeeps and Taxies	Buses	Goods Vehicles	Others	All Vehicles
1991	14200	2954	331	1356	2533	21374
1996	23252	4204	449	2031	3850	33786
2001	38556	7058	634	2948	5795	54991
2002	41581	7613	635	2974	6121	58924
2003	47519	8599	721	3492	6676	67007
2004	51922	9451	768	3749	6828	72718
2005	58799	10320	892	4031	7457	81501
2006	64743	11526	992	4436	7921	89618

Source: GoI, 2009.

India largely depends on external sources for its supply of petroleum products. Table 3.5 shows the supply and consumption of petroleum products in India. The significant supply demand gap poses considerable energy security concerns for India. The table also shows the carbon dioxide emissions due to the consumption of petroleum products. The rising demand for petroleum products increased the CO_2 emission by more than 2.3 times over the period 1995-2008. Fiscal instruments such as eco-taxes have an important role to play in facilitating transition towards low-carbon economy.

Table 3.5: Consumption and Supply of Petroleum Products in India

Year	Total Consumption of Petroleum Products (000 barrels per day)	Total Oil Supply (000 barrels per day)	CO_2 Emission (million metric tones)
1995	1574.7	769.7	216.8
1996	1680.9	750.9	228.8
1997	1765.5	779.6	240.9
1998	1844.4	761.3	257.5
1999	2031.3	764.8	268.0
2000	2127.4	770.1	281.6
2001	2183.7	781.6	281.1
2002	2263.4	812.7	300.5
2003	2346.3	815.0	295.1
2004	2429.6	851.4	306.0
2005	2512.4	835.2	314.2
2006	2690.9	860.4	349.2
2007	2845.0	887.3	369.2
2008	2962.0	889.7	384.4

Source: http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=44&pid=44&aid=1).

Table 3.6: Primary Energy in India – Production and Consumption

(in quadrillion btu)

Year	Total Primary Energy Production	Total Primary Energy Consumption
1995	9.484	11.443
1996	8.746	11.042
1997	9.166	11.637
1998	9.368	12.166
1999	9.585	12.988
2000	9.832	13.462
2001	10.291	13.937
2002	9.946	13.753
2003	10.506	14.196
2004	11.098	15.347
2005	11.759	16.321
2006	12.407	17.619
2007	13.048	19.094

Source: http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=44&pid=44&aid=1.

Table 3.6 shows the total primary energy production and consumption in India over the period 1995 to 2007. The gap between the production and consumption is increasing and it reached from about 1.05 quadrillion btu in 1995 to about 6.05 quadrillion btu in 2007. Over this period the generation of electricity from renewable resources has also increased – from about 70 billion kwh in 1995 to 130.5 billion kwh in 2008. Price rationalization coupled with effective subsidies could provide impetus for further penetration of renewable resources.

3.4 Environmental Pollution

It is well established through the statistics of CPCB and other agencies that the environmental pollution – water, air as well as solid waste – has been in excess of the national ambient standards. For instance, the water pollution levels measured in terms of biochemical oxygen demand (BOD) in several rivers has been observed to be well above the water quality criteria. Similarly the respirable suspended particulate matter (RSPM) – the main air pollutant from public health point of view – has been well above the national ambient air quality standard in several monitoring stations.

In addition to this overall picture, deteriorating conditions of certain hot-spot areas further highlight the need for urgent policy intervention. The Blacksmith Institute of New York started a new initiative to identify the worst polluted places of the world in

2006. In the years 2006 and 2007 the top ten worst polluted places are selected on the basis of size of affected population, severity of the toxin involved, impact on children's health and development, evidence of a clear pathway of contamination, and existing and reliable evidence of health impact. Legal and institutional reforms and use of market based instruments for effective environmental management is an important policy priority, especially with regard to the air pollution.

Over the past one decade the composition of household energy-mix showed very little variation in rural India. The evidence from NSS data shows that use of solid fuels (including, firewood, coal/coke, and dung cake) has slightly decreased from 1993-94 to 2004-05 with the percentage of household using such fuels as primary energy source for cooking declining from 95 to 85 percent[1]. The urban India, on the other hand, registered significant change over the same period, with percentage of households using solid fuels declining from 40 in 1993-94 to 26 in 2004-05. One of the major differences between rural and urban Indian households is in terms of their use of kerosene as cooking fuel. Compared to almost negligible use of this fuel in rural India, kerosene played the crucial role as the transition fuel in urban India. Of course, LPG penetration has been impressive in urban India. Figure 3.4 shows the composition of various fuels used as primary cooking fuels by the rural and urban Indian households over the past one decade. There are significant regional differences in India in terms of the consumption of solid fuels. In rural India, barring the Eastern Indian states, the rest of the states showed some penetration of LPG with about 10 to 12 percent of households reporting this fuel as primary source for cooking in the year 2004-05. With the exception of the Western Indian states, all states showed very little consumption of kerosene for cooking. In urban India, penetration of LPG has been very impressive with all the regions having more than 50 percent of the households consuming LPG as primary cooking fuel in the year 2004-05. Further, in all the regions, kerosene served as transition fuel. In terms of the solid fuels, the Southern and the Eastern states have showed similar pattern of consumption over the years, whereas the Western and the Northern states exhibited comparable consumption pattern of these fuels in the last decade.

---

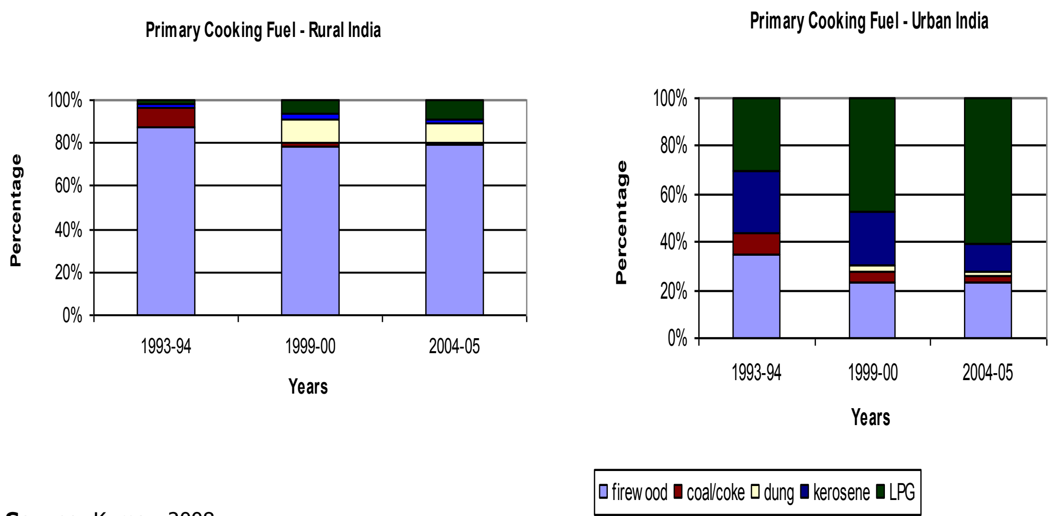
[1] Firewood consumption in rural India slightly increased from 2004-05 to 2009-10 with about 75.92 percent of rural population reporting firewood as their primary source of cooking fuel. Urban households on the other hand reduced their dependence further on firewood during 2004-05 to 2009-10 with only 17.56 percent of population reporting firewood as their primary source of cooking fuel.

Continued dependence on solid fuels is a major cause for concern from a health perspective. However, meeting the energy needs of large number of rural households through conventional fossil fuels could lead to significant increase in greenhouse gas emissions. There is emerging evidence about the beneficial effects of using solid fuels through improved cookstoves. Creating enabling conditions for faster and deeper penetration of such energy use options becomes yet another policy priority for India.

Use of pesticides is one of the main reasons for land and water pollution. The state-wise pesticide consumption over the past decade shows that Uttar Pradesh, Punjab, Haryana, West Bengal, Rajasthan, and Maharashtra have maintained high consumption of pesticides throughout the period. On the other hand, states like Andhra Pradesh have registered sharp fall in the pesticide consumption. Scope for promoting organic agriculture could be explored to arrest the soil quality decline in areas with high pesticide (and fertilizer) consumption.

While much attention has been paid in the past to the air and water pollution, more and more evidence is emerging regarding the solid waste problems in India. In particular the municipal solid waste management is posing significant burden to the local governments. It is estimated that about 35 to 45 million tons of municipal solid waste is generated annually, with urban centers contributing to more than 80 percent of the total waste generated. The average waste generated per capita is estimated as 300 to 500 grams per day in 2000. With the urban population poised to grow by about 40 percent in the next 10 years, the municipal solid waste is bound to acquire primary importance in India and offers itself for the green economy intervention.

Figure 3.4: Primary Source of Energy for Cooking in India: 1993-94 to 2004-05



Source: Kumar, 2008.

3.5 Summary

India's national circumstances provide clear rationale for policy interventions that could be seen through green economy perspective. Some such interventions are listed below based on the above discussion:

- There is clear need for resurgence of agricultural growth that not only puts less pressure on the environment but also provides livelihood opportunities for vast rural population and contributes towards poverty eradication. Organic agriculture could be seen as one such green economy initiative. Scope for promoting organic agriculture could also be explored to arrest the soil quality decline in areas with high pesticide (and fertilizer) consumption.
- Similar interventions are also needed in other green sectors such as water and forestry.
- Given the high emission intensity of the construction sector, meeting the challenge of housing shortage would result in large-scale emissions of pollutants, unless measures are taken to develop green building practices.
- Transport provides yet another opportunity for green economy intervention through the possible introduction of hybrid cars and rapid mass transport systems.
- The rising demand for petroleum products increased the CO_2 emission by more than 2.3 times over the period 1990-2008 in India. Fiscal instruments such as

eco-taxes have an important role to play in facilitating transition towards low-carbon economy.

- Over this period the generation of electricity from renewable resources has also increased – from about 70 billion kwh in 1990 to 130.5 billion kwh in 2008. Price rationalization coupled with effective subsidies could provide impetus for further penetration of renewable resources.
- Legal and institutional reforms and use of market based instruments for effective environmental management is an important policy priority, especially with regard to the air pollution.
- There is emerging evidence about the beneficial effects of using solid fuels through improved cookstoves. Creating enabling conditions for faster and deeper penetration of such energy use options becomes yet another policy priority for India.

Chapter 4

GREEN ECONOMY – GROWTH AND DEVELOPMENT IMPLICATIONS

An export-led development strategy presumes an unlimited demand for exports particularly from developing countries. However, current evidence shows an increasing degree of price competition among developing countries to access developed country markets. On the other hand, except for primary commodities and raw materials, the largest developed economies are not able to significantly absorb manufacturing exports coming from most developing countries. So even in the absence of a protectionist wave in developed countries, the export-led model is showing signs of exhaustion.

For most developing countries, the path toward sustainable long-term development needs to strike a better balance between domestic-led and export-led growth. Such a balance may also allow growth with equity, as labor income becomes a crucial element of aggregate demand and not merely a cost to be minimized in the interest of external competitiveness. In this context, a well targeted transition towards a green economy may indeed offer a more integrated approach to economic growth and sustainable development. Moreover, the pressing need of addressing the potential negative impacts of global climate change adds a sense of urgency to the green economy.

What needs to change is the way in which priority is assigned to sustainable development and long-term economic prospects within national and global trade policies. Trade policy formulation is almost always thoroughly dominated by short-term commercial considerations. As a result, trade policy advances a very narrow aspect of the national sustainable development interest. There can be no doubt that the interests of national exporters and national producers are a legitimate focus of trade policy. However, the problem arises when trade expansion remains the exclusive focus of development policy. Additionally, issues of common global concern (and interest) such as climate change receive virtually no attention from decision-makers involved in the promotion of export-led growth. Yet, in the long run, short-term national commercial interest is often neither in the global interest nor even in the national interest.

In an export-led development strategy, the multilateral trading system seeks to provide the favourable environment for economic gains, while domestic policies are tasked with sharing the benefits within the economy and to manage those gains towards sustainable development. In a global trade system with sustainable development as the central focus, the global system should encourage inclusion of all economic actors and equally seek social and environmental benefits. This would lead to a system not solely based on the principle of commercial reciprocity but also on the search for global sustainable development.

Moving towards a green economy implies not only the mainstreaming of green niches in specific sectors of the economy but to change the overall social construct. The sustainable development challenge for a green economy is to be able to produce more wealth, employment and better social services, coupled with a lower absolute use of natural resources, greater reliance on less carbon-intensive and renewable energy, and without causing regional displacements due to uneven endowment of natural resources.

The transition to a green economy would imply significant investments to revamp and structurally change, (a) the production function of the economy, (b) its infrastructure, and (c) spur investments for continuous technology development. It will also imply the transformation of the consumption patterns to adequately synchronize them with the full value of the welfare benefits that consumers receive from goods and services. It is difficult to imagine a transition phase in which, at least in the early stages, the internalization of the environmental and social costs do not result in a reduction in real income. Obviously, developed economies would have at hand greater financial, human resource and technological means to navigate this transition at relatively lower costs. Conversely, developing economies could be disproportionately left with higher transition costs to a greener economy. Hence, there is a real basis to argue for a net transfer of financial resources so that developing countries can leapfrog to a higher degree of sustainable development. This holds particularly true if one admits that a more sustainable, green and less carbon-intensive world economy is essentially a "global common good" that provides benefits for all humanity. Short of accepting this, the mere internalization of environmental costs is a costly extra effort that many countries, developing and developed countries alike, may not be willing to voluntarily make or undertake in isolation.

With regards to the social and human well-being aspect of the transition phase to a green economy, new mechanisms to share the costs will be required. Transition costs could affect segments of society in different ways, not only in terms of labour force re-training, but mostly in adapting to the new (higher post-internalization) market price levels. If the last 20 years have provided a lesson in this regard, it is that adequate and due compensation to the underprivileged is not an automatic mechanism available in most countries. Well-targeted and innovative policies to address these market failures are therefore required.

Green economy debate should also focus on continuing and growing differences in consumption patterns between the haves and have-nots. The difference is clear both across developed and developing countries and across rich and poor within the developing countries. Without adequate attention to this glaring developmental failure any discussion on structural changes through green economy would only have limited impact.

In GESDPE India should attach greater importance to activities which enhance livelihood opportunities for the poor and hence poverty eradication while greening the economy. A tentative list of activities under GESDPE would include agriculture, forestry, ecosystem services, conservation and sustainable use of biodiversity, conservation of water, low carbon energy development and recycling and reuse of solid and other wastes. Incidentally some of these sectors have also been highlighted by the Thirteenth Finance Commission in its recommendations. It has recommended grants for incentivizing states to improve forest cover and forest quality, promote renewable energy and set up water regulatory authorities for rational allocation and pricing of irrigation of water.

While discussion on all these sectors and potential green economy initiatives is beyond the scope of this report, the report will address issues related to agriculture, water, energy, environment and construction sectors in the following chapters.

Chapter 5

PRIORITY SECTORS AND GREEN ECONOMY INITIATIVES - AGRICULTURE

5.1 Introduction

Agriculture ensures food and nutritional security, provides income and employment for more than half of India's population and caters to the raw material needs of the important industrial sectors. Agriculture also has positive externalities such as the provision of environmental services and amenities through carbon sequestration and the maintenance of rural landscapes. It is widely recognized that agricultural intensification saved vast areas of natural forest and grassland, which would have been destroyed in the absence of higher crop yields. However, agricultural intensification is not without its concomitant negative impacts on the environment. It has contributed to land and water resource degradation, loss of biodiversity, mining of soil nutrients, depletion of groundwater and greenhouse gas emission. Globally, agriculture accounts for about 15 percent of all anthropogenic greenhouse gas emissions. The sector's emissions are expected to rise nearly 30 percent between 2005 and 2020. The recent estimates of greenhouse emissions from Indian agriculture report that it constitutes 17% of the total emissions in India, while land-use change and forestry have been reported to be a net sink of carbon (Government of India, 2010). These problems emerged as a consequence of agricultural intensification and increasing mechanization of agricultural operations including groundwater pumping, and are likely to intensify in future as most of the incremental crop production in India will have to come from intensification as there is limited scope for expansion of arable land.

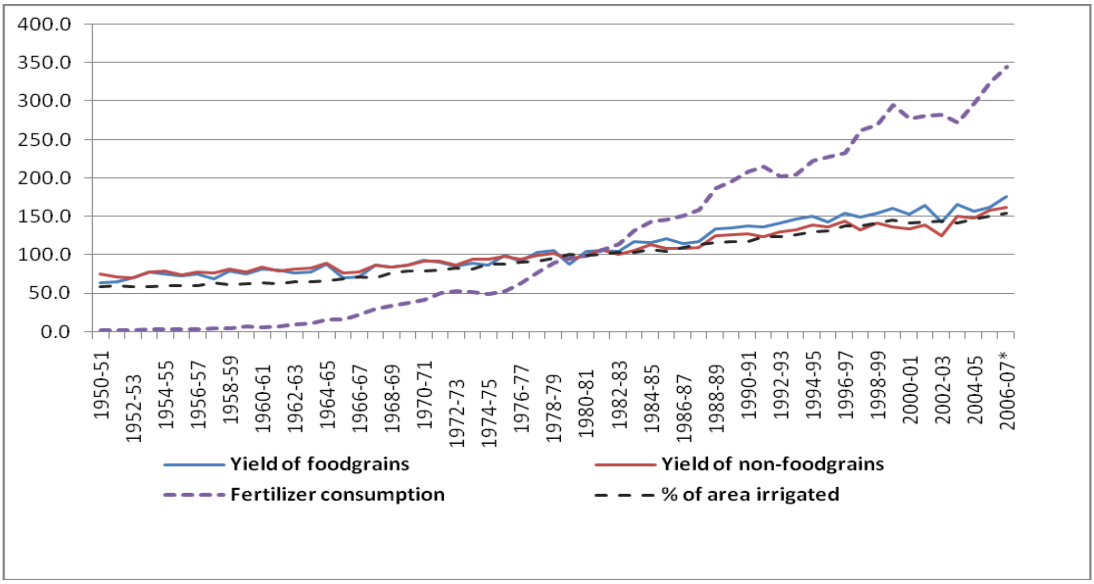
5.2 Agriculture and Environmental Linkages

5.2.1 Extensive and Intensive Agriculture

Both extensive and intensive agricultural practices have resulted in a variety of land and soil degradation problems. The area of land affected by some form of soil degradation has increased from about 112 million ha in 1950 to about 174 million ha in 2000 (Government of India, 2000). The increasing population pressure and the consequent need for higher food production has resulted in expansion in area under cultivation in India from 118 mha in 1950-51 to 140 mha in 2007-08, while the gross cropped area increased from 132 m.ha to 196 m.ha during the same period. Consequently, cropping intensity has increased from about 111 per cent to about 140 per cent. Fertilizer use intensity has increased from a mere 0.50 kg per ha of net sown area to about 150 kg per ha of net sown area and to 110 kg per ha of net sown area. Area under groundwater irrigation is on continuous increase resulting in overexploitation and / or saline water intrusion into aquifers in many parts of Western and Southern India (refer Figure 5.1 and Figure 5.2).

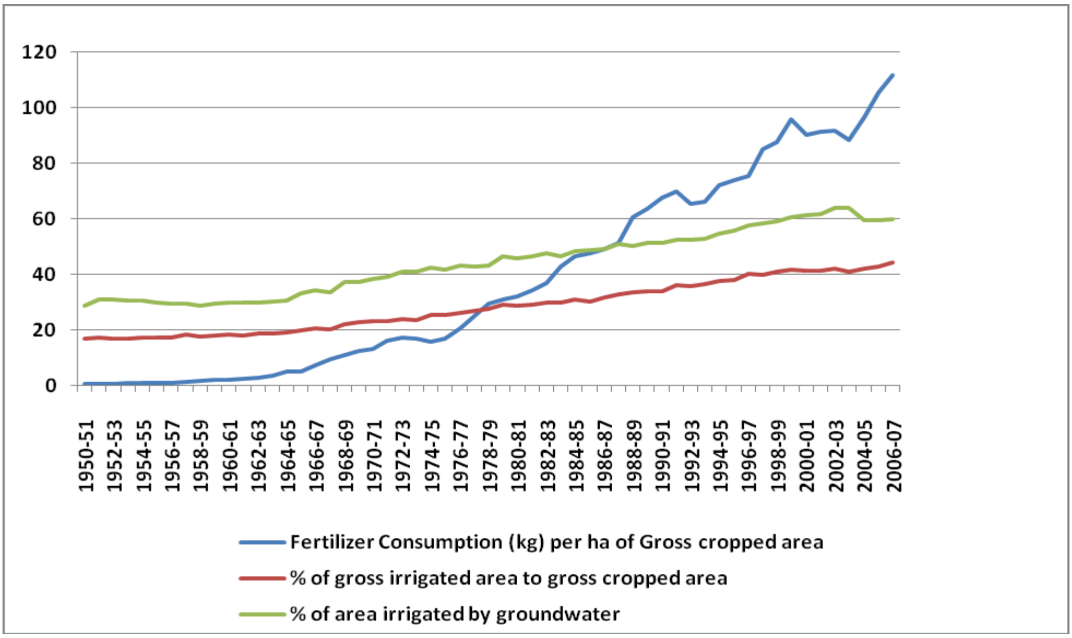
Figure 5.1: Index Number of Yield, Fertilizer Consumption and Area irrigated

(Base: Triennium ending 1981-82=100)



Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation.

Figure 5.2: Fertilizer Consumption and Irrigation Development in India



Source: Ministry of Chemicals & Fertilizers, Department of Fertilizers.

Recent analysis of a large number of long-term soil fertility experiments has shown that yields have stagnated or declined for rice and wheat, the two major crops of the country, raising concerns about the long-term sustainability of intensively cultivated production systems and food security of the region (Ladha et al., 2003). Non-judicious use of nutrient in relation to amount, timing, and balance has been identified as a possible reason for such yield stagnation/decline (Ladha et al., 2005). Agricultural intensification through increased application of external chemical inputs has, in general, resulted in increased environmental degradation including pollution of soil and water, greenhouse gas (GHG) emissions and depletion of soil nutrients[2].

Fertilizer Pollution: Since the 1970s due to extensive use of fertilizers, leaching of nitrate from soils into surface water and groundwater has become an issue in almost all industrial countries. In India fertilizer use increased from 18 lakh tones in 1960s to 180 lakh tones in 1990s (Table 5.1), but its usage varies widely across states and regions

---

[2] There are some studies which show that intensive agriculture has produced positive benefits through avoided emission due to enhanced yield and crop production. Further, studies have shown that soil organic carbon has increased in the intensive agricultural areas of Punjab (Benbi and Brar, 2009).

depending on the level of intensification of agriculture. The nitrates leached from mineral fertilizer and manure use poses a risk to human health and contributes to eutrophication of rivers, lakes and coastal waters. The problem occurs primarily when N application rates exceed crop nutrient uptake and due to lack of proper management practices. The risk depends on crop type and yield, soil type.

Table 5.1: Fertilizer use in Agriculture (lakh tons)

Particulars	**Period***					
	1950s	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**
Nitrogen	1.83	11.99	32.77	67.84	112.82	144.28
Phosphorous	0.34	3.77	10.41	26.40	42.75	58.55
Potash	0.18	1.83	5.68	10.39	14.61	27.61
Total	2.37	17.60	48.85	104.64	170.18	230.43

* Average of triennium ending 1959-60, 1969-70, 1979-80, 1989-90, 1999-00, and 2008-09.
Source: Ministry of Chemicals & Fertilizers, Department of Fertilizers.

Pesticide Pollution: Pesticide consumption in India kept on increasing till 1990-91 but at a slower rate and since 1991-92 it has been declining. Currently the pesticide consumption is around 44 thousand tonnes. The reason for the reversal of trend in pesticide use could be due to development of resistant crop cultivars and development of more efficient pesticide molecules, which require in small quantities for a given level of pest control. India is currently the largest manufacturer of Pesticides in Asia, second only to Japan. Many of the pesticides commonly sold in developing countries are extremely hazardous chemicals that are banned or restricted for use in developed countries. Pesticide policies and regulations are in their infancy in many developing countries and, as a result, pesticide misuse is prevalent. Concerns about health and environmental effects associated with pesticide use were raised in many quarters. Evidence of pesticide threat to human health and of the tradeoff between health and economic effects has been documented well in recent studies.

Table 5.2: Pesticide Consumption in India

Year	Pesticides (in 000 tonnes of technical grade material)
2000-01	43.58
2001-02	47.02
2002-03	48.30
2003-04	41.00
2004-05	40.67
2005-06	39.77
2006-07	41.51
2007-08	44.77
2008-09	43.86
2009-10	41.82
2010-11	55.54

Source: Ministry of Agriculture; Lok Sabha Unstarred Question No. 3545, dt. 15.12.2011.

Nutrient mining: Nutrient mining occurs when there are not adequate technological responses to replace the soil nutrients taken out by crops with organic or mineral fertilizer inputs, leguminous crops, nitrogen-fixing algae and so on. Continuous nutrient mining over a long period is a threat to sustainability of agricultural production. The problem is serious in both semi-arid areas where livestock manure is in short supply and the use of mineral fertilizers is seldom economic, and in intensively cropped areas where nutrient application does not balance the nutrient removal. A rice-wheat sequence that yields 7 t/ha of unhusked rice and 5 t/ha of wheat removes more than 300 kg nitrogen (N), 30 kg phosphorous (P) and 300 kg potassium (K) per ha from the soil. Even with the recommended rate of fertilization in this system, a negative balance of the primary nutrients still exists (Singh et al., 2000). The nutrient-use efficiency of the added fertilizers is dropping; so the farmers must add increasing amounts of fertilizer in order to merely maintain yields. For example, the partial factor productivity of NPK for food grain production has dropped from 80.9 in 1966–67 to 16.0 kg food grain per kg NPK application in 2003–04 (Benbi *et al*, 2006). The current level of nutrient balance in Indian soils is estimated to be negative with nutrient removal of 32 million tonnes and addition through fertilizers and manures accounting for 24.6 million tonnes, thus resulting in nutrient mining of the order of 7.4 million tonnes.

Water Resource Degradation: Intensive use of groundwater for irrigation rapidly expanded with the adoption of tubewell and mechanical pump technology. Consequently groundwater withdrawals in India have surged from less than 20 cubic kilometers (km^3)

in 1950s to more than 150 km^3 now, making India by far the largest user of groundwater in the world. About 55-60 per cent of India’s agricultural lands rely on groundwater for irrigation. Over-pumping has led to increased investment or operating costs as falling water tables have necessitated deeper wells and greater energy consumption for pumping. In some instances poor farmers without the capital to deepen their wells have had to revert to rainfed production. In others the necessary adjustments have been too late and desertification sets in. Small farmers with little access to expensive pumps and often insecure water rights are most affected. Water logging and salinization has affected nearly 20 m. ha in India and it is the second important cause of land degradation in India. Of particular concern are those irrigated areas in semi-arid regions that support large rural populations, such as the western Punjab and Indus valley where large areas of waterlogged saline land are spreading through the intensively irrigated plains.

Methane Emission from Agriculture: Submerged fields under paddy cultivation results in anaerobic decomposition of organic matter, thus leading to methane production flooded rice fields. Researchers have calculated that paddies worldwide release about 50 million tonnes of methane annually. Notably, India is responsible for nearly a third of the estimated global methane emissions, which may be due to the high temperatures in India's rice-growing regions, the large cultivation areas and the practice of continuously flooding paddies. Incorporating previous season rice straw / other crops residues, which is a common practice, also adds to methane emission.

NO_2 Emission from Fertilizer Application: It is projected that by the year 2020, total fertilizer demand will increase to 47.4 million tonnes from 18.2 million tonnes for the year 2000. Increased demand for fertilizer is attributed to more and more land under HYV and increased awareness among farmers to use more fertilizers for higher yields. HYV consumes more fertilizer. The total demand for nitrogen fertilizers is projected to reach 33.4 million tonnes for the year 2020. Use of synthetic fertilizer is the largest source of N_2O emissions presently and is projected to retain this prominence in future also. N_2O emissions from use of synthetic fertilizer for the year 2020 are projected to reach 0.532 million tonnes from 0.178 million tonnes for the year 2000 (Anand et al, 2006).

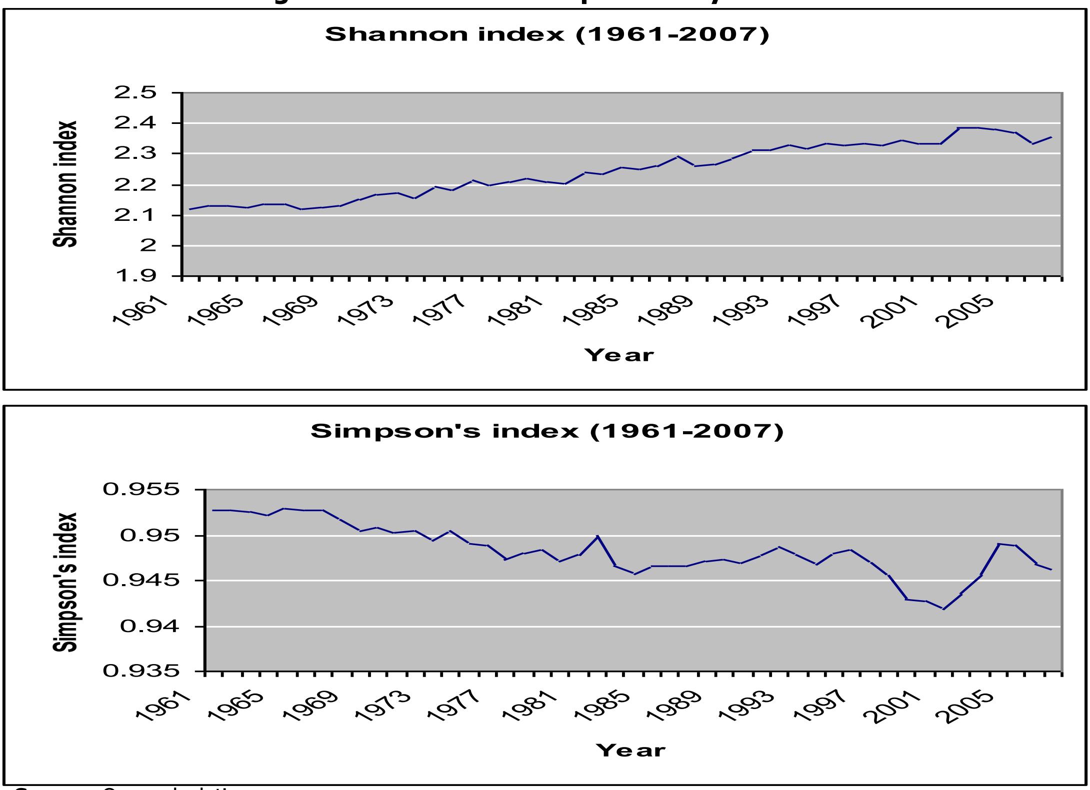
Energy Use in Agriculture: Extensive and intensive cultivation has contributed for phenomenal growth in both renewable and non-renewable energy consumption in Indian agriculture. Electricity consumption for irrigation purposes has increased manifold due to huge expansion in groundwater irrigation. Subsidized supply of electricity, transmission losses, and low pumping efficiency have also contributed for excessive use of electricity in agriculture. Energy for other farm operations such as ploughing, leveling, weeding, harvest, transport and pest control is also increasing due to increase in mechanization of these operations. GHG emission from India's increasing consumption of electricity for groundwater pumping has been estimated to range from 58.7 to 88 million tonnes of CO_2 equivalent (mtCO_2e) under different scenarios during the year 2000. The growth in emissions is estimated to peak in 2040 to reach 139 to 208.6 mtCO_2e with the peak in irrigation water use deep wells powered by electricity are the largest single source of CO_2 emissions (Nelson et al., 2009).

5.2.2 Loss of Biological and Crop Diversity

Biological diversity is the variability among all living organisms existing on earth in various ecosystems and ecological complexes. This diversity is the basis of continuous evolution of life forms and in turn maintaining the life-sustaining systems of the biosphere. Throughout history, human beings have used thousands of plant species for food, many of which have also been domesticated. Today only 150 plant species are cultivated, 12 of which provide approximately 75 percent of our food and four of which produce over half of the food we consume. This involution has increased the vulnerability of agriculture. Genetic diversity has been and remains an important factor in maintaining and increasing agricultural productivity. It is estimated that approximately 35 per cent of the production of modern new rice varieties has been attributable to the genetic resource input. Rice germplasm have been estimated to be responsible for 20 per cent of the green revolution in rice production (Evenson, 1995). The loss of wild relatives of crops and of native crop varieties that are better adapted to unfavourable or changing environmental conditions could be particularly serious for crop introduction or breeding programmes to adapt to climate change. Wild sources of food in general remain particularly important for the poor and landless, and are especially important during times of famine and insecurity or conflict where normal food supply mechanisms are disrupted and local or displaced populations have limited access to other forms of food. India is one of the 12-mega diverse countries of the world. With only 2.5% of the land area, India already accounts for 7.8% of the global recorded species.

There is increasing pressures on biodiversity within agricultural production systems. Spread of high yielding varieties/GM crops and the consequent mono-cropping and intensive cultivations have reduced the spatial distribution of species, destruction of the habitats of beneficial insects and birds that help to keep crop pests under control. Diversity can be measured in two different ways. One is **species richness** or the number of species in an environment. The second is **species evenness,** which is a measure of the evenness of distribution of individuals in the species. Two widely used indices are the Shannon and the Simpson indices. These measure both species richness and evenness. The Shannon index is based on the rationale that greater diversity corresponds to greater uncertainty in picking at random an individual of a particular species. The minimum value is 0 while relatively diverse systems have a value of 3 to 4. The Simpson's index measures the probability that two individuals randomly selected from a sample will belong to the same species. Its value varies between 0 and 1, 0 meaning no diversity and 1 meaning very high diversity. The Simpson's index has been criticized as it gives greater weight to species evenness than richness. The Shannon index, on the other hand gives greater weight to species richness. Figure 5.3 shows trends in various measures of crop diversity in India over the period 1961-2007.

Figure 5.3: Trends in Crop Diversity in India



Source: Own calculations.

The graphs provide contrasting information. While the Shannon index are increasing over time, the Simpson's indices are showing a declining trend. This difference is due to the fact that each of these indices measures a different aspect of crop diversity. The Shannon and the Simpson's indices measure both species richness and species evenness. However, as mentioned above, the Shannon's index gives greater weight to species richness while the Simpson's index is biased towards species evenness. The increase in the Shannon index can therefore be attributed to the increase in species richness and the decline in the Simpson's index to the decrease in species evenness.

To summarize, in India, during the period 1961-2007, species richness has been increasing while species evenness has been decreasing. This means that although the number of crops has increased, the distribution of area among these crops is not equal. In other words, a few crops have come to dominate over others.

The reduction in species evenness can be explained by the increasing importance given to rice and wheat in agricultural policy. The area shares of rice and wheat have been increasing over the years, while that of traditionally grown coarse grains have been reducing. Wheat first started gaining importance in India's agricultural policy during the food crisis of the 1950s when the country was forced to import wheat from USA. Further, the Green revolution in the 1960s introduced high yielding varieties (HYV) of rice and wheat. The use of HYV seeds along with chemical fertilizers led to huge increases in productivity. This encouraged farmers to increase the area under rice and wheat. Rice and wheat were encouraged both on the production side and consumption. The PDS provided a market for these crops. Consumption of rice and wheat increased due to the subsidized prices offered under the PDS system. Also, guaranteed support prices were offered to farmers for these crops. Coarse grains, on the other hand, were not given any such benefits. Therefore, it was only natural that farmers shifted away from coarse grain to rice and wheat cultivation. From 1960 to 2000 the area under millets has fallen from 30% to 16% (Murthy, 2004). This shift resulted not only in a reduction in crop diversity but also in crop variety diversity. According to Kothari (1994) an estimated 95% of the rice varieties in Andhra Pradesh have been lost. Thousands of varieties of rice, cotton, minor millets, pulses, and other crops are no longer in use. Thanks to the Green Revolution, India has achieved self sufficiency in food grain production. From the late 60s, the rate of growth of food production generally exceeded the population growth. The per capita availability increased from 157 kg per year in 1955 to 177 kg in 1995. Food production has risen roughly four times since independence. However now, food grain production is starting to decline. The per capita availability of food grains has declined to 428.8 grams per capita per day in 1999 from 468.5 grams per capita per day in 1991. The monoculture of rice and wheat has lead to groundwater extraction, pollution, soil salinization and many other problems. The Food Insecurity Atlas of Rural

India, released in 2001, revealed that the Punjab-Haryana region, today India's bread basket could lose its production potential within a few decades if the current patterns agricultural cultivation persists.

5.3 Initiatives for Green Economy in Agriculture

Green agriculture is characterized by shifting both industrial and subsistence farming towards ecologically sound farming practices such as efficient use of water, extensive use of organic and natural soil nutrients, optimal tillage, and integrated pest control. Building green agriculture requires physical capital assets, financial investments, research and capacity building in five key areas: soil fertility management; more efficient and sustainable water use; crop and livestock diversification; biological plant and animal health management; and appropriate farm level mechanization.

The negative impacts from agricultural intensification on the environment are threats to sustainability of agricultural production systems. The definition of sustainability emphasizes two key concepts: the needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs. Thus, the concept of sustainability takes into account a long-term view of the resource base vis-à-vis agricultural production, equity issues and the role of technology, institutions and policy. It is evident that increasing agricultural production and food security cannot be achieved at zero environmental cost at least in the medium term future. The issue therefore is whether environmental costs can be minimized so that agricultural production and food security is not at risk. Greener agriculture, therefore, aims at safeguarding the productive potential of agricultural resources for future generations and minimizing the trade-offs between economy and environment. Green agriculture is an important step towards a profitable long-term future for farming combining strong economic performance with the sustainable use of natural resources in agriculture.

Most of the negative impacts from agricultural intensification on the environment can be reduced or prevented by an appropriate mix of technologies, institutions and policies. A sustainable approach should try to find out answers for questions like: What are the technological options for putting agriculture on a greener pathway while at the same time not only achieving present requirements, and also laying the foundation for sustainable agricultural development in the longer term? Second, given the inevitability of some tradeoffs between environmental concerns and development (in general) in the medium-term future, what other actions are required to minimize them and ensure progress in agriculture? What kind of institutions and policies would enable to minimize the trade off?

There are several possible interventions to promote green growth in agriculture. Important among them are i) sustainable land management practices; ii) conservation and protection of water resources; iii) reducing chemical inputs application through integrated pest and disease management, integrated weed management, and integrated nutrient management; and iv) organic farming. In addition in the context of green agriculture it is imperative to discuss the strategies to reduce GHG emissions from agriculture and the role of biotechnology and biofuels.

5.3.1 Land Management

Erosion from steep slopes that are difficult to cultivate and inherently unstable is commonly followed by the re-deposition of sediments in reservoirs, in river valleys and estuaries. On the other hand, by reducing the storage capacity of drainage systems this erosion can contribute to severe flooding, loss of human life and serious economic losses and it may be impossible to restore eroded slopes to their original vegetation. Investment in soil conservation practices prevents such environmental problems. Watershed development programmes can also be strengthened for soil and water conservation. The problem with land degradation is that it is a very slow process and difficult to recognize it in the short run. Similarly the impact of soil conservation is also felt in the long run, and farmers with short time preferences may not make necessary investments.

Farmers in various parts of the world are mining soil nutrients because they lack access to sufficient organic manure or mineral fertilizer. Sustainable agricultural production depends on replacing most of the soil nutrients removed in the harvesting of crops, otherwise nutrient mining will take place and production will not be sustainable. More location specific research is needed on the use of mineral fertilizers with organic manures and other biological inputs. In particular there is need for better and less costly integrated plant nutrient systems and improved transport and marketing systems to lower relative mineral fertilizer prices, and provide incentives for more sustainable agricultural practices. This requires more investment on soil testing and other policy initiatives. Land degradation in dry land areas and consequent desertification can be prevented by improvements in farm practices, such as soil moisture conservation, and the development through research of leguminous live mulches and other water conservation techniques. There is now greater emphasis on improved water management and drainage through investments and institutional changes. The assessment of land degradation is greatly hindered by serious weaknesses in our knowledge of the current situation and systematic methods and infrastructure is required for effective monitoring and accounting of land degradation.

5.3.2 Water Management

Water scarcity and inter-sectoral competition for water are major problems. Reduced groundwater recharge because of deforestation and soil degradation is also an important issue. The approaches for sustainable use of water in agriculture include increasing water use efficiency, improving the management of surface irrigation systems, people's participation in operation and maintenance of irrigation systems, and promotion of water saving crops and technologies like drip irrigation systems. Research is needed to find more economic ways of preventing further deterioration of existing water resources and to widen the technological options for the future as well as to identify institutional characteristics of successful irrigation management systems. To address the issue of salinization: (i) greater investment in better drainage and distribution canals (ii) better water management, for example through the increasing involvement of farmers in water users' associations and similar bodies; and (iii) stronger economic incentives for water conservation, through appropriate water-pricing policies which reflects the scarcity value of the water are required.

Economic policies often dictated by political compulsions leads to inappropriate incentives for farmers in the choice of technology and water management practices. Water markets can efficiently allocate water among different users. However efficient functioning of water markets requires strong institutional frameworks and secure water rights. Energy subsidies encourage groundwater mining and the under pricing of canal water steers farmers away from water-efficient crops.

Water scarcity often result in low productivity and extensive agriculture, increased use of energy for lifting water from deeper aquifers, while at the same time promoting adoption of water-saving crop pattern and water-saving technologies that are helpful to increase productivity per unit of water used. Therefore, policies that make the farmers realize the scarcity value of water are the immediate priorities. Removal of fiscally and environmentally unsustainable policies in water sector tops the list of such policies. As electrical energy consumption in agriculture is directly proportional to the volume of groundwater used for agriculture, water-saving technologies could often result in energy saving.

5.3.3 Regulation of Pesticide Use and Reducing Pesticide Pollution

Improved screening methods for pesticide safety and environmental health legislation are needed to reduce the mammalian toxicity of pesticides and to assess other potential environmental damage. Developed countries are increasingly using taxes and regulatory measures to reduce pesticide use. Research in "smart" pesticides using advances in biotechnology, knowledge of insect hormones and insight into the ecological basis of pest control, etc. is likely to result in safer control.

Environmental problems arise from the accumulation of pesticide residues along the food chain, in soils and in water and a number of important lessons can be drawn from past experience. Moreover, in the context of consumer safety and the WTO agreements, rigorous procedures must be in place to ensure food safety and enable agricultural exports. Rigorous testing procedures must be in place to determine the safety of pesticides before they are allowed on the market. It is s essential to relook into the testing, licensing and control procedures and have to tighten the procedures with a view on environmental and human and animal health. There must be comprehensive and precise monitoring systems to give early warning of residue buildup. The international sharing of information, e.g. through the Codex Alimentarius, provides valuable support to developing countries that lack adequate monitoring and testing facilities. Economic as well as regulatory measures need to be implemented to create economic incentives to reduce pesticide use. Sufficient institutional capacity also needs to be created for effective implementation of such policies. Focus of plant protection research needs to be gradually shifted towards development of alternative methods of pest control to reduce pesticide use in agriculture like Integrated Pest Management (IPM). Implementation of IPM framework is complementary strategy in our efforts to minimize the use of pesticides.

Integrated Pest Management (IPM): The intensification of farming facilitates pest buildup, and the high-yielding varieties are often more susceptible to pests than traditional ones. IPM promotes primarily biological, cultural and physical pest management techniques, and uses chemicals only when essential. It uses a combination of methods to achieve environmentally safe and economically feasible alternative to chemical control of pests. Bio-agents and bio-pesticides are the important components in the IPM strategy. To ensure the success of this process, the presence and density of pests and their predators and the degree of pest damage are systematically monitored. No action is taken as long as the level of the pest population remains within specified limits. Naturally occurring biological control is encouraged, for example through the use of alternate plant species or varieties that resist pests, as is the adoption of land management, fertilization and irrigation practices that reduce pest problems. If pesticides are to be used, those with the lowest toxicity to humans and non-target organisms should be the primary option. Precise timing and application of pesticides are essential. Broad spectrum pesticides are used only as a last resort when careful monitoring indicates they are needed according to pre-established guidelines. In this broader focus, judicious fertilizer use is also receiving attention. IPM is a decision-making and action-oriented process that applies the most appropriate pest control methods and strategy to each situation.

5.3.4 Reducing External Inputs through Integrated Nutrient Management

Developed countries in Europe and North America have used a number of research and regulatory measures to limit pollution from fertilizers, such as research on slow release and other less polluting formulations, tighter emission and discharge standards for fertilizer factories with higher fines on the violations, public and private extension services, physical limits on the use of manure and mineral fertilizers and application of the nutrient budget approach. All of these actions are or will be relevant to India also. They can be formulated in the framework of a strategy for integrated plant nutrition. The consumer-led drive towards organic agriculture and adoption of no-till/conservation agriculture (NT/CA) are complementary strategies for reducing pollution by fertilizers.

Substitution of Chemical Inputs with Bio-inputs: Indiscriminate use of synthetic fertilizers has led to the pollution and contamination of the soil, water bodies, and destroyed micro-organisms and beneficial insects thus making crop production more prone to pests and diseases and reduced soil fertility. Therefore, biofertilizers offer a promising alternative to chemical fertilizers. It is estimated that by 2020, to achieve the targeted production of 321 million tonnes of food grain, the requirement of nutrient will be 28.8 million tonnes, while their availability will be only 21.6 million tonnes leading to a deficit of about 7.2 million tones (Mahdil et al., 2010). Therefore, biofertilizers have a predominant role to play in meeting the nutrient requirements in future. To the extent the biofertilizers replace inorganic fertilizers, there will be twin advantages of reduced GHG emission during the production of chemical fertilizers and the soil organic carbon will increase thus resulting additional capture of carbon in the soils.

Table 5.3: Some Projections on the Nutrient Availability (NPK) from Few Organic Resources: 2005-2025

Particulars	2005	2010	2025
Nutrient (theoretical potential) in million tonnes			
Human excreta	2.00	2.24	2.60
Livestock dung	6.64	7.00	7.54
Crop residues	6.21	7.10	10.27
Nutrient (considered tappable) million tonnes			
Human excreta	1.60	1.80	2.10
Livestock dung	2.00	2.10	2.26
Crop residues	2.05	2.34	3.39
TOTAL	5.05	6.24	7.75

Source: Mahajan and Gupta, 2009.

An alternative estimate of availability of organic inputs / raw materials provided by National Centre of Organic Farming[3] is given below:

i)	Live stock	=	2.47 million tons
ii)	Crop residues	=	2.00 million tons
iii)	Biogas slurry	=	0.12 million tons
iv)	Biofertiliser	=	0.20 million tons
v)	Green manure	=	0.10 million tons
vi)	City refuse	=	0.68 million tons
vii)	Others	=	1.00 million tons
	(Rural compost, Vermicompost, Agricultural Waste)	=	6.57 million tons
	Total	=	7.0 million tons

In spite of the significant environmental benefits, large-scale use of bio-inputs is constrained by several factors. Inadequate supply due to limited production capacity is an important constraint. Currently, there are about 114 producers of organic inputs and bio-fertilizers with an installed capacity of 18,500 tons. According to estimates of the National Bio-fertilizer Development Center (NBDC) and the Bio-Tech Consortium of India Ltd (BCIL) about 344,800 to 507,032 tons of bio-fertilizers are required for Indian

[3] See http://ncof.dacnet.nic.in/

agriculture[4]. As the gap between available production capacity and the demand for biofertilizers is substantial, there is a need to make huge public and private investment in building additional capacity for biofertilizer production.

Table 5.4: Biofertilizer Production in India

Year	Biofertilizer production (Tonnes)
1992-93	2005
1997-98	7105
2003-04	9799
2008-09	24455

There are several constraints in the adoption of biofertilizers also, such as supply shortages and uncertainties, lack of experience in handling biofertilizers, and lack of quality standards. Of course, slow response of crop yield in early stages of adoption of biofertilizers is one of the main constraints in its adoption. Biofertilizers have important environmental and long-term implications, negating the adverse effects of chemicals. At the farm level, the gains from increased use of technology can have spatial and temporal spill-over through lesser water pollution and soil damage than chemical fertilizers. The environmental gains from the new technology may not be perceived over a short span of time unlike for chemical fertilizers, which yield quick returns. At the same time the farmer has to incur considerable initial cost in terms of skill acquisition and risk. In agrarian situations where agents often operate with bounded rationality, adoption may be slow and influenced greatly by neighbours' experiences over time. In view of the multitude of constraints affecting biofertilizer production and consumption, strong government intervention in the form of provision of subsidies, credit and insurance, training, research and extension is needed at least in the early stages of promoting biofertilizers.

5.3.5 Organic / Sustainable Agricultural Practices

Sustainable and organic farming practices are the major contributors for achieving green growth in agriculture. With increasing adoption of organic farming practices in many parts of India, it is emerging as a promising alternative for mitigating greenhouse gas emission from agriculture, apart from producing a host of other environmental and health benefits. Adoption rate of sustainable agricultural practices in India was estimated to be in the order of 4.5 million ha per year, with a carbon sequestration potential of 78.2

[4] Please see http://www.imdr.edu/marketing_of_bioferlizers.html for further details.

million tonnes of carbon over the period 2003-2012, with a net present value of US $ 541.3 million over this period (Niles, et al, 2002).

Present Status and Future Potentials of Organic Farming: Organic farming is an option in agricultural production that enables Indian smallholders to attain household food security and modest income while regenerating the land, regaining biodiversity, and supplying quality food to local communities. Organic farming in India is still in its nascent stage, in spite of some initiatives by the Central and State Governments. Several forward looking strategies were initiated in 2000, including constitution of a steering group on agriculture that identified organic farming as national challenge and suggested its implementation in project mode during the 10th Plan with special emphasis on North East region and rain fed areas; the recommendation by National Agricultural Policy (2000) for promotion of traditional knowledge of agriculture relating to organic farming and its scientific up-gradation; the recommendation of the task force on organic farming constituted by the Department of Agriculture and Cooperation (DAC), Ministry of Agriculture; and the launching of National Programme for Organic Production (NPOP) with active support from the Ministry of Commerce for export promotion. Under the NPOP, documents like National standards, accreditation criteria for accrediting inspection and certification agencies, accreditation procedure, inspection and certification procedures have been prepared and approved by National Steering Committee.

The world organic market is now 26 billion US$. The organic area in India is 2.5 million hectare including certified forest areas (Table 5.5). Further, non-certified organic area is more than certified organic area. The National Centre of Organic Farming under Ministry of Agriculture is promoting organic farming as facilitator across the country and providing various assistances to organic entrepreneurs and farmers. The immediate task is to ensure availability of organic inputs and low cost certification process. There is already demand from farmers that there should be separate standards and certification procedures for domestic market. Considering the forward movement of organic market across the world however, there is no need of diluting the standards made for purely organic. But the demand for alternative standard has stemmed from the fact that the large proportion of organic farming either by default or by sustainable practice with use of negligible chemicals could not be certified as the existing standard does not permit it. As a result of it, many farmers in the country are not getting any advantage from the view point of income generation.

Table 5.5: Organic farming in India: An overview (2004-05)

1.	Certified area	2.5 million ha
2.	Total certified product	115,238 metric tonne
3.	Total project certified	332
4	Number of processing units	158
5.	Accredited inspection and certifying agencies	11
6.	Number of products exported	35
7.	States involved in organic export	
(i)	Kerala	1232 metric tonne
(ii)	West Bengal	937 metric tonne
(iii)	Karnataka	476 metric tonne
(iv)	Tamil Nadu	514 metric tonne
(v)	Punjab	521 metric tonne
(vi)	Himachal Pradesh	375 metric tonne
8.	All India total organic export	6472 metric tonne
9.	Premium collected against organic export	Rs. 80-90 crore (tentative)

Source: APEDA, 2004-05.

Problems Facing Organic Agriculture: An important attribute of organic farming technologies is that they minimize the use of external inputs viz., inorganic fertilizers, pesticides, mechanical inputs, and other capital-intensive inputs which characterize conventional farming systems. Instead organic farming results in substitution by family and hired labour, improved management, and use locally available natural resources for external inputs. The labor intensity is both a distinguishing characteristic of organic farming system and a primary constraint influencing their adoption. The availability of local resources such as organic fertilizers and other bio-inputs is also a major constraint in many places. Lack of well-organized certification and quality control arrangements for organic production and products, production and marketing associated with inadequate knowledge on organic farming practices and products and lack of consumer awareness about health and environmental benefits of organic products coupled with low purchasing power in countries such as India are the main constraints affecting widespread adoption of organic farming practices.

Most of the studies done in Europe and in the US suggest a reduction in yield for most crops in comparison to conventional agriculture, particularly in the first two or three years following conversion (Lotter 2003). However, the impacts on crop yield and net profits under organic farming are crop-specific and agro-climatically dependent. A survey of about 200 projects in developing countries in which contemporary organic practices were introduced showed increase in average yield between 5 to 10 percent in irrigated crops and 50 to 100 percent in rainfed crops (Pretty and Hine 2001). Studies have shown that organic farms are less sensitive to climate variability than conventional farms (Welsh, 1999; Drinkwater et al., 1998), and organic cropping reduces the variability in net returns (Helmers et al. 1986). Besides the direct environmental benefits from reduced / no chemical farming, organic agriculture has other benefits such as organic farming systems will reduce the dependence of farmers on energy, with higher solar energy capture, and organic farming can increase the efficiency of energy use per unit of production. It was found that energy use could be reduced by as much as 31 per cent in organic corn production as compared to conventional production and captured 180 per cent higher solar energy, besides increasing soil organic matter substantially (Pimental, 2006).

Though organic farming is environmentally viable option, its economic impacts need to be assessed in a more realistic way so as to make a strong case for it as a sustainable and holistic option. The impact of organic farming has to be addressed in terms of (i) increased requirement of labour and skill, (ii) its impact on productivity and hence on production and price levels of food and non-food crops; (iii) its impact on costs and returns to the farmers; and (iv) its impact on land use changes at macro-level, as reduced productivity / production might lead to diversion of more land for agriculture.

Only limited evidence exists to provide clear support for the viability of organic agriculture, especially in terms of providing adequate livelihood to the farmers pursuing it and lead to overall food security. A recent study by Charyulu and Biswas (2010) provided comparison of organic and conventional agriculture across different agricultural systems in India (Table 5.6). From the table it is clear that organic farming has relatively lower productivity than the conventional farming in most cases, but has more net-revenue (at least in some cases) if the unit prices are more favourable. Studies have also shown that organic farming requires less inputs but more labour. The crucial issues that emerge in this context include:

- Will the price premium enjoyed by the outputs of the organic agriculture continue under wide-spread adoption of such farming practices? If not, how effective this green economy initiative would be in alleviating poverty and providing food security?

- While organic farming could facilitate creation of jobs/livelihoods for a significant number of people in the short-run, the associated lower-productivity may lead to overall efficiency losses in the long-run.

Table 5.6: Comparison of Organic and Conventional Farming Systems: India

Sl.No.	Crop/State	Parameter	Organic Farming	Conventional Farming
1	Paddy, Punjab	(i) Yield (kg/acre)	1335	1836
		(ii) Net revenue (Rs/acre)	17828	20897
2	Wheat, Punjab	(i) Yield (kg/acre)	1170	2042
		(ii) Net revenue (Rs/acre)	28747	24755
3	Cotton, Punjab	(i) Yield (kg/acre)	825	1125
		(ii) Net revenue (Rs/acre)	17673	19608
4	Paddy, UP	(i) Yield (kg/acre)	1518	1807
		(ii) Net revenue (Rs/acre)	11488	17190
5	Sugarcane, UP	(i) Yield (kg/acre)	27364	24333
		(ii) Net revenue (Rs/acre)	30961	26054
6	Wheat, UP	(i) Yield (kg/acre)	1519	1682
		(ii) Net revenue (Rs/acre)	14045	10101
7	Sugarcane, Maharashtra	(i) Yield (kg/acre)	38375	38000
		(ii) Net revenue (Rs/acre)	38854	28680
8	Cotton, Gujarat	(i) Yield (kg/acre)	1263	1400
		(ii) Net revenue (Rs/acre)	34299	27112

Source: Charyulu and Biswas, 2010.

5.3.6 GHG Mitigation Strategies in Agriculture

Apart from the sustainable agricultural practices / strategies discussed above, there are specific strategies pertaining to mitigating GHG emission from agriculture and increasing carbon sequestration through appropriate crop choices (biofuels, agro-forestry, leguminous crops) and crop management practices. They are:

a. increasing carbon sinks in soil organic matter and above-ground biomass;
b. reducing / avoiding carbon dioxide and other GHG emissions from farms by reducing fossil fuel energy use, and reduction in chemical inputs;
c. increasing biofuel production; and
d. increasing renewable energy production from biomass that either substitutes for consumption of fossil fuels or replaces inefficient burning of fuelwood and/or crop residues.

Land Use Changes and Agroforestry Systems as Carbon Sinks: Land-management actions that enhance the uptake of CO_2 or reduce its emissions have the potential to remove a significant amount of CO_2 from the atmosphere if the trees are harvested, accompanied by regeneration of the area, and sequestered carbon is locked through non-destructive (non-CO_2 emitting) use of such wood. Evidence is now emerging that agroforestry systems are promising management practices to increase aboveground and soil carbon stocks to mitigate greenhouse gas emissions. Watson *et al* (2000) reviewed the carbon-sequestration potential of changing landuse management towards more sustainable practices, and concluded that the greatest dividend comes from conversion of arable to agroforestry arising from both increased soil organic matter and above-ground woody biomass.

Carbon management through afforestation and reforestation in degraded natural forests is a useful option, but agroforestry is attractive because: (i) it sequesters carbon in vegetation and possibly in soils depending on the preconversion soil C; (ii) the more intensive use of land for agricultural production reduces the need for slash and burn or shifting cultivation, which contributes to deforestation; (iii) the wood products produced under agroforestry serve as a substitute for similar products unsustainably harvested from the natural forest and (iv) to the extent that agroforestry increases the income of farmers, it reduces the incentive for further extraction from the natural forest for income augmentation. In countries such as India, agro-forestry is the cheapest means of achieving sequestration through land use (Lipper and Cavatassi, 2003). The C sequestration potential of tropical agroforestry systems in recent studies is estimated between 12 and 228 Mg/ha, with a median value of 95 Mg/ha. In India, average sequestration potential in agroforestry has been estimated to be 25 tC/ha over 96 million ha, but there is a considerable variation in different regions depending upon the biomass production (Pandey, 2007). However, compared to degraded systems, agroforestry may hold more carbon. In order to fully exploit the unrealized potential of carbon sequestration through agroforestry, innovative policies that accounts not only for above-ground biomass productivity but also carbon sequestration in the soil, are required. Besides carbon sequestration, nitrogen fixing trees grown in the agro forestry systems are capable of fixing about 50 -100 Kg N/ha/year (Tewari, 1995).

To assure success, agro-forestry (for carbon sequestration) sites should meet a set of preconditions, including: areas of underutilized low-biomass land use systems that are available for rehabilitation; smallholders interested in tree farming; accessible markets for tree products; a supportive local government and sufficient infrastructure;

and a transparent and equitable relationship between project partners (Roshetko, et al, 2002).

Carbon Capture in Soils: As a major carbon pool on earth, soil organic carbon may act either as a sink or a source of atmospheric CO_2, a greenhouse gas. Soil organic carbon is also impacting fertility, and, in turn, crop yields (Benbi and Brar, 2009). Therefore, an important and economical way to increase carbon in the terrestrial biosphere is to enhance soil carbon accumulation in agricultural ecosystems (Kauppi and Sedjo 2001). A change in agricultural practice can increase carbon sequestration in soils. Management options for sequestering soil organic carbon (SOC) include a decrease in tillage intensity, a change from continuous to rotation cropping, and a decrease in fallow period (Paustian et al., 2000). In addition to mitigating greenhouse gas emissions, carbon sequestration strategies for agricultural soils can provide environmental benefits such as decreased soil erosion, increased soil water capacity, increased retention of soil nutrients and increased productivity, reduced risk of soil erosion and sedimentation, decreased eutrophication and water contamination (Follett, 2001; Lal 2007). Use of animal manures and crop residues to enhance soil biodiversity, especially earthworm activity and cover cropping in organic agricultural systems can contribute to soil organic carbon sequestration.

The total potential for SOC sequestration in Indian soils is estimated to be 12.7 to 16.5 X 10^6 tonnes of carbon/year. In addition, there is also a potential of soil inorganic carbon sequestration estimated at 21.8 to 25.6 X 10^6 tonnes of carbon/year. With reduction in erosion-induced emission of 4.3 to 7.2 X 10^6 tonnes of carbon/year, total potential of soil C sequestration in India is estimated to be 39.3 to 49.3 X 10^6 tonnes of carbon/year (Lal, 2004).

Crop Residue Management: Drop in soil organic matter (SOM) due to limited return of organic biomass owing to residue burning has been identified as one of the key impediments to achieve sustainability of the system. Burning crop residues due to lack of efficient and user-friendly technologies for in-situ recycling (Jat et al, 2004) not only leads to loss of considerable amount of N, P, K and S but also contributes to the global NO2 and CO_2 budget (Grace et al. 2002) and destruction of beneficial micro-flora of the soil (Jat and Pal, 2000; Timsina and Connor 2001). Substantial quantum (80.12 mt/annum) of crop residues is available (Pal et al, 2002) for recycling in rice-wheat system having a nutrient potential (NPK) of 1.61 mt and fertilizer replacement value of 0.804 mt if, location/situation specific efficient technologies are made available to the farmers.

Reduced Tillage or Zero Tillage: One of the most important principles of Conservation Agriculture is minimal soil disturbance. Recent years have seen rapid adoption of 'conservation tillage' or 'zero tillage', first in Americas, which is spreading to Asian countries. These systems of cultivation maintain a permanent or semi-permanent organic cover on the soil, comprising either a growing crop or dead organic matter in the form of a mulch or green manure. The function is to protect the soil physically from the action of sun, rain and wind, and to feed soil biota, thus reducing soil erosion and improving SOM and carbon content. No-till or zero till system has been tested and is presently being practiced over 2.0 million hectares of India (RWC-CIMMYT, 2005). This technology is more relevant in the higher yielding, more mechanised areas of India, where most land preparation is now done with tractors.

In India, the burning of non-conventional fuel for farm operations and resultant emission of greenhouse gases is severe in agriculturally most important region, i.e., Indo-Gangetic basin. Rice-wheat is the dominant system of this region wherein conventional method of land preparation/sowing, not only disturbs the soil environment but also leads to atmospheric pollution. It is estimated that for each liter of diesel fuel consumed, 2.6 kg of CO_2 is released to the atmosphere. Assuming that 150 liters of fuel is used per hectare per annum for tractor uses and irrigation purposes in conventional system, would amount to nearly 400 kg CO_2 being emitted per annum per hectare. Hence, in the direction of CA, no-till system has been proved to be the important step in the conservation agriculture and economic growth. A number of works have been done (Gupta et al 2002, 2005, Ladha et al 2003, Malik et al, 2005) to demonstrate the savings on fuel, labour, irrigation water, production cost, energy etc along with positive effects on soil health and environmental quality benefits of no-till system in India.

A major factor inhibiting the adoption of reduced tillage practices is the additional risk perceived by farmers and its effect on net revenues. These risks include the potential for reduced yields during early years of adoption, increased yield variability that reduced tillage practices may introduce, input use variability, and the human and/or physical capital investments that producers may have to incur. The threshold level of net returns at which farmers would begin to increase the adoption of conservation tillage could be achieved through incentives such as subsidies. This incentive must overcome the cost associated with variability of net returns before a risk-averse farmer will adopt reduced tillage practices. Therefore, before finding the incentive level that will induce a switch to reduced tillage, farmer risk-aversion behavior must be considered (Ugarte, et al, 2004).

Energy Saving in Agricultural Operations: Since in agriculture sector, the quality of electricity supply is poor, the tariff structure is a flat rate and in most cases, zero, there exists no incentive to invest in high efficiency pump-sets, characterized by wastage of electricity. Pump efficiency has the most dramatic effect on carbon emissions from electricity used for groundwater pumping. If pumps are only 20 percent efficient instead of the 30 percent, carbon emissions increase by 50 percent over the baseline (Nelson, 2009). There is a scope for achieving 40 – 45 % saving in electrical energy consumption through demand side management options (Bureau of Energy Efficiency and Maharashtra Electricity Development Authority, 2007).

5.3.7 Biotechnology in Agriculture

The primary benefits of agricultural biotechnology arise from productivity gains and quality improvements. This mean higher crop yields, lower pesticide applications, less demanding production techniques, higher product quality, better storage and easier processing, etc. Biotechnology holds the promise of boosting productivity the same way as the green revolution during the late 1960s and 1970s. Much of the incremental food production in the future has to come from higher yields. But the last decade witnessed a slowdown in yield growth in some high intensity systems in India. The Bt cotton has already demonstrated that biotechnology could kick-start a new virtuous cycle of productivity growth, increased output and revenues.

The other important advantage of biotechnology includes:

- The embedded nature of the technology, such as pest resistance in Bt cotton, have reduced output losses that are typically caused by inappropriate or inadequate input applications. So such embedded technologies are beneficial for countries like India where sophisticated production techniques are difficult to implement or where majority of farmers do not command the management skills to apply inputs at the right time, sequence and amount.

- The marginal production environments such as dry land and degraded lands are often characterized by drought, moisture stress, extreme temperatures, soil salinity or acidity. These resource poor regions are where majority of the poor live and increasing the potential to grow food in such environments is therefore doubly important in the fight against hunger and poverty. Biotechnology is a potent tool for development of cultivars with traits to cope with such biotic and abiotic stresses.
- A study carried out in India found that Bt cotton has reduced pesticide applications by 50%, with the largest reductions of 70% occurring in the most toxic types of chemicals. Bt has notably reduced the incidence of acute pesticide poisoning among cotton growers. These effects have become more pronounced with increasing technology adoption rates. Bt cotton now helps to avoid several million cases of pesticide poisoning in India every year, which also entails sizeable health cost savings besides reducing pesticide residues in agro-ecosystems. Extrapolating the estimation results to India as a whole, Bt cotton now helps to avoid at least 2.4 million cases of pesticide poisoning every year, which is equivalent to a health cost saving of 14 million US$. These are lower-bound estimates of the health benefits, because they neglect the positive spillovers that Bt cotton entails. Alternative estimates suggest that Bt cotton may avoid up to 9 million poisoning incidences per year, which translates into a health cost saving of 51 million US$ (Kouser and Qaim, 2011).

Bt technology may not be the only option to reduce chemical pesticide use in cotton production. In some regions, pesticides are overused, entailing a disruption of beneficial insects and increasing pest levels (Gutierrez et al., 2006; Pemsl et al., 2008). In such cases, pesticide reductions would be possible without a loss in productivity. More careful pest scouting and biological control measures—such as promoted in integrated pest management (IPM) programs—could also help to cut down chemical pesticide use. However, IPM is labor and knowledge intensive, so that it is not widely adopted in smallholder agriculture (Lee, 2005). In any case, IPM and Bt technology are highly complementary approaches (Romeis et al., 2008), so that pursuing one should not be seen as a substitute for the other.

Globally, adoption of biotech crop varieties has reduced pesticide spraying by 352 million kg (-8.4%) and, as a result, decreased the environmental impact associated with herbicide and insecticide use on these crops (as measured by the environmental impact quotient) by 16.3%. The technology has also significantly reduced the release of greenhouse gas emissions from this cropping area, which, in 2008, was equivalent to removing 6.9 million cars from the roads (Brookes and Barfoot, 2010). Therefore, development and adoption of drought tolerant and pest- and disease-resistant crop varieties through genetic engineering offers tremendous potential to reduce GHG emission besides increasing productivity and farm income in India.

5.3.8 Biofuels

Biofuels offer huge potential to ensure sustainable supply of green energy for Indian economy, besides creating rural employment through productive use of wastelands. It was estimated that by dedicating 33 mha of degraded lands at a woody biomass productivity of 4 tonnes per ha per year, 100 TWh of electricity could be produced annually, meeting most of the rural electricity needs as well as providing carbon mitigation benefit of 40 MtC annually (Pretty, et al 2011). The total area of wasteland that could be successfully harnessed for biofuel (Jatropha) cultivation in India has been estimated to be 32.3 mha. However, actual availability based on access of land for biofuel plantations depends on a number of factors including climatic and soil conditions, access to infrastructure such as roads and electricity, as well as the ownership of the land. The available information about wasteland suitability for oilseed plantations is sketchy and a proper wasteland mapping exercise should precede any major biodiesel development program in India (Gunatilake, 2011). Francis et al (2005) have estimated that cultivation of jatropha in 10 mha of wastelands by the year 2030 will produce about 5 million litres of biodiesel per year with an annual carbon sequestration potential of about 23 million tonnes, besides generating additional 5 million man-days of employment.

Bioethanol production from sugarcane offers significant potential to substitute for fossil fuel. However, area under sugarcane needs to be stepped up substantially to meet the increasing ethanol demand under different scenarios of ethanol blending with petrol. Using simulation exercises, Schaldach et al (2011) estimated that, the area for sugarcane production increases by 46% (5% blending scenario), 79% (10% blending) and 144% (20% blending) under various blending scenarios. Expansion in sugarcane area is at the expense of the extent of natural land, which correspondingly decreases by 45%, 47% and 51%. However, adoption of yield increasing technologies such as drip-fertigation has huge potential to increase the existing yield levels of sugarcane and hence area expansion could be minimized if these technologies are adequtely supported through public policy.

5.4 Green Initiatives, Rural Employment and Equity

Environmental concerns are no longer a luxury for developing countries or for the poor. When high environmental costs are imposed under conditions of poverty, it is commonly taken for granted that poverty explains the behavior of people vis-a-vis the resources. The hypothesized mechanism works (in economic parlance) via the shortening of the time horizon of the poor. This means that in conditions of abject poverty the need for survival today takes high precedence over considerations for survival tomorrow. The poor simply do not have sufficient means to provide for today and also invest in resource conservation and improvement to provide for tomorrow. But sustaining the resource base is in fact a pre condition for achieving an inclusive growth and ensuring equity in agriculture on which a large number of poor farmers depend for sustenance. Degradation of natural resources undermines the basis for agricultural production and increases vulnerability, particularly of the small and marginal farmers. Agricultural resources are the major economic assets on which majority of farmers in India depend for employment and income. Unsustainable use of natural resources like land, water, forests, diversity of crops imposes high economic losses in the long-run.

Green initiatives often create more jobs than conventional approaches, thus contributing for poverty reduction. According to a Woods Hole Research Center report, India could create some 900,000 jobs in biomass gasification by 2025. Another 150,000 people might find employment in advanced biomass cooking technologies. These numbers do not include jobs generated in biomass collection and on biomass plantations (Holdren, 2007).

Soil conservation activities such as land terracing, contouring, and building irrigation structures are labor intensive and are urgently needed to prevent further resource degradation. Removing subsidies for chemical fertilizers and pesticides and embracing alternatives such as integrated pest management and greater crop rotation and diversification would have positive job implications.

The transition to sustainable agriculture will involve greater use of organic farming methods, another growing source of jobs. If the demand for organic produce continues to grow worldwide, employment growth in this area would be substantial since most organic farming practices are labour-intensive, thus helping the landless poor to benefit from green growth initiatives.

Agroforestry could contribute to livelihood improvement in India, where people have a long history and accumulated local knowledge. Trees in agroforestry systems can provide host to globally valued products and thus support livelihoods locally. Suitable community plantations of timber and non-timber forest products in tribal areas can potentially serve the multiple goals of conserving useful species, carbon sequestration and livelihood improvement of local people. Besides benefiting directly from local forestry products, payments for carbon credits to poor forest communities and farmers growing agro-forestry will provide substantial income support thus reducing poverty significantly.

Land use change is a key requirement for improving rural incomes and making a significant reduction in poverty levels globally. Land use change is also a relatively low cost and rapidly implementable means of climate change mitigation. To the extent that the land use changes required for poverty alleviation coincide with that required for carbon sequestration, significant synergies can be harnessed in meeting both objectives. However, it is not always a case of "win-win" situation. In some situations, land use changes which lead to poverty reduction may conflict with carbon sequestration, or be much less efficient than other types of land use change as a source of climate change mitigation, just as carbon sequestering land use changes may actually exacerbate poverty. Clearly, therefore, some categorization of land use changes in terms of their impacts on poverty reduction and carbon sequestration will be useful for targeting efforts. Information on the conditions under which tradeoffs versus synergies are present between poverty alleviation and carbon sequestration is essential for designing projects which generate both, as well as indicating the need for compensation in tradeoff situations.

The participation of poor in carbon sequestration programs and the costs and benefits to them are determined by the property rights over land, opportunity costs of land, risks associated with land use changes, investment capital required to make land use changes, and the ability of current and proposed land use in carbon sequestration (Lipper and Cavatassi, 2003). To overcome the problems of property rights and opportunity costs associated with land conversion, the wastelands may be distributed to the rural poor on long-term lease following Tamil Nadu's model of two-acres of free land distribution scheme. Biofuel plantations and/or agro-forestry plantations for carbon sequestration should be made mandatory for such land transfer programs.

5.5 Road Map for Operationalizing Green Initiatives

Primary interest for policy is not only how to break the vicious circle between increasing poverty and resource degradation but also how to manage the process of development in ways which minimize the trade-offs between it and the environment. Such an approach should ensure that it is not solely anchored on a carbon-centric approach but encompasses the whole array of environmental and equity concerns of Indian agriculture. Public investments in roads, education, irrigation, and research and development (R&D) can produce competitive rates of return and positive outcomes for poverty and the environment especially in less-favored areas.

Many factors affect private incentives for managing resources, including information, prices, subsidies, interest rates, market access, risk, property rights, technology, and collective action. Getting the incentives right is the first step towards sustainability. Improving natural resource management requires removing price and subsidy policies that send the wrong signals to farmers, strengthening property rights, providing long-term support to natural resource management. The issue of private interests of farmers and the larger social value of the environmental services they degrade needs to be addressed through suitable interventions. Incentives comprise not only better prices for outputs and lower ones for inputs but also the provision to agriculture of public goods such as infrastructure, education, research, and payments for environmental / ecosystem services from agriculture, etc.

In India, small farmers are showing preference for organic farming practices because it reduces their cost of cultivation (FAO, 2007). Small-farm agriculture involves a qualitative move away from environmentally harmful inputs and toward methods that utilize more human labor, farmer expertise, and community experience. Small farmers' organizations and agricultural workers' unions stress that land reform, access to markets, affordable finance, and other resources are all essential to achieve sustainable agriculture.

5.5.1 Land use and land management policies

Land use is an important dimension of promoting green growth in agriculture in India. As the population pressure on land is increasing, so is the need to produce more and more food with limited land resources. While enhancing agricultural productivity continues to be a major land-saving strategy, long-term policies are needed to allocate land in an economically optimal and ecologically sustainable basis. Land zoning, land use planning, use of wastelands for productive purposes and protection and conservation of common property resources are some of the strategies to manage the quantitative dimension of land. Diversion of prime agricultural lands for non-agricultural purposes needs to be regulated at national, state and at region-levels. Protection of CPR and open access land resources may be achieved through assigning private property rights over the entire land or assigning usufructory rights over the productive benefits from such lands.

5.5.2 Incentives for Eco-friendly Practices

The existing policies on various subsidies to agricultural sector need to be reviewed so as to rationalize them on economic and environmental grounds. Policy changes should particularly focus on the reduction and eventual removal of ecologically perverse subsidies that distort the true costs of unsustainable agricultural inputs, and on instigating pricing and regulatory reforms that account for associated environmental degradation costs in food and commodity prices. Environmentally harmful subsidies such as electricity and water subsidy need to be replaced with subsidies for conservation activities such as land management, agroforestry, micro-irrigation, and wasteland and watershed development that will provide multiple economic and environmental benefits. For example, changes in agricultural land management, such as conservation tillage, agroforestry, and rehabilitation of degraded land, could also make a major contribution to greenhouse gas mitigation, enrich the soil, improve yields, and create jobs. Further, removing subsidies that make water inexpensive would create an incentive to conserve resources and stimulate investments in field leveling and drainage, generating on-farm employment.

Agriculture provides several ecosystem services such as pollination, biological control, soil formation, nutrient cycling, carbon accumulation, and nitrogen fixation, and provides ecosystem goods such as food, fodder and fibre (Sandhu et al 2010). Adoption of green agriculture and natural resource management practices has significant positive externalities which cannot be captured by the farmers. Hence, payment for environmental services is an important strategy that appears to have significant potential to increase the economic incentives of sustainable farming, besides providing green employment. Activities such as watershed and forest protection generate universal social benefits, such as clean drinking water, carbon sequestration, and protection of biodiversity. The providers of these services should be compensated via payments from those who benefit from the services so as to make these programs economically viable and sustainable over time.

5.5.3 Policy on Biotechnology

Appropriate policy action could help reconcile some of the conflicting interests of the various stakeholders. A critical analysis of costs and benefits is required to identify appropriate policies. The disconnection of risks and benefits affects numerous stakeholders: consumers versus producers; private companies versus public research institutions. Part of the risk that makes consumers reluctant to accept genetically modified (GM) products are not actual risk but perceived risk. In part, this risk perception reflects a lack of transparency and calls for measures that help to maximize transparency for the consumer. Appropriate labelling is an important step towards higher transparency and thus towards lower risk. It would also help facilitate trade since labels help products to comply with international standards. But labeling requires effective regulatory framework and may result in substantial additional costs and incentives for fraud. The real risk arises due to insufficient testing and premature releases of GM crops for field applications. This calls for better risk assessment procedures and commensurate rules and regulations to minimize the risks associated with applying GM technology.

5.5.4 Policy on GHG mitigation

Site-specific adaptation of appropriate conservation technologies will be needed for sequestering soil organic carbon and reducing nitrous oxide (N_2O) emission. Adoption of improved conservation technologies to mitigate GHG emission should consider: (i) the C sequestration or GHG mitigation potential of alternative technologies or practices, (ii) the price offered for adopting various practices, (iii) the ease with which producers can alter land use and management activities, (iv) the ancillary benefits to soil, water and air quality upon adoption of practices to sequester SOC or mitigate GHG emission, and (v) the effectiveness and efficiency of various policies (Follett et al 2005). Development of improved conservation technologies to reduce GHG emissions could become part of more comprehensive conservation programs aimed at environmental protection, food security, and agricultural sustainability. An overarching research need is to determine the multiple benefits and trade-offs of improved conservation technologies so that land managers can systematically meet production and environmental goals and so that the most effective policies can be devised.

Several studies indicate that agriculture can sequester carbon at a cost competitive with other forms of GHG reductions. The models show that carbon sequestration rates and the amounts achievable vary regionally, and that costs of achieving sequestration depend on whether the sequestration is achieved through afforestation or cropland management changes. Costs also depend on: (1) whether payments are offered per hectare for all hectares in specified management or land uses, or per tonne of carbon sequestered; (2) whether all farmers using a desired practice or only new adopters are eligible to receive payments; and (3) the length of the payment period (Paustian et al, 2006). Transaction costs need to be considered and relate to monitoring, verification, and enforcement. The costs of verification include the impacts of uncertainties and vulnerabilities. Uncertainties are particularly high for methane and nitrous oxide emissions. Sequestered carbon, on the other hand, is vulnerable because wildfires or management changes can rapidly release the amount that has been stored. Risk-averse preferences imply that uncertain and vulnerable emission reductions have a lower value than certain and permanent emission reduction (Schneider and Kumar, 2008). Therefore, GHG mitigation strategies under Indian context should take into account these factors so as to decide upon appropriate mix of strategies with minimal cost for given level of carbon sequestration, besides ensuring suitable compensation to the agents involved, mostly the farmers and the rural poor.

5.5.5 Biofuel Policy

Producing biofuel from eroded soils promises to achieve both wasteland reclamation and fuel security goals and is therefore in line with the Government of India's policy of national development. As for as ethanol production from sugarcane is concerned, there are at least three key issues that need to be addressed: i) sugarcane is water-intensive crop and hence increase in price of ethanol will result in diversion of large quantities of water for sugarcane cultivation thus threatening food security; ii) the high opportunity of cost of using molasses and sugarcane syrup for ethanol production; and iii) the price of molasses high temporal variation and hence diversion of large quantities of molasses for ethanol production will increase the price risks. Therefore, possibilities for using alternative feedstocks such as tropical sugar beet, maize, etc for ethanol production should be explored. An important constraint in making land use changes towards biofuel production is the relative profitability of land in alternative uses. Competitiveness of biofuels could be further enhanced if the savings of greenhouse gas emissions resulting from substituting biofuel for fossil fuels were to be monetized in the form of tradable carbon credits (Certified Emission Reductions of greenhouse gases) through the Clean Development Mechanism under the provisions of the Kyoto Protocol.

5.5.6 Policy on Organic farming

Organic farming practices are not standardized and remain largely location- and crop-specific. Lack of certification standards and manpower availability for certification, public good nature of the ecological benefits of organic farming, lack of consumer and producer awareness about its long-term benefits all hinder its large-scale adoption. Hence, public support and government intervention in organic farming could revolve around the following aspects:

Financial policy instruments (supply side)

- Producer support by area payments: Payments may be considered for conversion to and/or continuation of organic farming
- Inspection cost support- The cost of inspection and certification should be shared by the government
- Grants/subsidies for making initial investments
- Animal welfare / improvement programme to increase and sustain animal-based organic farming activities

Financial policy instruments (Demand side)

- Support for marketing initiatives
- Public procurement projects
- Investment grants for processing and distribution of organic products
- Support for marketing of organic agricultural products
- Support for new sales structure
- Feasibility studies, market analyses and inventories
- Investment grants for consumer cooperatives selling organic products

Capacity building policy instruments (Supply side)

- Advice and technical assistance
- Vocational training and education programmes to create awareness about organic production methods as well as the environmental and sustainability benefits of organic farming
- Research support for organic farming
- Investment grants for demonstration projects
- Support for capacity building and institutional structures

Capacity building policy instruments (Demand side)

- Information and promotion campaign to create awareness about environmental and health benefits of organic products
- Public education and research on demand side issues in marketing, processing, distribution of organic products and consumer attitude towards organic products
- Support for fairs, exhibitions and organic events

Efforts may be made to promote organic green food or eco-friendly food (which allows the use of limited and specified agrochemicals of safe level in the line of standard made by local Public Health Department) as being practiced by China on large scale. By this way, much of the cultivated land can be transformed to organic production and environmental efficiency can be increased. But the whole process needs more study and it is ultimate choice of farmer and consumer who will finally dictate the policy for better agriculture in the country (Bhattacharyya and Chakraborty, 2005).

With the focus on climate change, there are now strongly competing claims as to which farming systems—conventional or organic—deliver most in terms of reducing greenhouse gas emissions. Organic farming's reduced productivity and reliance on livestock as an integral part of the system is seen by some as a weakness, but by others as a way of significantly reducing fossil energy inputs, reducing nitrous oxide emissions associated with manufacture and use of nitrogen fertilisers and providing opportunities for soil organic carbon sequestration. At the same time, other environmental concerns still need to be part of the equation. More robust evidence-based assessments of these issues are needed to help identify the relative merits of different approaches and optimal future development paths (Stolze and Lampkin, 2009).

5.5.7 The Role of Information and Institutions

The critical roles of improved management practices and information in the adoption of sustainable agricultural and natural resource management practices implies that the mechanisms by which information about these alternatives is developed, transmitted, and diffused are especially critical to these systems. Information may shape problem awareness and attitudes, which have been shown to be important factors in framing the outlooks and expectations of farmers toward resource problems and technology choice. This awareness is often the first step in leading to subsequent changes in management practices including technology adoption. Therefore, the delivery of right information at right place and at right time plays a key role in enhancing the adoption of sustainable farming practices. Policies to improve the information and knowledge base are likely to lead to important impacts.

Institutions play a role at all levels in green agriculture, as in high-input, high-productivity agriculture. The importance of assured land access deserves emphasis, in part because this is one of the key areas for government policy. Many adoption analyses of sustainable agriculture and natural resource management technologies have demonstrated the key role played by land titling and customary land rights in influencing adoption. Factors that limit the access to resources such as lack of land title, the uncertainty of traditional usufructory rights, land rental, and the prevalence of land encroachments have been shown to reduce the adoption of environment-friendly farming practices. Capital-intensive technologies such as soil conservation, water-saving technologies such as drip or sprinkler irrigation systems, etc will not be adopted when there are significant uncertainties in capturing their long-term benefits. Assuring rights to land and water resources will facilitate farm households in gaining the long-term benefits of current period investments and technology adoption, and thereby make those investments more attractive. Rural households engaged in managing rural common property resources such as irrigation tanks, pasture lands, and community forestry cannot be expected to invest in expensive maintenance or conservation unless there is a secure and long-term rights over the usufructs and multi-benefit attributes of these resources.

Collective action plays a key role in ensuring sustainable resource management in agriculture. Collective action is also important in enabling farmers to address market imperfections and transactions costs, such as in surmounting information, credit, and marketing constraints. Agricultural and rural development policies should have a specific and well-crafted policy component to ensure collective action towards resource management and conservation. The model of Self-Help Groups could be emulated to ensure the success of such policies.

National agricultural research system in India has made strides in refocusing at least some of the agricultural research portfolios on low-external input agriculture and natural resource management systems, however, the commodity orientation of our research systems still dominates. Therefore, reorienting our national agricultural research system on sustainable agricultural production and natural resource management is the need of the hour. The critical constraints are typically not ones that are most directly addressable by basic laboratory and experiment station-based research, but by an interactive process of adaptive research based on identifying farmers' (often highly heterogeneous) needs, and fostering collaborations among farmers, scientists, extension workers, and the institutions, both formal and informal, with which they are associated. This agenda calls for a three-dimensional research paradigm that integrates scientific investigation across genetics and biotechnology, ecology and natural resources and not least socio-economics to keep in focus the development environment that characterizes the livelihoods and food security of the poor. A strong research agenda for rainfed areas is necessary to ensure further growth in productivity of foodgrains. Technological advances in biotechnology, biofuel production and biomass energy need to be fully exploited. Similarly, research on organic farming needs to be stepped up to standardize organic farming practices for various crops and regions. Applied research and NGO networks, working in concert with farmers, are particularly well suited to serve as a vehicle for the development, transmission, and adaptation of this knowledge. The revolution in information technology for precision farming, applied research in understanding ecological systems as production ecology and gene revolution for advancement in biotechnology have brought about major technological changes in agriculture, which need to be exploited to benefit the environment and for promoting green growth in agriculture. Increased investments in demand-led, farmer-centered adaptive research on sustainable agriculture and natural resource management technologies will help in improving understanding of the under-lying scientific base of integrated nutrient management, integrated pest management, and other similar practices and systems.

5.6 Conclusions

By way of summary the Table 5.7 provides an overview of prioritization of various policies for ushering green initiatives in agricultural sector in India.

Table 5.7: Prioritization of Policies for Agriculture

Details	***High impact strategies***	***Slow Impact strategies***
Short-term measures	• Integrated pest management • Integrated nutrient management • Integrated weed management • Reduced tillage • Application of soil mulch • Cover crops / green manure crops • Increasing water use efficiency • Midseason draining of rice fields • Crop rotation with legume crops • Management of agricultural residues	• Use of biofertilizers and biopesticides • Precision farming • Ethanol from molasses
Long-term measures	• Watershed development • Agroforestry • Biofuel plantations • Biotechnology • Organic farming • Zero tillage • Withdrawal of subsidy to chemical fertilizers, electricity	• Soil conservation • Biotechnology • Rainfed agricultural development • Reduced post-harvest losses

Chapter 6

PRIORITY SECTORS FOR GREEN ECONOMY INITIATIVES – WATER

6.1 Introduction

India with 2.4 percent of world area and 16 percent of world population shares just 4 percent of global fresh water (Planning Commission, 2008). Being a vast and monsoon-dependent country, water resource potential of India displays a wide variation across time and space. For instance, the average annual precipitation varies from 130 millimeter (mm) in Rajasthan dessert to 11000 mm—the world's highest rainfall—in Assam Mountains. Notably, three fourths of rainfall in India is received just in four months during June-September. Table 6.1 provides information on the water resources potential of the country. From an overall perspective, the total water resource potential of the country is estimated to be about 1869 billion cubic meter (bcum) of which only 1122 bcum can be utilizable under current economic and technological conditions. But, the actually developed resource at present is only about 644 bcum, representing only 57 percent of the utilizable potential.

As shown in Table 6.2, the total water requirement of the country is projected to be in the range of 784-850 bcum by 2025 and 973-1180 bcum by 2050 (GOI, 1999 and 2000). Such an increasing supply-demand gap, especially in the face of economic growth and demographic expansion, leads to a steep decline in per capita water availability. For instance, the per capital water availability, which was 5277 cubic meter (cum) in 1955, has declined to 1970 cum at present. Although non-irrigation demand is likely to quadruple, the essentially rural and agricultural basis of Indian economy will continue to orient the water sector essentially towards its irrigation sub-sector. This underlined the critical role of water in supporting food and fiber production and livelihood generation.

Table 6.1: Water Resource Potential of India

No	Particulars	Supply (bcum)
1	Annual Precipitation	4000
2	Available Water Resources (47%)	1869
3	Utilizable Water Resources (60%)	1122
	Surface Water (Storage and diversion)	*690*
	Groundwater (Replenishable)	*432*
4	Present Use (SW 63%; GW 37%)-(56%)	640
	Irrigation	*501*
	Domestic	*30*
	Industry, Energy, and Others	*74*

Table 6.2: Projected Water Demand by Sectors: 2025 and 2050 (in bcum)

Use	1998	Year 2010		%	Year 2025		%	Year 2050		%
		Low	High		Low	High		Low	High	
Irrigation	524	543	557	78	561	611	72	628	817	68
Domestic	30	42	43	6	55	62	7	90	111	9
Industry	30	37	37	5	67	67	8	81	81	7
Power	9	18	19	3	31	33	4	63	70	6
Navigation	0	7	7	1	10	10	1	15	15	1
Ecology	0	5	5	0	10	10	1	20	20	2
Evaporation	36	42	42	1	50	50	6	76	76	7
Total	629	694	710	100	784	843	100	973	1180	100

Source: GOI, 1999

6.1.1 Economic Contributions

From a national perspective, the water sector plays a critical role in the overall structure of Indian economy thanks to its critical role both in consumption and production. As a result, the poverty alleviation and livelihood generation roles of water sector are very critical from a green economy perspective. Given its current level of food consumption and projected population of around 1.6 billion, India is expected to have a food demand of about 400 million tones (mt)—about twice the present food production—by 2050. Meeting this raised food demand requires an additional irrigation of 60 mha (Amarasinghe, et al., 2007a and 2007b). Considering the fact that water available for irrigation will be reduced due to increase in non-irrigation needs, this additional irrigation has to be achieved essentially through an improvement in use efficiency. The National Water Mission, which is one of the eight missions associated with the National Action

Plan on Climate Change aims to achieve a 20 percent improvement in water use efficiency, especially in agriculture.

In addition to the huge magnitude of employment and income generated in irrigated agriculture, the water development projects also create considerable amount of both direct and indirect employment. The total employment in this respect is estimated to be about 20 million man years annually (Planning Commission, 2008). Beside the socio-economic benefits from non-consumptive uses such as navigation, water sector also contribute green hydropower. Of the total installed capacity of 224906 mega watt (mw) from all power sources, hydropower accounts for to 51207 mw. This represents a share of about one-fourth in the total power generating capacity in the country (Planning Commission, 2008). It is in view of these multiple economic and energy contributions that water sector remains an important component of the economy-wide green economy initiatives.

6.1.2 Issues and Challenges

From the perspective of its transition to a green economy, the water sector faces a plethora of issues and challenges. These issues and challenges can be broadly classified in terms of three critical gaps: the physical gap, financial gap, and economic/incentive gap (Saleth, 2004). These three gaps capture respectively the physical and economic sustainability of the resource system, financial viability of the water sector, and economic efficiency of resource use. The physical gap can be evaluated in terms of both the gap between water resource potential and its utilization as well as the gap between water demand and supply. The financial gap can be indicated in terms of the gap between water sector investment and cost recovery. Similarly, the economic/incentive gap can be reckoned in terms of the gap between the average actual economic value of water and the water rate being charged. The utilization gap is already shown in Table 6.1. The demand-supply gap, which has already assumed serious proportions at the local and regional context, is also growing at the national and aggregate level. This can be seen from Table 6.2, which relates the projected water requirements for 2025 and 2050 with the water resource potential that would be available. As can be seen, under the scenario of high population growth and economic growth, water demand in 2050 will exceed our water resource potential.

The demand-supply gap in the overall sectoral context is clear from tables 6.1 and 6.2. In the particular context of irrigation sub-sector, which accounts for the major share of water use, the demand-supply gap is very serious as the actual irrigation potential created so far is only about 88 million hectare (mha) whereas the gross sown area is 185 mha. Even if the estimated ultimate irrigation potential of 139 mha is fully developed, India will still continue to have this irrigation gap as the gross sown area is expected to grow further to 210 mha by 2025. The problem is going to be complicated further by the declining share of irrigation caused by the increasing demand pressures from other water sub-sectors, including environment. This clearly suggests the impending danger of physical water scarcity in future unless policy actions are taken right now in terms of an effective water demand and supply management initiatives. Such initiatives include not only major water institutional reforms but also a large scale program of investment in water infrastructure.

The financial gap in the water sector can be approximated by the difference between the total investment costs and total revenue in the irrigation sector. The total investment in irrigation during 1951-2012 is estimated to be Indian Rupees (INR) 3053 billion at current prices (Planning Commission, 2008; CWC, 2009). The total investment in canal sector alone during 1951-2012 amounts to INR 1727. Even if we assume a simple rate of 8 percent to account for both interest and depreciation, the annual financial cost of canal irrigation provision comes to about INR 139 billion. But, the total annual revenue during 2001-02, the latest year for which we have published data, has been just about INR 7 billion (CWC, 2009). Such a magnitude of financial gap clearly shows the poor performance of cost recovery and water pricing policies and organizational mechanisms involved in fee collection.

The incentive gap shows the extent that water charges remain below the economic value of water. They are related neither to productivity nor to provision cost. They cover hardly 5 percent of water productivity and 8 percent of O&M costs (GOI, 1992a). Paradoxically, since the low water charges are not even fully recovered, the arrears are also accumulating over time leading to a huge financial loss. The low and uneconomic water rates also lead to an incentive problem causing widespread water use inefficiency. The incentive gap can be approximated by the gap among water productivity, supply cost, and water rates. In canal regions, while water productivity has a range of INR 714-5812/hectare (ha), the supply cost has a range of INR 90-603/ha. But, water rates are in the range of INR 6-1000/ha) (GOI, 1992a).

6.1.3 Potential Impacts due to Climate Change

The problems of the water sector are to be further complicated by the negative impacts of climate changes. Global temperatures, if left unchecked, will imply a global warming of at least 1.4°C by the end this century (IPCC, 2007). A warmer climate means that the water or hydrological cycle will be accelerated, creating major disturbances in the temporal and regional patterns of rainfall and water availability. As a result, water is the main medium through which most impacts of climatic change will be felt (Stern, 2008).

For India, where groundwater depletion and water pollution have already assumed serious proportions, the impact of climate change will add further pressure on water resources. Table 6.3 shows the past and projected impacts of climatic change on rainfall under different levels of temperature for India. Although the rising temperature observed in India during the past 100 years has not shown any effect on rainfall pattern at the national level, there are significant variations at the regional level (Mall, et al., 2006). For instance, in the Indo-Gangetic region, the mean summer rainfall over its western parts shows an increasing trend (170 mm over 100 years), but the same in the central and eastern parts of that region show a declining trend (5-50 mm over 100 years).

Notably, a westward shift in rainfall activities has been observed over the past 100 years in the Indo-Gangetic region. In terms of summer monsoon rainfall, the northeast and northwest regions of India experienced a -6 to 8 percent variation whereas the west coast and central peninsula experienced a 10 to 12 percent increase in rainfall (Mall, et al., 2006). There is likely to be a general reduction in run-off level in most river basins of India, with the exception of those relying on the Himalayan system. Since evaporation will be increasing throughout India, there will be a major pressure on available water, especially during the non-monsoon periods. With varying run-off and increasing evaporation, net recharge is expected to get reduced, affecting also groundwater level in many regions in India.

Table 6.3: Past and Projected Impact of Temperature on Rainfall in India

Temperature	Rainfall
Rise in temperature of 0.4°C observed during the past 100 years	• No Change
Winter temperature in the range of 1.0-4.0°C over the next century	• Precipitation increase by 20 percent • Increase in inter-year variability in rainfall • Increase in the number of heavy rainfall days
Average temperature in the Range of 2.3-4.8°C over the next century	• Increase in frequency of heavy rainfall events
Surface temperature in the range of 3.5-5.5°C over the next century	• Increase in annual mean rainfall by 7-10 percent • Decline in winter rainfall by 5-25 percent • Increase in monsoon rainfall by 10-15 percent • Increase of monsoon rainfall of over 30 percent in North-West India by 2050 • Higher than normal rainfall in the Western semi-arid parts of India • Decline in winter rainfall by 10-20 percent in Central India by 2050

Source: Mall, et al., (2006).

6.2 Green Economy Initiatives in Water Sector

Provision of reliable and clean water for direct consumption and adequate and timely water for food, energy, and industrial production is a prerequisite for a green economy (UNEP, 2011: 118). When water of adequate quantity and quality is not delivered to the poor and economic and use inefficiencies persist in water sector, there are heavy social costs in terms of the financial and welfare losses. Initiatives that improve water provision and reduce economic inefficiencies in the water sector can both reduce the social costs and also release substantial funds for investment in developing additional water infrastructure and in reviving the health of both the water dependent and water producing ecosystems. Water savings achieved through improvement in water use efficiency in the agricultural and urban sectors can also help in meeting the environmental flow needs of rivers. Ecosystem functions and environmental flows generate economically valuable food and livelihood options for the poor.

What are the initiatives that will green the water sector? According the UNEP (2011:118), if the 'business-as-usual' continues with no improvement in water use efficiency, the global water demand will exceed water supply by 40 percent by 2030. Improvement in water productivity and increase in water supply through dam construction, desalination, and water recycling are expected to cover only 40 percent of this supply gap. But, the remaining 60 percent needs to come from investment in water infrastructure, water institutional reforms, and development of new technologies. This global projection not only indicates the likely magnitude of the supply gap for India but also suggests the potential initiatives that are to be taken to green the Indian water sector.

The initiatives for creating of additional water supplies such as dam construction and desalinization involve heavy investment and technology. Apart from these traditional options, the initiatives involving the inter-linking of rivers and investment in water-dependent ecosystems that generate additional water (Pattanayak, 2004; Lele and Venkatachalam, 2006) are also very important from a future perspective, especially in the context of climate change. Besides these supply-side initiatives, there are also demand-side initiatives involving institutional and policy reforms. These include: water pricing for full-cost recovery, power tariff and supply policies, water entitlement systems for sectors, regions, and individuals, user and stakeholder participation, water saving technologies and crop patterns, and water allocation mechanisms, including water markets. Since these initiatives improve the incentive for water use efficiency, they will help in promoting water demand management. When investments on supply-side initiatives are coupled with institutional and policy reforms needed for water demand management, the financial implications of green initiatives in the water sector can be also reduced substantially.

6.2.1 Initiatives for Water Pricing and Cost Recovery

Setting the prices rights is a major initiative for a green water economy. Appropriately set water rates will send the correct signals about the economic and scarcity value of water. While the requirements of correct water rates are clear, raising the water rates are considered politically risky, though farmers are, in fact, willing to pay higher rates provided water supply is timely and reliable. The 1972 Irrigation Commission had suggested that water rates have to be fixed so as to cover, at least, 5 percent of gross income in the case of food crops and 12 percent in the case of commercial crops. The Jakhade Committee of 1987, which has underlined the efficiency function of water pricing policy, has suggested that if the method and level of water rates are such as to capture and convey scarcity value of the resource, they can both induce efficiency and ensure full cost recovery at the same time. The Vaidyanathan Committee has suggested the recovery of working expenses plus one percent of the interest on capital investment (GOI, 1992a).

Table 6.4 shows the prevailing water rates for flow irrigation being applied in the canal commands across the states. As can be seen the rates in most states are too low to play both the efficiency and cost recovery functions of water pricing policy. Although many states (e.g., Andhra Pradesh, Karnataka, and Tamil Nadu) have recently revised water rates up to three times, water rates cover not even a fraction of the working expenses. The percentage of the recovery of working expenses varies from 78 percent in Gujarat to about 5 percent in the case of most other states (CWC, 2009). The present level and method of fixing water rates are unable to play the dual roles of cost recovery and resource use efficiency. These dual roles cannot be expected unless water pricing policy forms part of an institutional and technical arrangement needed for facilitating canal modernization, volumetric distribution, group-based allocation, and local management (GOI, 1992a; Saleth, 1996). Although urban water rates are far higher than the water rates in canal regions, the general problems of cost recovery and use inefficiency also loom large in urban water sector.

Table 6.4: Water Rates for Flow Irrigation Across States

Sl.No.	States/UT	For irrigation purposes (Rate INR/ha)	Date since applicable	Status as on
1	Andhra Pradesh	148.20 to 1235.00	1.7.1996	23.4.03
2	Arunachal Pradesh	No water rates		25.2.02
3	Assam	150.00 to 751.00	30.3.2000	09.5.01
4	Bihar	74.10 to 370.50	1995/2001	28.02.03
5	Chhattisgarh	123.50 to 741.00	15.6.1999	Feb.04
6	Delhi	22.23 to 711.36	1951/1979	Nov.03
7	Goa	60.00 to 300.00	2.1.1998	24.3.06
8	Gujarat	70.00 to 2750.00	16.2.2001	1.3.06
9	Haryana	86.45 to 197.60	27.7.2000	29.11.05
10	Himachal Pradesh	21.23	1.6.2006	1.10.05
11	Jammu & Kashmir	49.42 to 247.10	1.4.2005	3.7.07
12	Jharkhand	74.10 to 370.50	26.11.2001	25.11.03
13	Karnataka	37.05 to 988.45	13.7.2000	24.10.05
14	Kerala	37.00 to 99.00	18.9.1974	18.3.06
15	Madhya Pradesh	50.00 to 960.00	1.11.2005	1.11.05
16	Maharashtra	238.00 to 6297.00	1.7.2003	25.10.05
17	Manipur	45.00 to 150.00	8.3.2007	8.3.07
18	Meghalaya	No water rates (100 proposed to be fixed)	-	28.2.06
19	Mizoram	No water rates	-	4.8.03
20	Nagaland	No water rates	-	12.4.06
21	Orissa	28.00 to 930.00	5.4.2002	1.3.06
22	Punjab	Abolished	14.2.1977	27.8.02
23	Rajasthan	29.64 to 607.62	24.5.1999	24.10.05
24	Sikkim	10.00 to 250.00	2002	10.3.06
25	Tamil Nadu	2.77 to 61.78	1.7.1962	4.3.02
26	Tripura	312.5	N.A.	26.10.05
27	Uttaranchal	60.00 to 948.00	18.9.1995	8.12.03
28	Uttar Pradesh	30.00 to 474.00	18.9.1995	Apr.02
29	West Bengal	37.05 to 123.50	6.4.1997	16.5.03
30	A & N Islands	No water rates	-	6.2.04
31	Chandigarh	No water rates	-	12.6.01
32	Dadra & Nagar Haveli	110.00 to 830.00	29.1.1996	31.8.05
33	Daman & Diu	200	1980	3.1.02
34	Lakshadweep	No water rates	-	8.3.06
35	Pondicherry	12.50 to 37.00		

Source: CWC, 2009.

6.2.2 Initiatives for Groundwater Regulation

While India has a relatively sound technical information base and expertise in water-related aspects, their utility at the practical level of regulation is extremely limited due to the lack of legal and organizational arrangements for enforcement and monitoring. The top-down approach inevitable in any centralized administrative set up and the attendant inability to tap locally available informal institutional potential (e.g., water-related local customs, water sharing conventions, and local level monitoring and enforcement mechanisms) constrain effective enforcement of even well-conceived policies. While well-spacing norm prohibits new wells within a radius of 200 meters (m) in most parts of India, the norm can be as high as 680 m in areas with deep tubewells and serious depletion (Shah, 1993:11). Similarly, there are also depth restrictions, especially for deep tubewells.

While a restricted power supply policy provides some regulatory respite, it is of little consequence in the face of large pumps and multiple wells. The effectiveness of regulations based on power tariff and supply policies is severely undermined not only by the availability of the diesel pumpset option but also by the presence of a 'kink' in the power demand curve of farmers.[5] Although groundwater markets are found to improve efficiency and equity in water use (Shah, 1993), they could, nevertheless, accentuate aquifer depletion under current legal and institutional regimes without water rights (i.e., legalized 'water quotas') (see Saleth, 1996). Thus, current legal and regulatory policies as well as the water markets reinforce rather than regulate the *de facto* control of groundwater by resource-rich farmers. In canal region, although the regulatory role of water pricing is limited, the policies of water rationing and rotational water supply are relatively effective in regulating water use.

6.2.3 Initiatives for Water Rights and Entitlements

The issue of water rights as a mechanism for allocation and accountability assumes importance in the context of green initiatives in water sector. India does not have any explicit legal framework specifying water rights, even though various acts have a basis for defining some form of such rights. British legislations in India during 1859-77 recognized the customary water rights of individuals and groups. Although the Easement Act of 1882 made water in all rivers and lakes as the absolute right of the state,

[5] The kink in power demand emerges from the gap between energy cost and the net value of output per unit of power. As long as this gap is substantial and can also be manipulated by crop choice, farmers will not reduce power consumption and hence, their power demand will be insensitive to power tariff changes (Saleth, 1996).

individual rights to both surface water and groundwater are recognized only indirectly through land rights. Thanks to the 'dominant heritage' principle implied in the Transfer of Property Act IV of 1882 and the Land Acquisition Act of 1894, a land owner can have a right to groundwater as it is considered an easement connected to the dominant heritage, i.e., land. In the case of canal water, the rights to access are limited only to those having access to land in canal command areas and these rights are only use rights and not ownership rights. The Model Groundwater (Control and Regulation) Bill of 1992, which was formulated and circulated by the Centre for the consideration of states, postulates a kind of groundwater permit system (1992b).

While legally specified formal water rights are absent, there are a variety of informal and rudimentary water rights systems. These rudimentary water rights systems include the *Shejpali* (Water Roster), *Pani Panchayats* (Water Councils), and *Warabandi* (time and turn-based water allocation) systems. Water rights are based on time under Warabandi, on flow-based volume under Shejpali, and irrigation needs under Pani Panchayats. Notably, both the time and volume-based water rights are linked to farm size, as they are determined in proportion to land owned or operated. But, in Pani Panchayat system, the rights are based on water shares, which are defined not by land but by family size. Notably, in the Pani Panchayat system, even the landless also have water shares, which they can sell implicitly through sharecropping arrangements with land owners requiring additional water (see Saleth, 2007). Urgent efforts are needed to develop these informal water rights system and extend their application in other regions as well (see Saleth, 2007; Narain, 2009).

6.2.4 Initiatives for Pumpset Rental and Groundwater Markets

Over-investment on wells and pumpsets by some farmers and non/under-investment on the same by others due to their land, water, and capital constraints led to the emergence of the phenomenon of rental markets for irrigation assets. Since these markets allow farmers to irrigate their farms by renting irrigation assets from their neighbors, they contribute both to equity in water use and better utilization of irrigation assets. According to the National Sample Survey Organization (NSSO) (1984 and 1985), about 10 percent of the total pumpsets in the country are involved in pumpset rentals. Since about 63 percent of these rentals occur with dugwells/tubewells with electric powered and permanently fitted pumps, a majority of the rentals involve water transfers as well. Since the rest of the rentals occur in the case of other water sources where pumps can be physically moved with little cost, it seems they occur independently of water transfers (Saleth and Thangaraj, 1993).

Despite their localized, fragmented, and uneven nature across regions, groundwater markets are growing in magnitude and gaining in significance. Shah (1993:250) has projected the area irrigated through groundwater markets to be up to 50 percent of the total gross irrigated area under private lift irrigation. Understandably, there are considerable variations across regions. The area irrigated through groundwater markets vary from up to 80 percent of the total irrigated area for north Gujarat (Shah, 1993:205) to 30 percent in the Vaigai Basin (Janakarajan, 1993). Although groundwater markets provide equity and efficiency benefits, they, however, contribute to aquifer depletion. It is possible to minimize the negative effects and enhance the positive benefits when groundwater markets operate within a legally specified water rights system.

6.2.5 Initiatives for Water Demand Management

Water demand management initiatives cover the six options: water pricing, water rights system, water markets, energy regulations, water saving technologies, and user/community organizations. While previous sections discuss the first three options, here, let us briefly discuss the remaining options. Evaluating energy regulations as a water demand management option, Malik (2009) concludes that much depends on their intrinsic nature and enforcement as well as a number of farm and region-specific factors such as farm size, well depth, crop pattern, water selling, and the groundwater hydro-geology itself. Energy regulations with a relatively higher and metered tariff can be more effective as compared to the ones involving fixed and flat rates. Similarly, direct supply regulations with fixed supply hours will be more effective than those involving energy prices, regardless of their levels and structure.

The water saving technologies can raise irrigation water use efficiency from 60 (sprinkler) to 90 (drip) percent. They can save water by 48 to 67 percent, energy costs by 44 to 67 percent, and labor costs by 29 to 60 percent (Narayanamoorthy, 2009). Sprinkler and drip systems are scale neutral and also economically viable for as many as 80 crops (Narayanamoorthy, 2009). Despite this, the total area under these technologies in India is not more than 0.5-0.6 mha and most of which is confined to four states, i.e., Maharashtra, Karnataka, Tamil Nadu, and Andhra Pradesh (Narayanamoorthy, 2009).

User/community organizations cover both the formal water user associations (WUAs) and also the informal water allocation systems such as the *Shejpali*, *Pani Panchayats*, and *Warabandi*. They can contribute to use efficiency and water savings. Their actual impact, however, depends on their area coverage and operational effectiveness. Despite them being promoted since the 1960s, the registered WUAs in India are only about 55501 users associations covering an area of 10.23 mha. Most of these WUAs are in Andhra Pradesh, Orissa, Haryana, Karnataka, Kerala, and West Bengal (Planning Commission, 2008). These figures, however, do not cover the informal and semi-formal systems. In any event, the total area covered by all forms of user and community organizations can be no more than 20 mha.

Although we have discussed the six demand management options separately, there are important operational linkages among them. These options also have linkages not only with many water and agricultural institutions but also with the water and agricultural sector goals. Figure 6.1 places water demand management both in the strategic context of the water and agricultural institutions as well as in the larger context of sectoral and economic goals. While all demand management options are important, the sequential linkages among them suggest that some are obviously more important than others. This is either due to their role of being the necessary conditions for others (e.g., user and community organizations as a necessary condition for both an effective water rights system and pricing policy) or due to the extent of their operational linkages with others (e.g., water rights system having linkages with water user organizations, water saving technologies, and water pricing policy).

From an impact perspective, the overall performance of a demand management strategy depends on the way it is designed and implemented. The strategy has to be designed in such a way as to exploit well the functional and structural linkages among the options and also benefit from the synergies of the sectoral and macro economic policies. For instance, the efficiency and equity benefits of water markets can be increased manifold when such markets operate within a volumetric water rights system and are also supported well by user-based management and enforcement mechanisms. Likewise, water pricing policy can be more effective both in cost recovery and in water allocation, if it is combined with volumetric delivery and user based allocation. Similar results can also be expected with other options, when they are aligned well with their counterparts. It is important to keep these points in mind while implementing the water demand management as part of the green initiatives in the water sector.

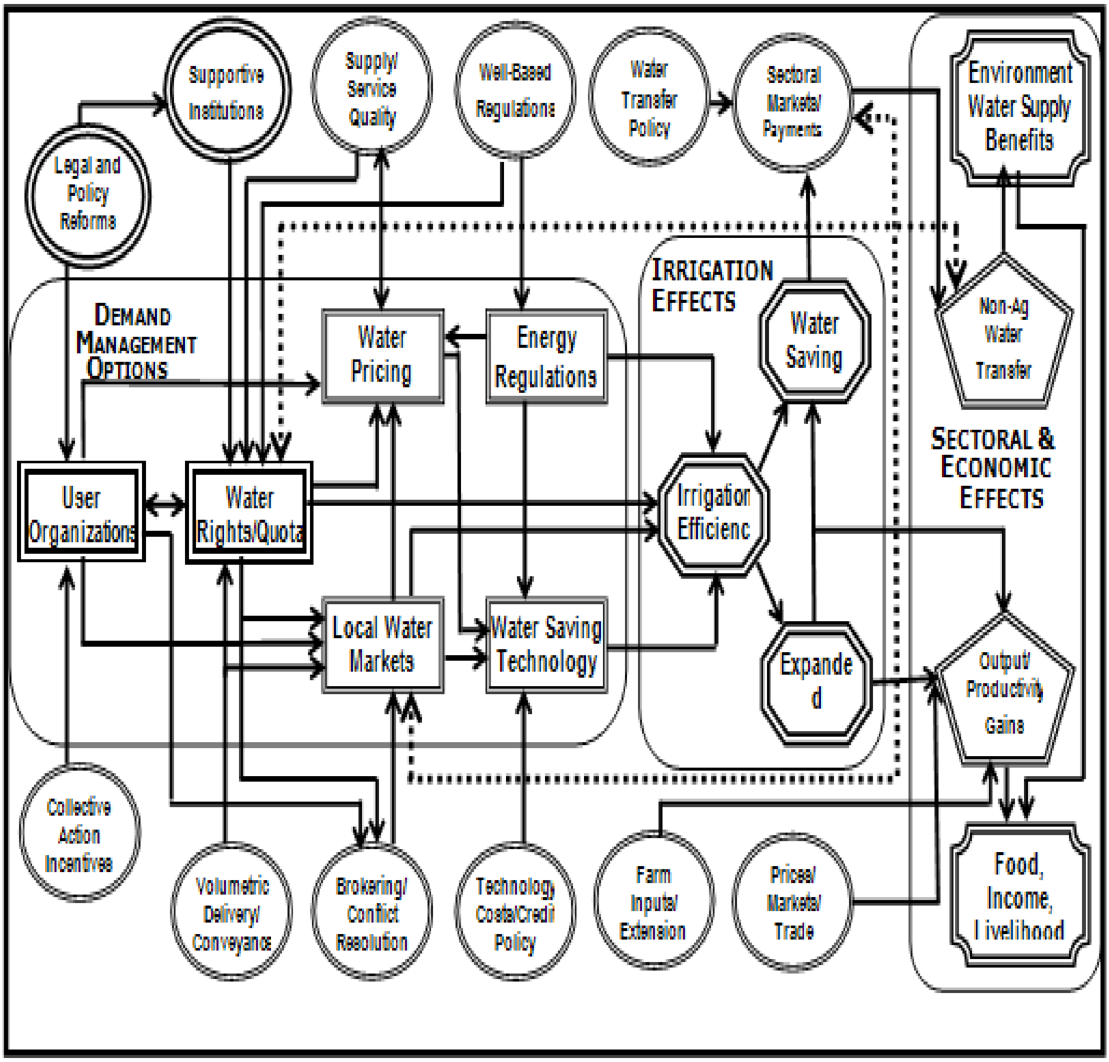
6.2.6 Initiatives for Water Supply Management

Although water demand management initiatives can lead to additional water supply thanks to their efficiency impacts and water saving effects, they will not be sufficient to completely solve the problem of water scarcity. There is also a need for effective initiatives for water supply management. This is particularly so not only in the context of climatic change, which is expected to have a major impact on the temporal and spatial patterns of water availability but also in the present context, where flood-drought syndrome is a serious national problem. While 51 mha is affected by drought mostly in the peninsular India, 40 mha is affected by floods mainly in Assam and Bihar (Planning Commission, 2008). The existing approaches to supply management such as the creation of additional storages, water harvesting, water reuse, and desalinization, though useful and important, cannot be that effective in countering the drought-flood syndrome associated with climate change.

One approach that can provide a more durable solution to the present and future water problems relates to the implementation of the National River Linking Project (NRLP). The idea behind NRLP is to capture part of the 747 bcm of water that runs waste to the sea, mainly from the Ganges and Brahmaputra, which account for the 60 percent of the water potential (Planning Commission, 2008). The NRLP will transfer surplus waters from the Ganges and Brahmaputra, especially during the monsoon season, to the water-deficit regions in central and southern India through 30 links—16 for Peninsular Rivers and 14 for the Himalayan Rivers (see Figure 6.2). The total amount of water that can be usefully transferred is estimated to be about 220 bcm. The feasibility reports—covering both the socio-economic, environmental, and hydro-geological impacts—for some of these links are already available and others are being prepared by the National Water Development Agency in collaboration with various research and technical bodies in India.

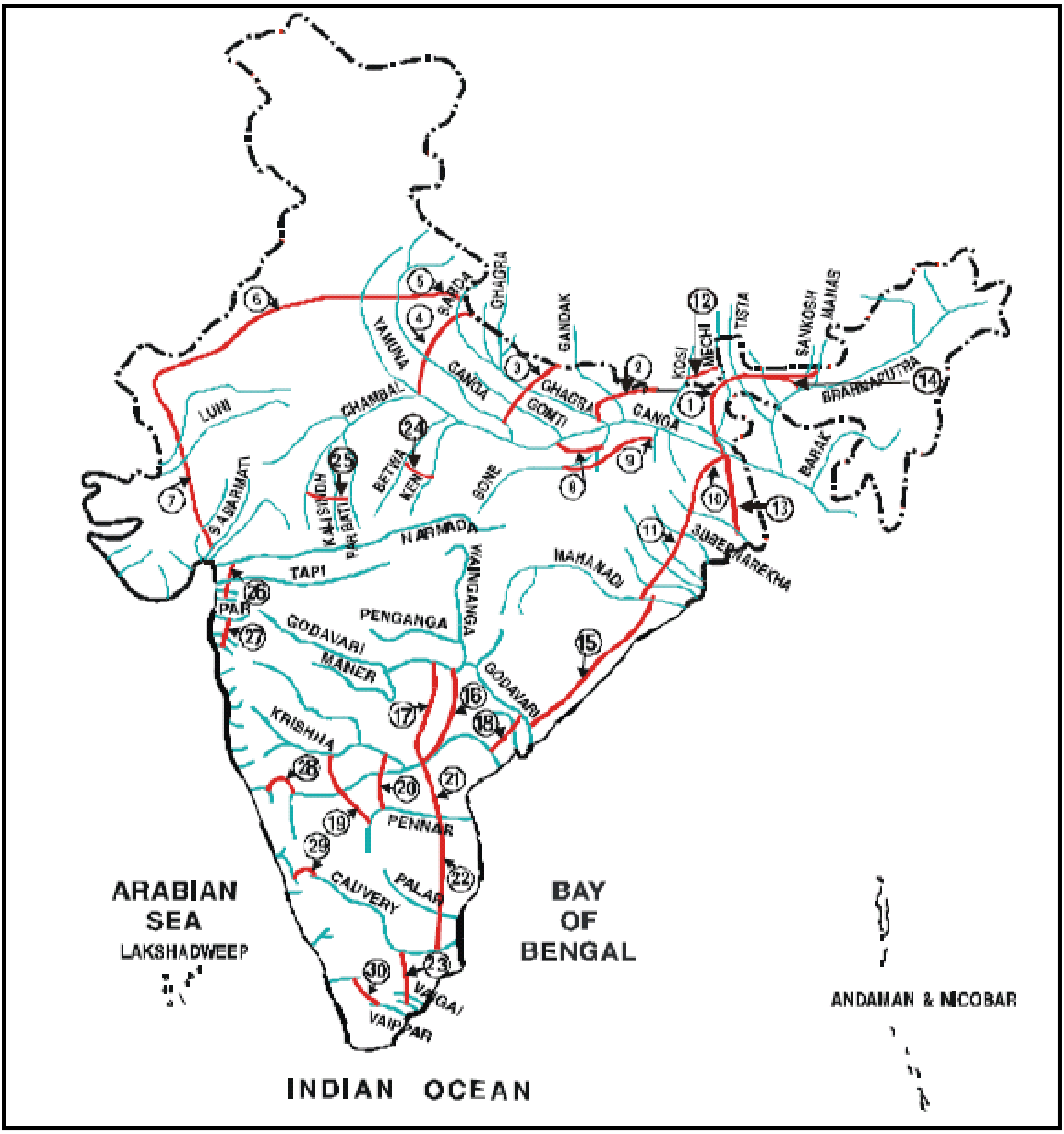
The NRLP, when completed, will be the largest water infrastructure project ever undertaken in the world. It will connect 37 Himalayan and Peninsular rivers through 30 links, involving 3000 storage dams and 12,500 km of water conveyance networks. This gigantic water grid is expected to handle 178 bcm of inter-basin water transfers. According to the evaluation study conducted by the National Council of Applied Economic Research (NCAER) in 2008, the NRLP is estimated to cost Indian Rupees (INR) 4545-5560 billion or about US$ 100-120 billion (see Table 6.5). This cost estimate is based on a detailed cost calculation for each of the 30 links (see NCAER, 2008). Notably, the cost calculations cover essentially the direct cost of construction and do not cover the indirect costs such as the loss of agricultural lands, negative environmental impacts, and resettlement and rehabilitation costs.

Figure 6.1: The Strategic Context of Water Demand Management Initiatives



Source: Saleth and Amarasinghe, 2009

Figure 6.2: National River Linking Projects with 30 Proposed Links



On the positive side, the NRLP is slated to provide extensive benefits in terms of additional irrigation, power generation, and drinking water supply. As can be seen in Table 6.6, the NRLP is expected to add 35 mha of irrigated area, create 25 giga watts of net power supply, and provide 12 bcm of drinking water supply. All these benefits are very important from a green economy perspective. The total annual value of these benefits will be INR 771 billion or US$ 17 billion. In addition to these direct benefits, there are also a variety of other benefits. For instance, besides the navigation and fishery benefits, the NRLP will also add, on an average, 2 million tones (mt) of foodgrains per year and lead to a 13 percent increase in agricultural income and 5 percent increase in non-agricultural income, thanks to its multiplier effects (NCAER, 2008: 51-53). The values of these benefits are not covered in the total value of annual benefits noted above. Despite the non-inclusion of these additional benefits, the NRLP still has a rate of return of 14 to 17 percent, depending on the cost estimates considered.

6.2.7 Meeting Environmental Flow Requirements

In 2006, the Ministry of Water Resources has constituted a Working Group Report of the Working Group to Advise Water Quality Assessment Authority on the minimum flow needs of rivers in India. Having gone through the issue, the Working Group has arrived at the following conclusions.

Table 6.5: Cost Estimates for the National River Linking Project

Particulars	Cost at 2002-03 Prices (Billion INR)	Cost at 2002-03 Prices (Billion US$)
Total Cost of 16 Peninsular Links	1193.06	26.34
Total Cost of 14 Himalayan Links	3352.25	74.00
Total Cost of All Links	4545.31	100.34
Total Cost of All Links	5560.00	122.74

Source: NCAER, 2008: 24-25.
Note: The exchange rate used here is: US$=INR45.6.

Table 6.6: Expected Direct Benefits of the National River Linking Project

Benefits	Quantity	Rate	Total Benefits (Billion INR)	Total Benefits (Billion US$)
Irrigation	30 Million Hectare	INR 17482/ha	524.46	11.58
Power	24800 Mega Watts	INR 1.67/Unit	4.14	0.09
Drinking Water	12 Billion Cubic Meter	INR 20.18/M^3	242.14	5.35
Total			770.74	17.01

Source: NCAER, 2008: 55.

(a) The maintenance of minimum flow has also to be considered as a water use since it restricts the quantity of water that can be diverted for other uses;
(b) The maintenance of minimum flow in the river during the lean season should be accepted as an importance objective of maintaining the river regime and water quality;
(c) There cannot be one single formula to determine the environmental flow requirements for all rivers. The ecology of each river, sometimes, different reaches within a river, has to be studied to compute the environmental flow;
(d) The guidelines for assessment of minimum flow should outline a practical and commonsensical process for setting flow regime in a river;

The Working Group recommends a minimum flow of not less than 2.5 percent of the 75 percent dependable annual flow expressed in cubic meters per second. It has also recommended one flushing flow during monsoon with peak not less that 250 percent of the 75 percent dependable annual flow expressed in cubic meters per second.

The minimum flow for meeting environmental needs suggested by the Working Group is far lower than those suggested by Smakhtin and Anputhas (2008), who have estimated the environmental flow requirements for the 13 major river systems in India under six different environmental management regimes. We consider the environmental flow requirements as a percentage of mean annual flow for the 13 river systems under two regimes: 'moderately modified river ecosystem' and 'critically modified river ecosystem'. Under the moderately modified regime the habitats and dynamics of the biota have been disturbed but the basic functions of the river ecosystems is still intact. Under the critically modified regime, the modification has reached a critical level with the loss of habitats and biota and river ecosystem functions are destroyed. Under the former regime, the environmental flow requirements vary from 46 percent of the mean annual flow for Brahmaputra to 7 percent for Mahi. The corresponding figures for these two rivers under the critically modified regime are 21 and 0.3 percent.

6.3 Scope, Feasibility and Obstacles for Green Initiatives

The scope, feasibility, and obstacles for the green initiatives needed in the water sector vary considerably. As to their focus and coverage of the green initiatives, some are context-specific whereas others are applicable in more generic context. For instance, water pricing is applicable mainly in canal regions. Similarly, energy regulations are confined mainly to groundwater areas. This is also true for water markets and water saving technologies, as they occur mostly in groundwater regions. The water saving technologies using micro-irrigation such as sprinklers and drips are rare in canal and other surface water based areas. But, water saving technologies involving crop choice and farm practices (e.g., tillage and land leveling practices and intensive cultivation methods) are applicable both in canal and groundwater regions. Similarly, the initiatives related to water rights and user and community organizations are relevant for both canal and groundwater regions.

Similarly, some of the green initiatives in the water sector have more direct and immediate impacts on water use efficiency and water demand whereas others have only indirect and gradual effects. For instance, water rights and water saving technologies have more direct effects on water use efficiency and water demand whereas the initiatives related to user organizations and energy regulations have only indirect effects. Notably, the green initiatives also differ considerably in terms of the practical and political economy conditions necessary for their effective adoption and implementation. On this count, water rights are the most difficult, followed by water pricing and energy regulations. But, water markets and user organizations are relatively easier to adopt, though they face implementation and regulation challenges. Water saving technologies, though politically benign, requires, however, favorable agronomic conditions and credit and technical supports. The adoption context, investment need, impact gestation, and political feasibility are the key factors determining the relative scale of adoption and impact of different demand management initiatives.

While there has been a widespread consensus on the need for the NRLP across the political spectrum, concrete initiative to start implementing the Project is lacking. But, the thrust came finally from the Supreme Court of India, which, acting on a public interest litigation, has directed the central government in 2002 to constitute a task force and complete the Project by 2012. Responding to the directive, the central government constituted the Taskforce on River Interlinking in early 2003. The Taskforce is to provide guidelines on norms for the appraisal of individual projects and specify the modalities for project funding so that the goal of inter-linking of rivers is achieved by the end of 2016. Considering the mammoth nature of the project, huge financial requirements, and serious legal, institutional, and technical constraints, this timeline seems to be not feasible.

Despite its immense benefits, the NRLP is not beyond controversy. The 12,500 km-long inland waterways planned under the NRLP will cause a massive human displacement and loss of farm land. The Project is also likely to disrupt the entire hydrological cycle by stopping the rivers from performing their ecological functions before reaching the oceans. Besides a major alteration of the geography of the country, the inter-basin water transfers are also to likely distribute pollution load across rivers and spread weeds across regions. More importantly, raising resources to the tune of INR 56,600 crores, which is close to thrice the annual amount of tax collected, for each year over a 10-year period is a daunting challenge. Besides the financial challenges, the Project has also to overcome major legal and political hurdles as water is a state subject and there are serious water-sharing conflicts among states in a number of rivers.

The scope and feasibility of achieving minimum flow requirements is limited in the case of most rivers. If business as usual path of water management and water use pattern continues, water demand is expected to increase by 22 percent by 2025 and 32 percent by 2050 (Amarasinghe, et al 2007a). With such demand growth, more and more basins are likely to face physical water scarcity, i.e., water withdrawal exceeding 60 percent of the potentially utilizable resource. Since withdrawal exceeding this level is expected to be both financially costly and environmentally difficult, more basins are also likely to face economic or financial water scarcity as well. This will have a pernicious effects on the on the food and livelihood as well as political fronts. On the other hand, the implications of not meeting the minimum flows needed for maintaining ecological and water quality benefits are also equally severe.

There is need for serious trade-offs the resolution of which depends on the extend use efficiency is achieved, especially in the irrigation sector that accounts for the predominant share of water. For instance, if the surface irrigation efficiency is increased from the present level of 40 percent to 60 percent, while keeping groundwater irrigation efficiency is increased from 60 percent to 80 percent, there will be a reduction in irrigation demand to the tune of 43 bcm. If it is possible to raise groundwater irrigation efficiency by an additional 5 percent, i.e., 85 percent, then, the total reduction in irrigation demand can be as high as 63 bcm (Amarasinghe et al, 2007a). In a sense, this represents the true magnitude of the potential for water savings that exists in agricultural sector at present. This potential can be realized gradually though the implementation of demand management initiatives. This water saving can be used for meeting either expanded irrigation or urban and environmental needed.

6.4 Roadmap for Operationalizing Green Initiatives in Water Sector

Realization of the hidden resource potential through a major improvement in water use efficiency and adding more water supplies by taping the unused runoff are the two key routes available for solving most of the problems besetting the water sector in India. Obviously, the roadmap for achieving the green goals in water sector, i.e., an efficient, equitable, and ecologically sustainable use and management of water resources, coincides with the timeframe for operationalizing the twin-strategy of water demand management and water supply augmentation. The specific initiatives associated with the twin-strategy are also clear from the previous section. But, the scope and feasibility of these initiatives differ as are the obstacles. The timeframe, institutional requirements, financial challenges, and political acceptability for the initiatives also vary. The effort for operationalizing the water demand and supply management initiatives should strategically use these variations.

Considering the institutional and policy requirements of demand management, what is needed is nothing short of some fundamental changes in the existing institutional arrangements governing water allocation and management. This fact clearly underlines the logical link between the implementation of the demand management strategy and the necessity of a broad water sector reforms. Indeed, demand management forms the spearhead around which water sector reforms are to be planned and implemented. While the strategic and institutional logic of designing demand managed strategy as part of a larger program of water sectors reforms is clear, its implementation is certainly not easy and quick. This is an important consideration when deciding on the roadmap or timeframe for the operationalization of the green initiatives in the water sector

Neither the stupendous nature of the task nor the heavy economic and political costs involved in transacting such a change in current context can be source for alarm or complacency. There are well tested reform design and implementation principles that can assist policy-makers to overcome the technical, financial, and political economy constraints and, thereby, effectively negotiating the green initiatives, including the demand management strategy and the institutional reforms (Saleth and Dinar, 2004). The reform design principles relate to the prioritization, sequencing, and packaging of institutional and technical components based on their impact, costs, and feasibility criteria. The reform implementation principles cover such strategic aspects as timing, coverage, and scale.

There are sequential linkages among the demand management initiatives as well as their underlying institutions (see Figure 6.1). For instance, user organizations remain the basis for the operation of water rights, water markets, and water pricing. Similarly, water rights are critical for the effective functioning of water markets and could also provide the incentives for the application of water saving technologies and improve the effectiveness of even energy regulations. Since the user organizations are the foundation for the emergence and operation of other institutions and do not involve much political opposition, they should receive top priority from the long-run perspective. But, in the short-run, the promotion of water saving technologies with the immediate and direct impact should receive priority.

Since the establishment of water rights system involves major legal, technical, and political challenges, the initial focus should be on creating some of the basic conditions for its emergence, such as the modernization of the water delivery systems and introduction of volumetric allocation as first steps. Along with their roles in facilitating the eventual introduction of water rights system, these conditions will also have direct roles in improving the effectiveness of water pricing. Besides these ways of sequencing and prioritizing demand management initiatives, there are also instances for packaging programs such as the system modernization to be combined with management transfer and higher water rates to be accompanied by improved service quality.

Since the design principles involving sequencing, prioritizing, and packaging work on the sequential linkages and path dependent nature of institutions, they help to reduce the transaction costs of creating each of the subsequent institutions. Also, in view of the institutional ecology principle, when a critical set of institutions are put in place, other institutions or new roles for existing institutions can develop on their own. For instance, when volumetric allocation is introduced, it would be possible to negotiate limits for water withdrawals, which can eventually lead to the emergence of water quota systems.

Similarly, when water rights are in place, real water markets centered on established water entitlements can emerge.

While the design principles do affect implementation, the principles related to the timing, coverage, and scale have a more strategic roles. This is because they work on the synergies and feedbacks emerging from the larger environment such as economic reforms, droughts and floods, and political change. Appropriately seizing such opportunities with proper timing is critical for the effectiveness of green initiatives. Beside the choice of right time, time is also significant for another important reason. This relates to the selection of suitable timeframe for the execution green initiatives, including the demand management strategy and its institutional reform program.

Since the green initiatives can be implemented only on an incremental way, a longer time frame involving, say, 10 year period is to be considered. But, within this frame, time dated components of the initiatives with clear prioritization and financial allocations can be planned for sequential implementation. The issue of scale and coverage is mainly determined by financial and technical considerations. Although there are economies of scale in undertaking large scale initiatives, they also face practical constraints. Ideally, it would be useful to prioritize regions and areas. For instance, while water pricing policy and energy regulations can cover a larger area, it is useful to target other options in areas facing sever water scarcity.

6.5 Existing Investment and Additional Financial Needs

India is making a huge investment on different segments of water sector such as irrigation and multi-purpose projects, command area development, urban water supply, power generation, flood control, and drainage and water conservation. While information on the level of investments in individual segments is available to some extent, the same on the total investment in water sector as a whole is not readily available. This is especially so as the investments are made by multiple entities such as various departments in the central and state governments as well as municipalities and other local governments. There are enormous amounts of investments made in the private sector, especially in groundwater sector both for irrigation and drinking water purposes. Here, an attempt is made to indicate the magnitude of existing levels of investments in the water sector based essentially on the level of investments in the irrigation and multi-purpose projects, command area development, flood control, and drainage and water conservation projects.

Table 6.7: Plan-wise Investment on Irrigation and Command Area Development: 1951-2012

(INR in Billions)

Period	Major & Medium	Minor			Command Area Devp.	Total Irrigation Expenditure	Total Plan Exp.	Share of Irrig sector
		State	Instituti-onal	Total				
First Plan (1951-56)	3.76	0.66		0.66		4.42	19.60	23
Second Plan (1956-61)	3.80	1.42	0.19	1.62		5.42	46.72	12
Third Plan (1961-66)	5.76	3.26	1.15	4.42		10.18	85.77	12
Annual Plans (1966-69)	4.30	3.21	2.35	5.56		9.86	66.25	15
Fourth Plan (1969-74)	12.42	5.06	6.61	11.67		24.10	157.79	15
Fifth Plan (1974-78)	25.16	6.28	7.99	14.26	1.48	40.90	286.53	14
Annual Plans (1978-80)	20.79	4.96	4.80	9.77	2.15	32.71	229.50	14
Sixth Plan (1980-85)	73.69	19.79	14.38	34.17	7.43	115.29	1092.92	11
Seventh Plan (1985-90)	111.07	31.32	30.61	61.93	14.48	187.48	2187.30	9
Annual Plan (1990-91)	26.35	8.12	6.76	14.88	2.86	44.08	583.69	8
Annual Plan (1991-92)	28.24	8.44	6.74	15.18	3.34	46.76	647.51	7
Eighth Plan (1992-97)	216.69	62.31	42.42	104.72	19.38	340.80	4854.57	7
Ninth Plan (1997-2002)	492.90	86.35	26.62	112.97	22.23	628.09	8440.31	7
Tenth Plan (2002-2007)	712.13	144.07		144.07	41.97	898.17	15256.39	6
Eleventh Plan (2008-12)	0.00					664.49		-
	1737.06	385.25	150.62	535.86	115.30	3052.72	33954.85	9

Source: Planning Commission, 2008; CWC, 2009.

Table 6.7 shows the investments in irrigation and multi-purpose projects, and command area development during 1951-2012. The total investment at current prices in these segments rose from over INR 4 billion during the first plan period (1951-56) to over 664 billion during the ongoing eleventh plan (2008-2012). While absolute level of this investment is on the increase over the years, the share of total plan expenditure going into irrigation and multipurpose projects and command area development programs is declining. For instance, this share has declined from 23 percent during the first plan to just 6 percent in the tenth plan. The total investments till date amount to INR 3053. This represents an overall share of 9 percent in the total plan expenditure during the entire plan period.

As can be seen from Table 6.7, the total investment includes the investment made both by the central and state governments as well as the credit institutions. The investment by the state and credit institutions goes essentially to the development of minor irrigation based on groundwater. Besides the investments on irrigation an multi-purpose projects and command area development programs, the government also makes significant level of investment in flood and sea erosion control and drainage projects. The total investment in these projects between 1990-91 and 2001-02 alone amounted to INR 100 billion (CWC, 2009). There is also a considerable amount of expenditure on flood relief. For instance, during 2002-2005, the government has paid on an average of INR 14 billion per year as flood relief (Planning Commission, 2008).

As to the future financial needs, India needs INR 5560 billion for completing the inter-basin water transfer scheme proposed under the NRLP. The completion of the NELP will require, at least, an annual investment of INR 555 billion over a 10 year period. While NRLP will add more to water supply by taping the unused or under used river flows, there is also the unrealized part of the ultimate irrigation potential. With the investment of INR 3053 billion over the last 60 years, India is able to develop only 87 mha of irrigation potential. To fully realize the ultimate irrigation potential of 140 mha, India has to spend much more than the total investment made so far because taping the additional irrigation potential will be costly in environmental and resettlement terms. The investment needs on the rehabilitation of the existing water infrastructure are huge as are the future funding needs of urban and rural water supply projects.

There investment needs of groundwater recharge projects and hydropower schemes are also enormous. The Central Groundwater Board has developed a master plan to recharge 36 bcm of rainwater into groundwater aquifers at a cost of INR 245 billion (Planning Commission, 2008). Except for the implementation of few pilot schemes in the tenth and eleventh plans, there has not been any major effort so far. But, this is an important plan as part of the green initiatives in the water sector. This is also true with the hydropower as it is a non-polluting and environmentally clean source of energy. While India has an estimated exploitable hydro-electric potential of about 148,700 MW, it has developed so far only 51207 mega watt, representing just a third of the exploitable potential. The total investment required to harness the full hydropower potential is estimated to be about INR 5000 billion.[6]

Since the investment of the magnitude required for all the major water projects noted above are too high to be financed through the traditional means of government

[6] See, http://www.eai.in/forum/viewtopic.php?f=15&t=53

revenues, India has to look for additional means for generating the required funds. Besides external funding through international aid and borrowing, India also has the option of generating resources through market borrowing as well as private sector participation. While there are projects whose benefits are too diffused to identify the beneficiaries for charging them appropriately, these projects do contribute to the welfare goals of income generation and poverty alleviation. But, there are other investments such as those in power and irrigation projects, which can be self-financing through appropriate charges.

6.6 Conclusions

Water sector plays a critical role both on the consumption and production spheres of the in Indian economy. Besides its role meeting water needs of urban and rural population, water sector contributes to food production, income and employment generation, livelihood creation, poverty alleviation, power generation, and navigation. Its contributions are also immense important for the environment and ecological systems. While its contributions are many and varied, water sector also faces serious problems due to inefficient, inequitable, and unsustainable use and management. In order to address these problems and enhance, thereby, the contributions of the sector, major initiatives are urgently needed. It is in this context, green economy initiatives in the water sector assume urgency and importance. In view of the critical role that water sector plays in the national economy, the effectiveness of green initiatives in the water sector determines the success of similar initiatives made at economy as a whole.

In this chapter, the most of the major green economy initiatives needed in the water sector have been discussed. These initiatives fall into two major categories: (a) initiatives for water demand management, where the focus is on achieving efficiency through institutional reforms, and (b) water supply management, where the focus is tapping additional resources through a program of investment and infrastructure. While there are *ad hoc* policies for promoting options such as user organizations, water saving technologies, water pricing reforms, and energy regulations with partial implementation, a clearly articulated demand management strategy is conspicuous for its absence. Now, it is time to formulate and implement such a strategy as part of the green initiatives within a timeframe of 5 to 10 years.

From the perspective of the water supply management strategy, the present supply management options such as the new storages, water harvesting, water recycling, and desalination are certainly important for augmenting water supply, especially in the context of few regions. But, even with their full implementation, they will not be able to deal neither with the current problem of water scarcity nor with the future disturbances in the level and distribution of water availability expected with climatic change. Clearly, the option involving the creation of a national water grid, as planned under the NRLP, constitutes the core of the strategy of water supply management in India on a sustainable basis. In view of its role in the equalization of water supply across space and time and the avoidance of the drought-flood syndrome, the supply management strategy centered on the NRLP can also function as an adaptation mechanism necessary to insulate the Indian water economy from the ill-effects of climatic change.

While there is a strong rationale for the green initiatives focused on demand and supply management, there are also major financial, technical, and political challenges. However, the green initiatives related to institutional reforms can be negotiated through these challenged using reform time-tested design and implementation principles. These principles relates to the sequencing, prioritization, and packaging of institutional or program components as well as the choice of right timing, scale, and spacing of their implementation. The central focus is to achieve immediate efficiency benefits as much as possible even while paving gradually the institutional and technical foundation needed for sustaining the long term gains. From a political economy perspective, a gradual approach pursued within an integrated framework is likely to neutralize political resistance, provide internal institutional pressure for subsequent reforms, minimize institutional transaction costs, and maximize long term social benefits.

The economic viability and strategic importance of the supply management strategy involving the NRLP are as clear as its financial, legal, and political challenges. The effectiveness and impact of the strategy depends on how it is negotiated and implemented within the prevailing economic, legal, and political constraints. Although implementation of the NRLP at one go is preferable for cost and benefit consideration, from a practical and strategic perspective, it has to be implemented in parts and in stages, focusing first on links with least costs and legal and political problems. The sequential implementation of the links is to be done within a specific and well-defined timeframe. This is likely to reduce the fiscal burden and create favorable conditions for the subsequent implementation of more difficult links. Simultaneously, the government has also to work on legal and institutional reforms needed to enhance the role of the central government in water development and conflict resolution among states.

As to the roadmap for the operationalization of the green initiatives, much depends on the requirements of individual initiatives. For instance, the initiatives for the promotion water saving technologies, pricing reforms, and energy regulations can be implemented fairly quickly. But, the initiatives needed for the creation of user associations and the establishment of water rights system require more time, say 2 to 5 years. Even among the two, the creation of user association is politically easier then the establishment of water rights system. In this case, initiatives will start with piloting such system in areas with severe water scarcity. On the initiatives related to supply management, those needed for new storage, groundwater recharge, water recycling, and desalinization can be undertaken within a timeframe of about 5 years. But, those needed for NRLP will take a minimum of 10 years, if not more. Financial availability and inter-state cooperation can also expedite the completion of NRLP.

As to the existing investment and additional financial needs, India needs a heavy investment to fully realize the water and hydropower potential. As government revenue will inadequate to meet the investment needs, India has to look for external aid and investment, internal market borrowing, and private sector investment. Finally, as to the stand that countries like India should take in the upcoming Rio+ 20, green initiatives, viewed in a larger context, are certainly beneficial. Green economy concept is only a necessary but not sufficient condition for sustainable development. Excessively carbon-focused approach to green economy, though relevant for the developed countries, has a very limited appeal to developing countries. What the developing countries need is open trade regime, free flow of technology and investment, and more equitable sharing of green responsibility.

Chapter 7

PRIORITY SECTORS FOR GREEN ECONOMY INITIATIVES – ENERGY

7.1 Introduction

What should we mean by green development process of energy? The objective of green development would require us to primarily address the following two issues in the context of energy:

- Enable removal of income and energy poverty and facilitate high economic growth
- Ensure improvements in efficiency of energy use, energy conversion and energy distribution to effectively address the eco-scarcity and environmental risks arising from energy use.

From the view point of reduction of eco-scarcity and environmental risk this would imply the following:

(a) Energy resource use efficiency in energy supply as well as final energy use efficiency by non-energy sector should be enhanced. This will have the twin benefit of reducing eco-scarcity of energy resource availability by reducing demand as well as reducing environmental pollution which would arise out of the process of the energy resource development and/or their compulsion as fuel.

(b) So far as the use of non-renewable resource use fossil fuels is concerned, we emphasize conservation of such resource use, discovery of new deposits of such resources or their replacement by new renewables in future - hydro, solar, wind, biofuels, etc. to offset the effects of eco-scarcity.

(c) In order to reduce environmental risks which may arise from the growing pollution externalities, the green development would prioritise the development of clean technologies involving use of fossil, bio-fuels, nuclear with reduced environmental externalities.

(d) To remove energy poverty by providing energy security to households by clean energy supply.

We would, however, like to point out here the importance of the backdrop of the macro-economic growth process while planning for its greening. High economic growth in the range of 8 to 9% has been assumed as an uncompromising target of India's development process. The process of economic reforms in its different phases is to so restructure the laws, regarding and institutional framework of investment, trade, fiscal and monetary policies that the fast growth of economy is facilitated for removing income poverty. As fast growth is considered as a necessary condition, though not sufficient, for poverty removal, such growth will have to be inevitably accompanied by industrialization, urbanization and growth of carbon intensive in infrastructure. If removing the dualism of high poverty co-existing with high growth as is being experienced in the Indian economy is one of the objective of our green development we have to be careful at the stage of energy planning and policy to ensure that the greening of energy use and supply pattern should not itself pose as a constraining factor for the growth process itself. Since cost economization has to be one of the important determining factors in these days of open global competitiveness, the fuel choice is bound to be primarily driven by the energy resource endowment of a country as given by the nature.

As India's major energy resource has been coal, we cannot wish away the role of coal in playing a role of the major fuel in the development of the Indian energy sector. However, the green development process would require such use of clean coal, technology or cleaner process in oil refining such that both the end products of coal or oil and their basic process of conversion are cleaner and safer involving much lower harmful pollution externalities. So far as the end use sectors of energy resources are concerned electric power and transport are the bulk users of energy resources responsible for at least two thirds of pollution externalities if not more. Since electricity is the cleanest and most efficient fuel for end use with widest use across the various sectors of the economy and coal being the cheapest fuel for power generation in India the share of coal is bound to dominate in the fuel mix of power generation. As the mobility of people and commodities is also a critical factor in development, the role of hydrocarbons and petroleum in particular cannot be dispensed with because of their virtual non-substitutability in the non-rail transport sector. However, even in such use of fuels, the thrust has to be on the resource use efficiency, conservation of fuel end use and such fuel switch from carbon to non-carbon ones as to make the process as low carbon as possible subject to fulfilling the growth targets.

As greening of the energy sector development would thus require the attainment of higher resource efficiency, energy conservation, fuel substitution and innovation of new technologies which would involve cost, any planning and policy decision for greening for a country like India inevitably would require the comparison of such costs with the benefit which the greening process would render through enhanced eco-services. This leads us to the issue of sustainable resource and environmental economic accounting as most of the benefits of enhanced eco-services are non-market ones and their monetization would require computing the accounting prices for such resources and eco-services like nature's capacity of waste degradation, water supply, pollination, climate control, purification of water or abating its pollution, etc. While these are challenging tasks, the SNA (1993) recommended the introduction of SEEA (Satellite System of Environmental Economic Accounting) developing physical inventory of resources and using the research outputs on the valuation of nature's services for various countries. The implementation of SEEA essentially involves the development of asset accounts of all kinds of capital stocks including natural resources – land, soil, minerals, forests, vegetation, etc and that of the qualitative degradation of land, soil, water and air to begin with. These would appear as a satellite account around the core macro-economic conventional one so that all these accounts when read together would be able to give ideas about trade-offs between the benefits and the costs both in physical and value terms enabling to decide how far green the Indian growth process can afford to be. While some work has been initiated, the progress towards implementation of SEEA as per government account has been quite limited in Indian context and the development of statistics of the Government of India is engaged in delineating the area of resources on which data can be collected and valuation of their depletion and for degradation is possible in the very round with a view to the adjustment of the macro-economic account. What is imperative in the context of green planning for Indian energy sector development is to introduce energy asset account giving the following:

(a) details of inventorisation of energy resources in the country – both non renewable and renewable ones, which are stock flow in nature. A stock flow resource is the material cause of production and is physically depleted in its use like coal, oil, gas, water in the dam for discharge for hydel generation, etc. (Daly & Farley 2004).
(b) details of pollution arising from energy resource development like coal mining, or hydroelectricity development as well as fuel combustion should be inventorised and incorporated in the asset account to reflect the degradation of the fund service resource like air, water body, land space etc. A fund service is a resource which constitutes the efficiency cause of production. The over use of its service may result in such degradation in quality as leading to the loss of productivity of eco system in rendering eco-services.
(c) Asset accounts should show both the variations in the physical and monetary units. This would require standardization of the methods of rental variation of resources reflecting their true scarcities from supply point of view and also value

of damage due to externalities arising from pollution and degradation of the concerned ecosystem (say a water body or air shed).

While the development of the above mentioned accounts as part of that of SEEA or some variant of it suiting a country's priority in developmental issues is critical for deciding how far India's energy sector can be greened, the readily non-availability of such accounts and reliable monetization of damage effects of environmental pollution would lead us at the present stage to adopt the approaches of finding out the least cost way of meeting the energy demand required to support a given macro-economic growth target, subject to two kinds of constraints:

(i) Maximum utilization of the available relatively clean fuels and the renewables.
(ii) To take a precautionary approach to ensure that certain environmental threshold of high marginal damage is not exceeded causing irreversible high loss of eco-capacities.

The Integrated Energy Policy Report of the Expert Group of the Planning Commission implicitly takes this approach while projecting energy scenarios which can possibly by adopted as the basis for formulating energy policy. We shall try to ascertain the scope of green development of energy sector as indicated by these projections and also explore similar scope or opportunities as being indicated by other studies as carried out by Sengupta (2010) and others recently.

7.2 Energy Resources and Supply

The energy system of Indian primarily consists of the energy carriers – fossil fuel, hydro and nuclear resources, and biomass. The use of these resources would generate two kinds of effects for the economy with sustainability implications – (a) depleting effects on the stock of natural resources and (b) degrading effects of the different phases of fuel or resource cycle on the natural environment (Velthuijsen et al., 1999). There are also other non-conventional renewable resources which can emerge as significant resources in India's future energy balance. The current pattern of energy use in India is heavily dependent on fossil fuels – coal, oil and natural gas – which would be depleted faster with any acceleration of growth of economic output. As of 2008, while the share of primary commercial energy in the total primary energy supply in India has been 73.6%, the share of fossil fuel in the same has been 70.5%. In the total commercial energy, the coal resource had the dominant share of 57%, followed by oil 32% and gas 7.8%. The shares of hydro and nuclear resources in the total primary commercial energy supply have been 2.15% and 0.84% respectively in the same year. The share of new renewable energy had thus only a very small one of 0.30% in the total primary commercial energy supply in 2008.

Table 7.1: Energy Balance of India, 2008 (in million tonne of oil equivalent)

Energy – carriers\ Sectors	**Coal & Lignite**	**Crude Oil**	**Oil prods.**	**Gas**	**Nuclear**	**Hydro**	**New Renewables**	**Combustible renewable and Waste**	**Electr-icity**	**Total**
TPES	261.4	169.3	-24.7	35.6	3.8	9.8	1.4	163.6	0.76	621
Use by Energy Industry:										
Electricity Plants	-190.2	-	-9.8	-15.6	-3.8	-9.8	-1.2	-1.1	71.4	-160.2
Oil Refineries	-	-166.2	166.4	-	-	-	-	-	-	0.2
Other Energy Industry*	-8.7	-3.1	2.3	0	-	-	-	-	0.44	-9.06
Energy Industry own energy use	-1.2	-	-11.9	-4.7	-	-	-	-	-4.7	-24.5
Energy Losses in T&D	-	-	-	-	-	-	-	-	-16.7	-16.7
TFC	61.3	-	122.3	15.3	-	-	0.17	162.4	51.2	412.67
Electricity Generation (billion kWh	569.31	-	34.15	81.93	14.71	164.30	13.76	1.97	-	830.13

Notes: TPES = Total Primary Energy Supplies, TPES = Production + Imports – Exports – International Bunkers + net Stock Increase and TFC = Total Final Consumption.
*Excludes Share of Blast Furnace and adjusted for transfers and statistical differences.
(-) sign indicates use by the concerned sector.
Totals may not exactly tally because of rounding approximation.

Source: IEA Energy Balances of Non-OECD countries, OECD, Paris, 2010.

All the carbon free energy resources constitute thus a meager 3.3% of the total commercial energy supplies of India. Thus the greening of India's fuel mix is really a big challenge to reckon with and requires careful consideration in balancing with the need for support to high growth targets of Indian economy (refer Table 7.1 for the energy balance of India in the year 2008).

7.2.1 Fossil Fuels

The estimate of balance of such ultimate recoverable reserve of conventional oil (i.e., crude oil plus natural gas liquids) yet to be produced has been found to be 2.5 billion barrel of oil while the production of oil has been 28.73 million bbl per year at the beginning of 2010. This would give us a resource to production ratio of 87 years. However, as per the Business as usual policy scenario the annual production of conventional oil is likely to reach a level of 34 billion bbl per annum in 2035. At such depletion rate, the balance of recoverable resources as on 2010 would last for 74 years. This does not take account of unconventional oil like Canadian oil sand or shale oil, etc. (World Energy Outlook, 2010).

In the case of natural gas the undiscovered resources are much more abundant relative to those of oil and are large enough to meet future global energy demand. Proven Gas reserves stood at 184 trillion cubic meter (tcm) at 2008 representing 58 years' production at the current global production rate and 42 years' production at the projected average annual growth rate of production at the rate 1.3% as per the New Policy Scenario of the World Energy outlook; unconventional gas forms a significant portion of gas reserves of USA and Canada. However, the overwhelming large portion – 54% of world's proven gas reserves are confined to just three countries – Iran, Qatar and Russia. Such proven gas reserves, however, constitute only a small portion of the total gas resources that are economically viable for extraction at the current technology that is at the current rate of recoverability and prices. The remaining recoverable reserve of natural gas from has been estimated by the World Energy Outlook 2010 to be 404 trillion cubic meter from conventional sources and 380 trillion cubic meter from unconventional sources, the total being 784 billion cubic meter which is equivalent to about 250 years of current production. The scale of unconventional gas resource available which includes shale gas, coal bed methane, tight gas and gas hydrates, is not known with certainty as these have been poorly explored in many parts of the world. As per the latest data available the production of natural gas in 2008 has been 3167 billion cubic meters in 2008.

Finally, coal resources constitute the largest non-renewable fuel resource with a share of 82% of world's total such resources. With a reserve totaling nearly 1000 billion tones coal resources can take care of demand for almost 150 years at the current production rate. The production of coal had in fact been 4.8 billon tonne in 2008. Coal reserves are geographically widely distributed, but largest deposits are located in USA, China, Russia, India and Australia. Unlike oil, the exploitation of gas has not been constrained by any kind of resource – nationalism except in Venezuela. However, actual coal extraction in future may be constrained in future not due to resource scarcity but for moderating GHG emissions.

India had a balance of recoverable reserves of 769 million tones of oil, 1050 million cubic meters of natural gas in 2009, while the production of oil and natural gas 33.51 million tonne of oil and 32.849 billion cubic meter of gas in 2008-09. These implied a reserve to production ratio of 23 years for oil and 32 years for natural gas. However, India imported almost 76% of her oil requirement form imports in 2008-09. So far as coal – the major fuel of India is concerned the estimates of ultimate recoverable reserve – i.e., was that of proved reserve and that of ultimate recoverable reserves had been 101.86 billion tonne and 264.5 billion tones respectively as on 1.1.2008, while the production has been 493 million tonne in 2008-09. This would imply a proved reserve to production ratio of 206 years. The resources lying upto 1200 meter depth of India would however, last for 537 years to meet the requirement of production at the current rate.

With economic growth the fossil fuel requirement is likely to go up and with cumulative depletion of such fuel resources, reserve to production ratio is likely to decline over time if the current trend of dependence on fossil fuel continues in the future. However, the historical experience has often shown upward movement of this ratio over time. The accretion of new reserves due to discoveries of new deposits of non renewable fossil or upward revision of the reserves of the earlier discoveries explain such movement of the ratio in the past. However, such accretion of reserves requiring investment of capital and finance cannot make these non-renewable resource renewable. With discovery it is only the undiscovered resources get proved as established reserves. As the total quantity of discovered and undiscovered resources in recoverable unit of any fuel or mineral is a constant, any amount of production would mean that there remains that much fewer of resources to meet the human need in future. Every discovery of resource comes from the ultimate stock of undiscovered resource which is non-replenishable and declining. All the fossil fuels sooner or later are bound to be exhausted and give rise to the problem of sustainability of the development process.

The actual phasing out of non-renewable resource would however depend not just on when the stock would get physically exhausted, but also on when the competing backstop or newly emerging green technologies (like solar powered thermal or photovoltaic or wind) would become competitive with the cost of use of the depleting fuel with the existing technology. With increasing depletion, the economy has to go into the increasingly difficult area for discovery and exploit increasingly difficult reserves from among the discovered ones. The marginal cost of supply of hydrocarbons or coal would therefore increase over time in the long run. On the other hand, the scarcity value of any such resource should ideally go up so as to be reflected in its optimal rental value to be built into the price of the fuel resource and drive the rate of depletion of the stock to be an optimal one. All these would make the use of such a conventional fossil fuel or nonrenewable resource costlier over time.

The Research and Development investment, on the other hand, is expected to bring down the cost of the competing technology over time. For example, the unit cost of wind power declined from Rs. 6 per kwh in 1985 to the present level of Rs. 2.5 per kwh making it ultimately competitive with the existing ones. Investment in exploration and extraction operations of a given fuel resource would then depend on the state of development of its potential substitutes. The actual amount of a discovered reserve is thus determined by not only what the biosphere can provide of that resource in a region, but also by the economic factors that determine the dynamics of competitiveness of one resource and the associated technology vis-a-vis the backstop one.

Besides, at the macro level an individual country's ability to discover and develop a resource depends also on the availability of capital for employment for such purpose and the associated macroeconomic opportunity cost of such engagement capital and therefore on the stage of development of the economy itself. What is important to notice here is that the magnitude of the known reserves of fuel or non fuel nonrenewable resource, their pattern of use and the time horizon of switching to other competing resources and technology (say from coal based to solar power) are all determined by the interaction of the economy and the ecosystems containing the deposits of the known or unknown amounts of reserves of the economy (see Meadows et al., 1992). However, policies can also play an important role in the speed of emergence of the competing renewable resources for replacing existing nonrenewables resources and influenced significantly the pace of movement towards their adaptation in the economic system.

However, for the dominant fossil fuel of today in the world, i.e., oil these exists a special problem of security faced by India. The studies on Hubbert's peak analysis shows that the oil production follows a Gaussian shape against the cumulative depletion and the peak of production would correspond to the stage when half of the ultimate stock of reserve has been depleted by the cumulative production in the past. Under the alternative assumptions regarding the estimate of ultimate recoverable reserves of crude oil and the choice of the model for estimation the econometric studies have shown the estimate of the year when that world is going to cross the Hubbert's peak is around 2014-2015 (Nel and Cooper 2009, Maggio and Cauiola 2009, Nashawi, et al 2010). India reached a plateau of peak production of oil from 1995 onwards. Her dependence on oil through import has secularly increased over time reaching at level of 76% in 2008-09, such dependency causes 35% of India's export earning to cover the value of the net import of crude oil and petroleum products.

There is also an additional problem with oil – with respect to its very uneven distribution across regions leading to serious problems of geopolitics. The OPEC countries of the Middle East, South East Asia, North Africa, Latin America contributed 42% of world crude oil production in 2009. At the beginning of 2010 the proportion of balance of ultimate recoverable was as high as 68% in the middle east and the former Soviet Union countries while it has been only 17% in North America. Out of 2.5 trillion barrels of ultimately recoverable oil reserve these two regions would have a share of almost 2 trillion barrel i.e. 80% of world's ultimate resource (World Energy Outlook 2010). This skewness of regional distribution of oil is also reflected in the share of energy import in the total commercial energy use of the different countries. This share has been 18% for high income industrialised countries, 21% of middle income countries which would include oil exporting countries of the east, 7% for China, 24% for India and -8% for low income countries in 2007 (WDI 2009). This shows vulnerability of India with reference to energy security.

As oil is by and large non-substitutable in a wide area of the transportation sector which is a strategic sector and plays a critical role in human mobility, the unequal distribution of oil reserves makes further an oil importing country like India extremely vulnerable in a situation of oil price fluctuation. An oil importing developing country with external debt problem may in fact face an energy crisis even if the world reserves are enough to meet the requirement of the world for a century at a moderate growth rate. The industrialised north would also face the problem of instability due to any sharp oil price hike in an oligopolistic market situation of such resource. The sustainability issue therefore often turns out to be globally a political economic as well as geopolitical one because of the skewed regional distribution of fossil fuel resources in the biosphere in the given context of technology and resource options as of the present. This security aspect is going to be another driving force for India to look for greener option of energy resources.

Apart from the consideration of scarcity of the resource supply, the environmental degradation caused by the use of fossil fuel which leads to the scarcity of a range of ecoservices as already referred to would add as an additional inducing factor for the green movement in energy.

7.2.2 Nuclear Energy

In spite of the well documented safety concerns, it is undeniable that nuclear energy is a vital component of the energy industry of the world and is going to be of increasing importance in India in the future. However, until now India has developed its nuclear energy programme almost entirely indigenously with little foreign collaboration and aid in this area because of India's nuclear policy of remaining a non-signatory of the Nuclear Nonproliferation Treaty. Unfortunately India is poorly endowed with low grade uranium which can supply fuel upto the requirement of 10,000 MW Pressurised Heavy Water Reactors (PHWR). India has set itself the target of installing 20,000 MW capacity by 2020, using new light water reactors. The uranium content of India's low grade ore is 0.1% while the same is 12-14% in the major sources abroad making the process costlier. (Planning Commission 2006). However, India has substantive reserve of thorium which has to be converted into fissile material through breeding to uranium 239 for any energy generation.

India has developed a programme of three stage development of nuclear power: the first stage with PHWR, the second stage with Fast Breeder Reactor (FBR), and the third stage with reactors based on uranium 233-thorium 232 cycle. (Planning Commission 2006, Kakodkar 2004). It is envisaged that the plutonium fuel and the recovered uranium from the PHWR of the first stage will provide the major fuel for the second stage. Thorium will be used as a blanket material in the breeder reactor of the second stage to breed uranium 239 for fission in the third stage. Table 7.2 shows the potential availability of nuclear energy which is quite large for the third stage. However, it is also envisaged that the PHWR of the first stage would have to be supplemented by some Light Water Reactor (LWR) based on the import of technology and fuel to produce enough plutonium for the second stage. If the nuclear programme is successful, then the nuclear option can provide large amount of clean electrical energy. The success of this programme would however depend on India's ability to import nuclear fuel overcoming the political constraints at home and abroad.

Table 7.2: Potential Availability of Nuclear Energy of India

Resource Base	Metal resource (tonnes)	Electricity Energy (GWe-Yr)	Electricity Capacity (MWe)
Uranium Metal	61,000		
(a) In PWHR	-	330	10,000
(b) in Breeder	-	42,200	5,00,000
Thorium Metal	2,25,000		
In Breeder	-	1,50,000	Very large

Source: Planning Commission, 2006.

There has however been a debate a few years ago on the issue of competitiveness and the policy of capacity expansion of nuclear energy by the government Ramana et.al (2005), and Ramana (2007) argued that coal based thermal power was cheaper than the nuclear power using the data of the Kaiga I and II and Kaiga III and IV Reactors with life of 40 years, for nuclear power and Raichur VII Power Station (RTPS VII) with life of 30 years for coal thermal and using the methods of discounted cash flow for obtaining the amortised cost per unit of energy. They also pointed out the sensitivity of such cost with respect to the choice of discount rate (see Table 7.3). Thakur S. (2005) and Srinivasan et. al (2005) argued on the other hand that some of the input data used in Ramana et. al (2005) were wrong and as per the correct data the cross over discount rate which would make coal cheaper option is not as low as worked out by Ramana et. al (2005).

Table 7.3: Comparative Amortised Cost of Nuclear and Coal Thermal Power Generation

(in Rs/kwh)

Discount rate (Percent)	Kaiga I and II Nuclear	Kaiga III and IV Nuclear	RTPS (VII) Coal Thermal
2	1.32	1.32	1.36
2.5	1.39	1.39	1.37
3	1.48	1.46	1.39
4	1.66	1.62	1.42
5	1.87	1.79	1.45
6	2.10	1.98	1.49

Source: Ramana et. al., 2005.

In a separate study, Bharadwaj et al (2006) have calculated the generation cost using an international price data and a capital cost of $ 1300 per KW for a plant size of 1,000 MW assuming a PLF of 80 percent, a debt-equity ratio of 70:30, weighted average cost of capital at 10 per cent, and a plant life of 30 years. This yielded the fixed cost, operating cost to be and total cost to be respectively, 2.61 cents, 1.2 cents and 3.81 cents per kwh i.e., Rs. 1.70/kwh assuming an exchange rate of Rs. 44.5 to a dollar. Similarly, another study of NPCIL (as reported by Srinivasan et.al 2005) mentions that nuclear power from PHWRs is competitive as compared to coal fired thermal power when the coal fired plant is located at a distance of about 1000 kms from pit head. The study is based on the comparison and adjustment of the average tariff charged by NPCIL with the average power purchase rate of SEBs.

This debate may have relevance in the context of choice of a project among alternative energy resource based routes of production in a shorter time horizon but not in a longer planning horizon. In the long run the growth of energy requirements of India to support the high economic growth rate would be so substantive that the relevant long run supply function of energy for not so long distant future years will have to be based on the use of a variety of energy resource based technologies as per the sequence of merit ordering of costs. In view of the growing deteriorating quality of coal, the cost of nuclear energy will be competitive over the coal based one for the additional supply at the margin when the aggregate supply of energy exceeds a certain critical level. Besides, none of the cost calculations of electrical energy as per Ramana et. al (2005) or of the Department of Atomic Energy internalizes any environmental cost of power generation. The debate does not thus throw any light on the merit ordering of coal vs. nuclear as per the social marginal cost of generation even for shorter time horizon. In any case as no individual fuel can dominate over others in all dimensions of financial and environmental costs, nuclear fuel will play surely a significant role in any green energy scenario for meeting the growing electrical energy need to support high economic growth in the future in view particularly of the negligible air pollution implication of this fuel. The comparative life cycle CO_2 emissions arising from the various energy resources as indicated in Table 7.4 establish clear advantage of the nuclear option over others in the context of control of climate change. The major challenge which will be associated with this option would be the R&D achievement in controlling, handling and disposal of the radio-active wastes arising and to ensure greater safety keeping in view of the seismic risks in the different regional parts of our subcontinent.

Table 7.4: Life Cycle CO_2 Emission from the Various Energy Resources

(in gm/kwh)

Energy Source	Life Cycle CO_2 Emissions
Coal	800-1200
Natural Gas	390-510
Nuclear	2-59
Wind	7-124
Solar PV	13-730
Biomass	15-100

Source: Bharadwaj, Tongia and Arunachalam, 2006.

7.2.3 Hydro Electricity

Environmental Externalities of Hydro-energy Resource Use

Of the commercial renewable fuel resources convertible into modern clean energy form, hydro-resource has been the most important one in all countries. The water in storage or flowing along a gradient is the resource which is used to generate the electrical energy, involving substantive use of capital. The same is true for wind, tidal, solar and other forms of non-conventional energy which are all ultimately derived from the solar energy as driving the atmospheric and hydrological system of the biosphere and harnessed for finally generating electricity. The converted final energy forms of electric power from such resources have also an upper bound per unit of time as all of them are driven by solar energy as determining the quantum of water flow and involves substantive use of capital and costs which vary across the resources. The hydroelectric dam and river valley projects have multiple objectives of supplying water for irrigation and domestic use, generating electricity and controlling flood, etc. While this form of energy has no adverse effect on air quality, the construction of dam disturbs the environmental equilibrium of the project region and even beyond. The submergence of large area of land will have dislocating and adverse effect on human settlements, wild life habitats, biodiversity and agricultural land. The deforestation in the energy catchment area by submergence for storing water resource may lead to soil erosion and silting of reservoir and also of down stream rivers and channels and growth of vegetation at channel bed with shallow streams in substantive part of the time in a year. All these would raise the risk of floods during monsoon in tropical regions when heavy rain fall often takes place in short duration.

However, the stagnation of water in large storage would also contribute to the charging of ground water in the surrounding areas depending on the rock structure. The storage water and the down stream water flow along rivers and irrigation canals, irrigation being mostly by flooding, may contribute to the rise of the ground water table if there is no appropriate drainage for the flow of water to the agricultural fields. This may down grade land by causing water logging and rise in the salinity of soil which would affect its fertility.

The environmental problems of a hydro project are site specific. The planning, design and management of the dam or reservoir and the entire downstream constitute a big challenge and task. Any failure in meeting the challenge is likely to end up with an environmental mess and disequilibrium of the ecosystem of the reservoir region and the river valley.

Finally, the stakeholders in the context of a multipurpose dam or reservoir project — people facing dislocation of the habitat, agriculturists, user of electric power, beneficiaries of wild life conservation and forests, fishermen, government and others concerned — may have serious conflict of interests, the resolution of which becomes also a necessity to minimise the impact of socio-economic adverse externalities of a hydroelectric project. It becomes thus debatable whether large hydro project will help to eradicate mass poverty. While the benefit of irrigation is surely to help the rural population through rise in agricultural productivity on the one hand, the displacement of human settlement, land degradation due to imperfect drainage, etc. may adversely affect the poorer section of the population on the other. The green development would thus advocate greater emphasis on micro-watershed management for meeting water requirements and micro hydel for power generation than investing in large storage by disturbing the ecosystem of rivers. However, as large dam remains still the largest source of carbon free energy resources, the designing of the projects need to take account of careful planning and design and adequate supplementary measures for avoiding, minimizing and compensating for losses or environmental damage.

Quantitative Role of Hydro-electricity

Among the renewable modern energy supplies hydroelectricity has nevertheless been the dominant one till now, although its share in the total primary commercial energy as well as in electrical energy has been declining over time. India's thermal hydro mix was ideally planned to be 60:40, while currently it is around 74:26 in terms of capacity. The major reasons for slowing down of the hydro capacities have been long gestation lag, geological uncertainties, contract management, resettlement and rehabilitation, etc. Besides weather conditions in India have caused uncertainties regarding water resource availabilities and low plant load factor. As a result hydro plants have turned out to be more expensive costing in the range of Rs. 6 to 7 crore per MW in comparison with the thermal plant whose capital cost has been in the range of Rs. 4 to 5 crore/MW. Table 7.5 gives the potential of hydro electricity and other renewable energy resources in terms of maximum annual flow of energy that may be harnessable. India's hydel resource potential is estimated to be 84000 MW at 60% load factor. The installed hydel capacity of the utility system as in 2005 has been about 32,326 MW which was operated at 29% load factor. In view of the low load factor due to the limitation of the water resources, the economics of small hydel plant of less than 25 MW capacity would work out better for peaking power than that of the large storage dams. Besides, most of the future hydel resource potential to be developed in India are located in the North Eastern region, Himachal Pradesh, and Uttaranchal. This implies the importance of fast development of the integrated national power grid for taking advantage of the full hydel potential for sustainable energy supply (Planning Commission 2006). Fortunately this has been by and large achieved by now.

7.2.4 Biomass and bioliquid Energy

Biomass

Biomass constitutes more than a quarter of the total primary energy supply even as of today in India. It is only a negligible fraction of such biomass including wastes that is converted today into biogas or electricity. Energy conversion technologies for biomass in traditional country ovens are highly inefficient; and the harmful gaseous emissions (CO, HC, particulate matters, etc.) cause problems of health for women and children in the households in the lower income classes who are exposed to these emissions. The indoor pollution causes respiratory infections and diseases leading to premature deaths. According to the estimates of World Health Organisation (2006), 1.3 million people, mostly women and children in developing countries, die every year prematurely due to the use of bio-mass which is a threat of health next in order of magnitude to only malnutrition, HIV/AIDS and water borne diseases (WHO, 2006).

Besides, valuable time and effort are devoted by mostly women and children for biomass fuel collection at the opportunity cost of a productive earning employment. In India, a case study points out that 85 million households spend 30 billion hours annually in fuel wood gathering (Parikh, et. al 2005). Over harvesting of biomass, particularly fuel wood as collected from forests have often the adverse impact of deforestation. In poorer regions of India, particularly in the Himalayan regions where access of the people to commercial energy is limited, there has been degradation of forests due to over use (Baland et. al 2006). A decrease in forest area or its degradation due to the lowering of crown density would adversely affect the carbon sequestration and would contribute to the accumulation of the stock of CO_2 in atmosphere and therefore to the global warming.

Although India depends on the renewable biomass which is as such carbon neutral if not over harvested, for 27% of her total primary energy requirement, this resource is used with low efficiency and without any conversion directly by the households causing health risks for them. The sustainable energy development for inclusive development will have to target the replacement of polluting biomass by cleaner modern energy with higher efficiency. Apart from the conventional commercial energy like electricity, kerosene and LPG, which can provide clean energy security for the households, there exists the potential of development of new renewable technologies in order to convert biomass resources to provide clean energy. The biomass resource itself can be converted into environmentally clean fuel like biogas by way of wood, dung or agro or other biotic waste gasification. In view of the inevitable dependence on biomass for cooking fuel, this option of biomass conversion has assumed importance of policy significance as a strategy for rural green energy development. It is possible to organize for example, both family sized and community sized plants if a critical minimum dung of animals can be mobilised for the plant involving voluntary cooperation of all the stakeholders in an incentive compatible way (Parikh and Parikh 1977).

Bioliquids

Apart from the animal wastes, plant biomass can also produce liquid fuel. Bio -diesel from plants like Jatropa, Karanj, and Mahua and ethanol from sugar cane are economically viable options which can reduce India's oil dependence provided sufficient waste lands can be mobilised or good quality land can be diverted for such use. The potentials of such bio fuels for India are given in Table 7.5.

Table 7.5: Renewable Energy Resources of India (in mtoe per year)

	Resources	Present	Potential
1	Hydro Power Capacity (in MW)	32	1,50,000
2	Biomass		
	(a) Fuelwood	140	620
	(b) Biogas*	0.1	15
3	Bio-Fuels @		
	(a) Biodiesel	-	20
	(b) Ethanol	<1	10
4	Solar @		
	(a) Photovoltaic		1200
	(b) Thermal		1200
5	Wind Energy	<1	10
6	Small Hydro-power	<1	5

Source: Planning Commission, 2006. * Based on the assumption of Community Plants. @ Based on assumptions regarding land availability (for details see the source.

The bio-fuel policy of the Government has set the target of use of 20% of bio-fuel in the blend for diesel or motor gasolier to be used for automotive energy in transport sector by 2017. The total demand for diesel as worked out by the Planning Commission has been about 143 million tonne in 2031 and that of bio-diesel requirement to be 29 million tones. Accordingly Planning Commission estimated the land requirement for the purpose to be 24 million hectares assuming some normative yield. There is however a problem regarding the estimate of availability of waste land for the use of such purpose. If the availability of land for jatropha cultivation be taken to be the culturable waste land and the land under miscellaneous trees crops and groves only which have been 3.45 million hectares and 13.24 million hectares respectively, the total availability of land works out to be 16.69 million hectare in 2006-07 which would be inadequate for the purpose in the long run. If we consider all kinds of degraded lands as existing in any category of land use to be suitable for jatropha cultivation, the estimate for land availability may go up to an estimate of 37 million hectares approx. However, this issue of availability of degraded land suitable for jatropha cultivation needs to be settled and also the modality of regulation of cultivation of such commercial crop to such degraded land area only would require to be decided since other wise high oil prices may cause such rise in the ground rent of land for energy cultivation that substantive land use diversion from food to energy may take place threatening food security. An exercise was carried out to find out the critical diesel price in US $ per billion which would make land use competitive for jatropha cultivation vis-à-vis cultivation of major crops and in selected states in 2004-05 cost price situation. These are presented in Table 7.6. A comparison of these critical prices with the actual diesel prices as experienced in the concerned period shows the clear vulnerability of our food and agricultural security if market forces are allowed to drive the land use pattern in the country.

Table 7.6: Critical Price of High Speed Diesel (HSD) (in US $ per barrel, 2004-05)

Crop	Andhra Pradesh	Haryana	Maharashtra	Tamil Nadu	Uttar Pradesh	Uttaranchal	Karnataka
Sugarcane	81	102	97	83	83	87	106
Wheat		60			54	51	
Bajra		49	49		50		
Paddy	64	65		52	53	53	55
Rapeseed & Mustard		59			57		
Cotton	62	65	51	50			56
Ragi				51			46
Groundnut	55		47	57			51
Urad	57		48	53	52		
Jowar	51		49	48			51
Sesamum				54	56		
Barley					52		
Masur					53		
Gram	61		52		59		
Tur	58		57		61		53
Maize	52				50	47	54
Moong	54		48				
Soyabean			52				
Sunflower	52		53				51
Safflower			53				
VFC Tobacco	56						

Note: The exchange rate for 2004-05 is assumed to be Rs 42.25 per US Dollar.
Source: Sengupta and Singhal, 2010.

Similarly high prices of gasoline can induce such rise in molasses prices in sugar industry that sugarcane cultivation may tend to compete out other crops threatening again the food security among others. Table 7.7 shows these critical gasoline prices for selected crops and states which would threaten their respective competitiveness vis-à-vis sugarcane for the year 2005-06. Given the price experience of gasoline in recent years in international market, these estimates of critical prices of gasoline point to the vulnerability of food security in terms of sugar supply. Thus, the land use change for the development of energy crop cultivation can have important socio economic effect which would need to be factored in before taking any decision on the large scale implementation of bio-fuel cultivation for green development.

Table 7.7: Critical Price of Gasoline for 2005-06 (in US$ per barrel)

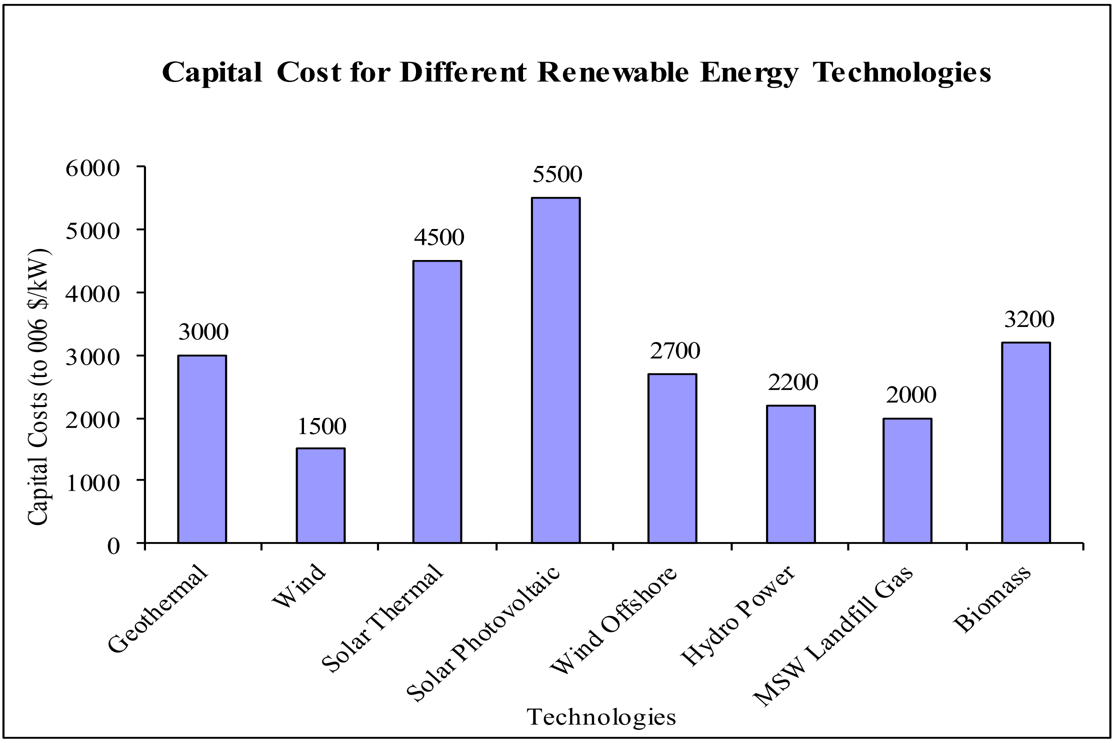
Crop	Andhra Pradesh	Haryana	Maharashtra	Tamil Nadu	Uttar Pradesh	Uttaranchal
Jowar	129.53		90.50	69.30		
Maize	136.26			76.26	54.49	44.00
Gram	141.72		100.60		73.33	
Cotton	134.34	136.89	95.50	72.61		
Moong	139.18		93.11			
Sunflower	131.31		97.62			
Urad	157.66		94.38	75.95	57.99	
Paddy	142.93	156.00	94.92	73.03	60.79	52.17
VFC Tobacco	143.16					
Groundnut	127.61		94.09	74.28		
Tur	137.71				66.44	
Wheat		145.61			60.79	45.08
Bajra		126.22	92.74		54.88	
Rapeseed & Mustard		147.29			66.81	
Soyabean			96.28			
Safflower			96.10			
Ragi			84.91	71.11		
Sesamum				76.10		
Masur					67.01	
Barley					57.80	

Source: Sengupta and Singhal, 2010.

7.2.5 Abiotic Sources of New and Renewable Energy

Finally, wind energy and solar thermal as well as photo voltaic solar electrical energy for electricity have substantive potential in India as indicated in Table 7.5. Wind power can be generated from the energy potential of on shore wind flow but only at a low load factor of about 20%. The solar thermal, on the other hand, is an economically feasible option mainly for water heating. The solar power is still a high cost option (Rs. 20/kwh). Even if further R& D effort reduces the cost of solar photo voltaic option as is hopefully expected, it would require substantive use of land (Planning Commission, 2006). Figure 7.1 shows current position of relative capital costs per kw in 2006 for the alternative renewable technologies showing the wind to be the cheapest option and solar PV the costliest one. As there is little material fuel involved in any of the options the relative capital costs would be the major determining factor of competitiveness of the new renewable technologies (Garg et. al 2010).

Figure 7.1: Capital Cost of Different Renewable Energy Technologies

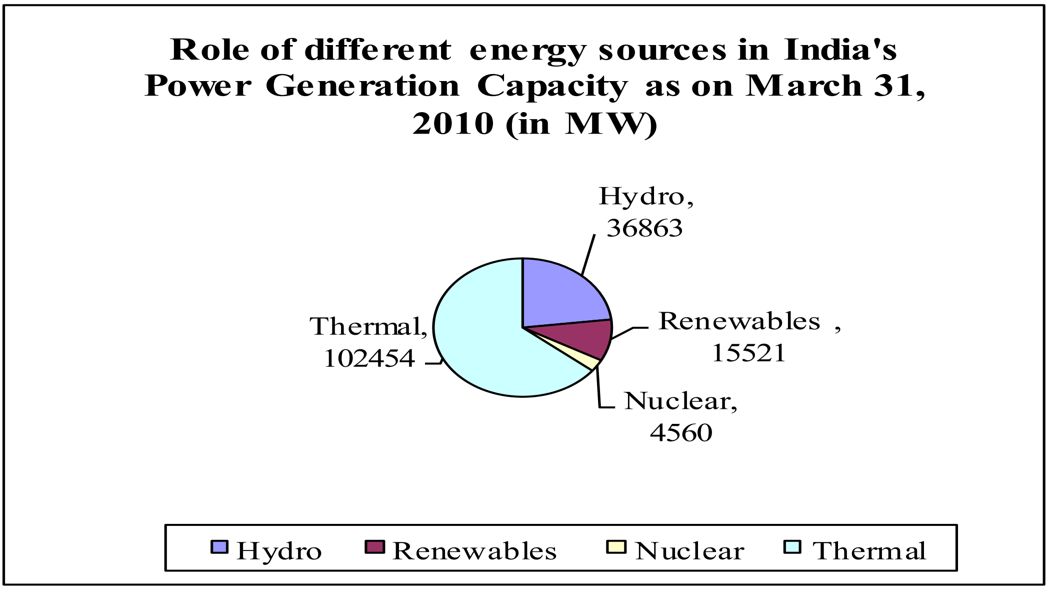


Source: Garg et al., 2010).

The figure 7.2 shows the shares of different energy resource based technologies in total power generation capacity of India, installed capacity of new renewable energy based power (i.e., excluding large storage based hydel power) technology being 15521 mw in a total of about 1,60,000 mw system on March 31, 2010. Figure 7.3 shows further the distribution of share of grid interactive alternative renewable energy capacities in

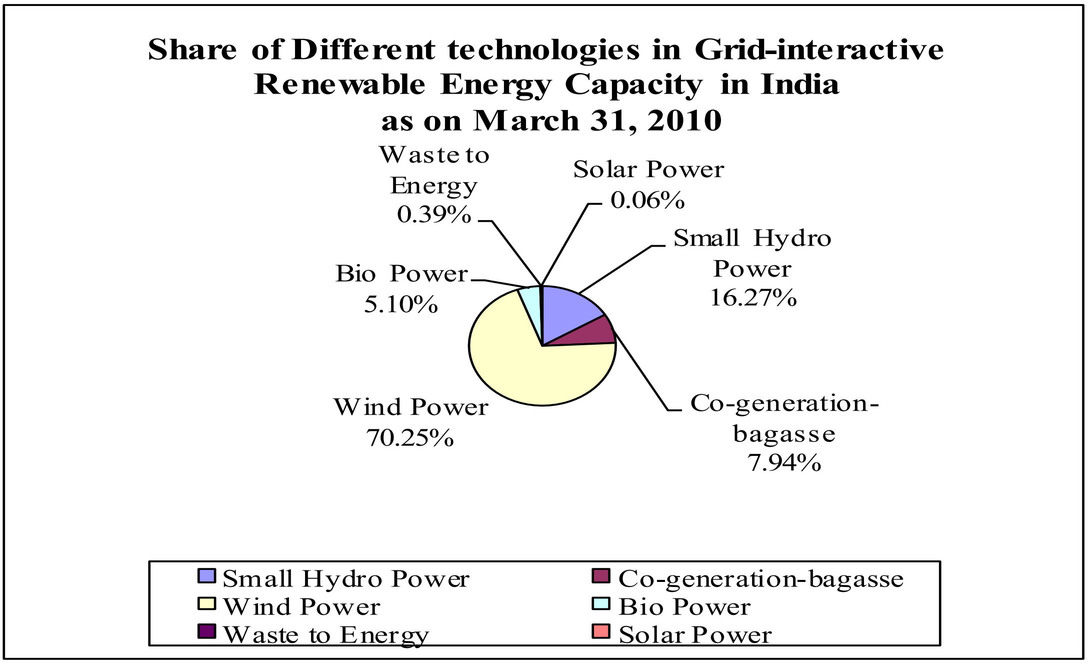
India as on the same date. These show wind power to be the dominant technology having 70% of the renewable grid connected power capacity and solar photo-voltaic having the least share of 0.06% in such grid connected systems. These are consistent with the findings of relative capital cost ordering of these technologies.

Figure 7.2: Energy Sources of India's Power Generation Capacity



Source: Garg et al., 2010.

Figure 7.3: Different Technologies in India's Renewable Energy Capacity



Source: Garg et al., 2010).

It is to be noted, however, that the renewable energy resources like solar radiation, wind flow, tidal wave, micro hydel and biomass can be used for generating thermal as well as electrical energy. All these renewables including storage based hydroelectricity as already pointed out are ultimately solar powered. However, the maximum of solar radiation reaching the earth is a finite, non-storable and dilute form of energy. The potential of electric power generation from the wind or tide or micro hydel water resource flows is limited and the time distribution of their availabilities somewhat determined exogenously for the human economy by nature. The divergence between the time distribution of demand for electric power which is essentially non-storable and the time distribution of availability of such non-storable basic resource creates the problem of full utilization of opportunities as well as meeting the demand unless there is a grid connection with such renewable resource based power supply. In the case of grid connectivity, the surplus wind power can be sold to and the deficit of its in an area can be drawn from the grid. In the calculus of relative competitiveness, it is also pointed out that the decentralized stand alone energy system in remote areas based on such locally available resources becomes competitive as there is no need to invest in transmission ensuring the cost to be on the low side. However, the mismatch between the time distributions of demand and supply of the basic resources would require either grid connection or alterative storage facility or availability of storable energy resource based supply (e.g., oil or hydro storage if such potentials are available) for meeting at least the consumers' satisfaction.

Just as renewable energy resources are not unlimited, nor they are entirely environmentally harmless. Biomass energy has the same set of environmental problems as with agricultural and forestry products. Some solar sources are of higher dilution depending on the location and climatic condition. Harvesting and effective use of the radiation may involve large collection areas and complex hi-tech storage mechanism (may be in hydrogen form by solar electric splitting of water molecule). Besides, photovoltaic solar cells have got some toxic material content and involve huge material yield loss from raw material. If any renewable energy resource use becomes again man-made capital intensive or construction intensive, the machinery and construction will congeal substantive amount of environmental pollution.

However, of all the non conventional or new energy options, hydro, wind and dung based biogas have the advantage of no significant land use diversion, while the solar power and any plant based fuel would require land which may have high social opportunity cost if it impinges on the food security of the country. The exploitation of such options for greening the energy scenario would thus therefore require careful land use planning for maintaining inter sectoral balance for maximising the social welfare of the people.

In spite of all the limitations of the new and renewable energies the total potential of generation electrical energy from such sources is really huge while only a miniscule fraction of it has been really exploited. Table 7.8 shows the estimated potential of power capacity and the cumulative achievement as on 31 March 2007 as per Eleventh Plan document. It is really the high capital cost of some of the options like solar photovoltaic as already noted which is the main reason for such low utilization of potential while subsidies acted as a barrier to cost reduction. However, the lack of entrepreneurship in the deployment of such capital and technology, lack of institutional support at the grassroot level, poor focus on training and management for using and maintaining such new technologies and the lack of awareness of rural community have been important additional factors which all together contributed to the poor achievement in this direction. Table 7.9 gives the technology wise estimates of both capital cost per MW of capacity as well as the unit costs of generation.

Table 7.8: Estimated Medium Term (2023) Potential and Cumulative Achievement of Renewable Energy, 2007

Source	Units	Estimated Potential	Cumulative Achievements
A. Grid Interactive Renewable Power			
Bio power from agro residues etc.	MW	16881	524.8
Wind Power	MW	45195	7092
Small hydro (<25 MW)	MW	15000	1975.60
Cogeneration (Bagasse)	MW	5000	615.83
Waste to Energy	MW	7000	43.45
B. CHP/distributed renewable power			
Solar	MW	50000	2.92
Biomass/Cogeneration	-	-	45.80
Biomass Gasifier	-	-	86.53
Energy Recovery from Waste	-	-	19.76

Source: Eleventh Plan Document, Planning Commission.

Table 7.9: Capital Cost and the Typical Cost of Generation of power from Renewable Sources

Source	Capital Cost (Rs. Per MW)	Estimated Cost of Generation per Unit (Rs. Kwh)
Small hydro power	5.00 to 6.00	1.50 to 2.50
Wind power	4.00 to 5.00	2.00 to 3.00
Biomass power	4.00	2.50 to 3.50
Bagasse cogeneration	3.5	2.50 to 3.00
Biomass gasifier	1.94	2.50 to 3.50
Solar photovoltaic	26.5	15.0 to 20.0
Energy from waste	2.50 to 10.0	2.50 to 7.50

Source: Eleventh Plan Document, Planning Commission.

Table 7.10: Mismatch between Renewable Energy (RE) Capacity Envisaged Under Policy and Capacity Addition Targeted

Details	2009-10	2010-11	2011-12	2016-17
Energy requirement (in billion kwh)	821	891	969	1392
Share of RE as mandated under NAPCC (in %)	5	6	7	12
Quantum of RE required (in billion kwh)	41	54	68	167
RE capacity addition targeted by MNRE (in MW)	15542	20376	25211	57000
Solar capacity targeted under JNNSM (in MW)			1000	10000
Quantum of RE available (in billion kwh) assuming 22% PLF	30	39	51	129
Additional RE required to meet RE share mandated under NAPCC (in billion kwh)	11	14	17	37

Source: Garg et.al, 2010.

However, the government of India has recently given a new thrust on the development of renewables particularly solar energy development. As part of the National Action Plan on climate change it has mandated certain share of renewable energy supply in the total annual electrical energy supply to the meet requirements over the time horizon 2009-10 to 2016-17 starting with 5% in 2009-10 and ending up with 12% share in the terminal year of 2016-17. The ministry of new and renewable energy (MNRE) has targeted certain capacity addition and the Jawaharlal Nehru National Solar Mission (JNNSM) has targeted some further solar power capacity addition over the same time horizon. Such additions amounted to 57000 MW as per MNRE plans and another 10,000 MW solar power as per JNNSM. Assuming a 22% PLF for such renewables and solar capacities, there would still remain shortfall of renewable energy supply of 11 to 37 billion units to meet the commitment of climate change actions (see Table 7.10). This would require further renewable capacity addition as part of immediate actions.

7.3 Energy Efficiency and Sustainable Development

In developing countries like India there exists enormous scope of energy conservation by upgrading technology, equipment and appliances in a wide range of areas of application — furnace, motors, insulation system, automobile engine, cooking burner, power generating system, and innumerable others. Also energy is used to power equipment to do some work. If the design of the latter or the entire device itself can be so changed that it will do the same work but with less of energy resource, it will lead to both conservation of energy resource for the future as well as reduce the pollution externality and prevent the process of erosion of eco-capacity. The efficiency considerations are also important in the supply of energy for final end use — i.e., in the process of energy resource extraction, conversion or refinement and transportation of energy. If the recoverability of coal (underground mine) be 40%, handling and transportation loss be 5%, conversion efficiency of coal be 30%, transmission and distribution loss be 25%, auxiliary loss (or power plants' own requirement) be 8%, 100 unit of in place geological thermal energy as congealed in coal will yield only 7.8 units of energy for final use. Very high transmission loss and low efficiency of conversion of energy resources into electric power causes substantive loss of energy resources and substantive pollution.

Lack of adequate application of efficient technology both on demand and supply sides of energy market in developing countries like India has been due to possible inadequacy of finance capital, absence of appropriate penalty cum incentive scheme or command and control measures to induce conservation and the persistence of highly irrational energy prices in India. Low and subsidized price of energy has led to the wasteful use of scarce resources and unsustainable pattern of energy use in India. With the increase in energy efficiency the same resources will last for longer period for the same pace of growth because of the virtual rise in the stock of resources in efficiency unit. Similarly, higher energy efficiency would also raise the level of flow of renewable energy in efficiency unit over time and support a higher level of economic activities. It is the employment of investible surplus of a society in R&D activities to develop energy efficient devices which can have favourable impact on the long run marginal cost of supply of the end product produced out of energy. One should here remember that rise in energy efficiency would often imply a substitution of energy by capital or other inputs. Such substitutions have of course to be efficient in the sense of reducing the total cost of production in term of all the basic factor prices, the factor prices being inclusive of the due share of scarcity rental for the existing fuel resources. In any case, the efficient energy conservations along with substitution of non-renewable resources by renewables would together relax the severity of the limitation of nature both as a source and sink permitting development to be green and sustainable at least for some more time to come.

7.3.1 Energy Resources Use and Energy Efficiency in India a Macro Overview

How far has the India's energy performance been efficient and environmentally sustainable? At macro level India's productivity of energy use has been lower than those of USA and high income countries but higher than those of China, low and middle income countries and the world average (see Table 7.11).

Table 7.11: Energy Consumption across Regions/Countries

Countries	Population 2008 (in millions)	GNI $ PPP (2008)	Primary Energy Use per capita (in kgoe)	Share of combustible wastes in primary energy 2007(in %)	Electricity production BkW in 2007	Productivity of Energy Use in 2005 PPP$/kgoe eq. 2007
India	1140	2930	529	27.2	803.4	4.9
China	1325	6010	1484	9.9	3279.2	3.4
USA	304	48430	7766	3.5	4322.9	5.5
Low Income	976	1354	423	49.3	336.8	3.2
Middle Income	4652	6133	1242	13.2	8665.5	4.4
High Income	1069	37665	5321	3.7	10858.4	6.5
World	6697	10415	1819	9.6	19818.9	4.2

Source: World Development Indicators, 2010.

Cross-country data on efficiency of energy as presented in Table 7.11 illustrates the variation of efficiency of use of energy with the level of development. In the initial phase of development the process of industrialization leads to increased penetration of commercial energy into the economy and raises the commercial energy intensity of GDP due to changes in the structural composition of GDP and substitution of biomass by modern efficient clean final energy. Besides, with the industrialization of developing countries there is also global relocation of industries, the energy and pollution intensive manufacturing industries moving from the developed countries to the developing ones and contributing to the upward pressure of commercial energy intensity of GDP. However, beyond a threshold level of development as indicated by the per capita income, the sectoral composition of national income would change in favour of services which is of lower energy intensity at the cost of share of manufactures whose energy intensity is higher. Besides, the ability to pay for efficient energy using technology also goes up and the preference of the people switches in favour of the environmentally cleaner and less energy and emission intensive technologies as reflected in the stringency of the energy efficiency and environmental standards enforced by the regulatory regime of a society. As a result, the energy intensity of GDP as a function of per capita GDP is normally expected to follow an inverted U-shaped curve. The GDP elasticity of commercial energy thus starts from a high value in the early stage of industrialization and thus declines with its progress and comes down below 1.

Table 7.12: Primary Energy Supply and Electricity

Year-Calendar	TPES (mtoe)	CMBRN (mtoe)	TPCES (mtoe)	FNLEN (mtoe)	ELG- Twh	FNLELC-Twh
1971	157.00	95.78	61.22	47.84	66.38	51.74
1975	208.52	132.21	76.36	56.56	85.93	65.58
1980	243.04	148.13	94.91	63.61	119.26	89.53
1985	292.28	162.33	129.95	87.59	188.48	138.14
1990	359.13	175.82	183.31	118.99	289.44	211.74
1995	430.05	188.65	241.40	146.92	417.62	309.19
2000	501.89	201.58	300.31	171.14	562.19	368.72
2005	537.31	158.12	379.19	199.05	699.04	477.91
2008	620.97	163.57	457.41	245.13	830.13	601.60

Source: IEA - Energy Balances of Non-OECD Countries, Different Volumes.

Thus the development process has got both the tendencies of raising total commercial energy use through increased scale and penetration effect, and that of lowering it by way of technical efficiency effect and the changing pattern of output composition effect as determined by the dynamics of the preference structure of the people for environmental and non-environmental goods. Given the expected distribution of future growth of global income among the countries with the increasing pace and share of GDP growth in the developing countries the aggregate global demand for commercial energy is likely to go up for considerable time in future although with a continuously declining global GDP elasticity of energy consumption. At macro level the energy efficiency of GDP has improved during the post economic reform era. Table 7.12, 7.13, and 7.14 describe the pattern of primary energy, primary commercial energy and final commercial energy supplies with fuel composition over the period 1971-2008. Table 7.15 on the other hand gives the trend of gross generation of electricity with fuel composition over the same period.

Table 7.13: Primary Commercial Resources Supplies and Resource Mix (in %)

Year-Calendar	TPCES (mtoe)	Coal	Oil	N.Gas	Nuclear Energy	Hydro	Non-Conv. Energy
1971	61.22	58.05	36.57	0.93	0.51	3.94	0.00
1975	76.36	62.65	31.40	1.24	0.77	3.97	0.00
1980	94.91	54.97	35.87	1.25	0.82	4.21	0.00
1985	129.95	58.66	33.94	3.16	0.86	3.48	0.00
1990	183.31	57.86	32.04	5.36	0.87	3.36	0.00
1995	241.40	57.45	30.73	6.74	0.86	2.58	0.02
2000	300.31	54.96	38.08	7.30	1.47	2.13	0.05
2005	379.19	54.85	33.91	7.61	1.19	2.27	0.14
2008	457.41	57.14	31.63	7.78	0.84	2.15	0.30

Source: IEA - Energy Balances of Non-OECD Countries, Different Volumes.

Table 7.14: Final Energy Supply and Shares of Fuels (in %)

Year	FNLEN (mtoe)	Coal	Oil	Gas	Electricity
1971	47.84	51.67	38.44	0.59	9.30
1975	56.56	52.88	36.17	0.97	9.97
1980	63.61	48.94	43.66	1.07	12.11
1985	87.59	40.66	43.77	2.71	13.56
1990	118.99	34.71	45.25	4.74	15.30
1995	146.92	25.70	50.48	5.72	18.10
2000	171.14	18.91	56.90	5.66	18.53
2005	199.05	18.96	53.38	7.01	20.65
2008	245.13	22.71	49.88	6.23	21.11

Source: IEA - Energy Balances of Non-OECD Countries, Different Volumes.

Table 7.15: Gross Electricity Generation and Fuel based Generation Mix (in %)

Year	ELG- Twh	Coal	Oil	Gas	Nuclear	Hydro
1971	66.38	49.09	6.32	0.57	1.79	42.22
1975	85.93	49.16	8.42	0.60	3.06	38.77
1980	119.26	51.54	6.39	0.52	2.52	39.04
1985	188.48	61.92	6.35	1.18	2.72	27.83
1990	289.44	66.20	3.47	3.44	2.12	24.76
1995	417.62	75.31	1.47	3.82	1.91	17.38
2000	562.19	70.69	4.86	7.65	3.01	13.25
2005	699.04	68.66	4.47	8.94	2.48	14.31
2008	830.13	68.58	4.11	9.87	1.77	13.77

Source: IEA - Energy Balances of Non-OECD Countries, Different Volumes)

Given the trend and pattern of the annual time series energy supply data as underlying the Tables 7.12 to 7.15, we have obtained the growth rates and estimates of GDP elasticities of energy in various forms and also of implied CO_2 emissions as presented in Table 7.16. This shows that there has been substantive drop of the GDP elasticity of energy at all levels of final commercial energy, primary energy, primary commercial energy and particularly of electrical energy – in the post reform period 1991-2005 below 1.00. These indicate significant improvement of efficiency in the use of primary energy in the economy in the post reform period. The final commercial energy intensity of GDP (excluding the share of residential sector) has in fact declined at an annual average rate of 3.52% during the post reform period while the primary commercial energy intensity and CO_2 intensity of GDP declined at the rate of 4.09 and 2.37% respectively per annum during the same period. A decomposition analysis further shows that the energy intensity of GDP on account of technical change alone (separating from the effects of structural change of the economy) would explain of an annual average decline of CO_2 intensity to the extent of 2.27% per annum during the period 1990 to 2005. While the sectoral compositional change in the post reform period tended to marginally raise the CO_2 intensity, the commercial fuel composition effect could explain a marginal small decline in CO_2 intensity, keeping other factors unchanged in this period (see Sengupta, 2010). It may further be noted that while the fuel composition of primary energy resources of the economy has shown gradual substitution of non-commercial biomass energy by modern commercial cleaner and efficient energy, the fuel composition of primary commercial energy and electricity generation have remained rigid over time in India as reflected in such results.

Table 7.16: Growth Rates and GDP-elasticities of Energy Use in India

Variable	Period	Growth Rate	GDP-elasticity
GDP at Factor Cost	1971-1990	4.4	-
	1991-2005	6.0	-
Real Price of Energy	1971-1990	2.2	-
	1991-2005	4.0	-
Real Price of Global Crude Oil	1971-1990	6.1	-
	1991-2005	5.1	-
CO_2	1971-1990	6.5	1.47
	1991-2005	4.4	0.75
Total Primary Energy	1971-1990	4.1	0.86
	1991-2005	2.8	0.52
Total Primary Commercial Energy	1971-1990	5.7	1.28
	1991-2005	4.8	0.79
Final Energy	1971-1990	4.7	1.09
	1991-2005	3.4	0.56
Gross Generation of Electricity	1971-1990	7.8	1.77
	1991-2005	5.7	0.98
Final Use of Electricity	1971-1990	7.5	1.71
	1991-2005	4.5	0.75

Source: Own estimation.

So far as the sectoral behaviour of energy consumption is concerned, it may be noted it is only the industry and transport among the non energy sectors which experienced decline of their energy intensity of GDP at the annual average rates of 5.7% and 4.6% per annum respectively between 1990 and 2005. On the other hand, the fuel energy intensity of agricultural GDP increased at the annual average rate of 1.25% and that of commercial and other services sector at the rate of 0.394% although the absolute levels of energy intensity are quite low as compared to other sectors. The latter results are explained by the operation of laws of diminishing returns in agriculture and by the proliferation of energy using, particularly electricity using newly developed service sector activities (like IT or IT aided services) in India. Finally, the final commercial energy intensity of the private final consumption expenditure of the residential sector increased at the rate of 2.27% per annum due to penetration of modern clean fuel and electricity into the households with the rise of their incomes. As industry and the residential sectors are largest two energy consuming sectors we will review the achievement and scope of energy savings in these two sectors. We shall however make our observations on energy consumption on transport sector and their fuel mix, although such conservation measures involve more of transport policy issues relating to the public-private mix of mode of transport and the design and fuel efficiency of automobiles. Table 7.17 shows the sectoral share of total energy consumption in 2008. This is to be taken as the base over which future energy requirement will grow to meet the demand for the 8 to 9% growth and point to the relative importance of conservation of fuel uses across sectors for the over all greening of the Indian development process.

Table 7.17: Sectoral Final Energy Use in India in 2008 (in %)

Sectors\ Fuels	**Coal (%)**	**Petroleum Products (%)**	**Gas (%)**	**New Renewables (%)**	**Biomass and Wastes (%)**	**Electricity (%)**	**Total in million tonne of oil equivalent (mtoe)**
Energy Use:							
Industry	35.04	18.67	2.92	-	23.43	19.30	120.43
Transport		93.1	4.39	-	0.33	2.21	45.32
Agriculture/ Forestry/ Fishery	-	42.86	0.79	-	-	56.35	16.45
Commercial and Public Services and Non-specified	54.86	0.91	-	-	20.95	22.74	29.64
Residential	1.72	13.74	0.43	0.10	77.62	6.50	164.73
Non Energy Use	-	75.57	24.43	-	-	-	36.59

Source: IEA, 2010.

7.3.2 Industrial Sector

While at the individual industry level there has been decline in the energy intensity of gross value added in the post reform period to various extent, the important issue for future green or sustainable development requires the ascertaining of the scope of further energy conservation at micro level. This is important as many of the firms of various industries are quite inefficient by international bench mark of efficiency standard. There has not been adequate econometric research for India to analyse the behaviour of specific energy consumption to identify the nature and quantum of energy saving or energy using technical progress and the main policy or institutional factor that have been responsible for the success or failure for energy conservation at such disaggregated level. (Bhattacharya and Cropper, 2010). There has been wide ranging qualitative discussions on the reasons for the non-adoption of adequate energy efficient technologies – like low electricity prices for all sectors excepting industrial and organized commercial sector, import tariff policies, high start up costs, lack of adequate funding resources, uncertainty regarding benefits of investment, unproductive subsidies encouraging neglect of consumer's satisfaction with the new energy conserving devices, lack of awareness and information and lack of enforcement of energy and environmental standards and goods labeling. All these act as potential barriers. What is needed for our assessment of the state of energy conservation and of adequacy and efficiency of our policy measures is the quantification of impact of changes in energy prices, energy efficiency standards, subsidies for new technology adoption as per the concerned elasticities precisely estimated on the basis of the data (Bhattacharya and Cropper 2010). However, Sathaye et.al (2005), Schumacher and Sathaye (1998, 1999a to 1999d) and Sanstad et.al (2006) have made some quantitative analysis of specific energy consumption using engineering approach and ascertain the scope of energy saving using a best practice bench mark analysis which are not based on any economic rationale. However, as industrial energy demand is a derived input demand some of these studies as referred to above have estimated cost functions and share equations for major inputs including energy to estimate the rate of energy saving technical progress in selected energy intensive industries, although these analyses given their limited scope and data used for analysis have not given any significant insight into the reason of why different industries have responded differently in adopting energy conserving technologies in India.

The studies by Sanstad et.al as well as by Schumacher and Sathaye worked with the data for the period 1973 – 1994, the results on energy saving technical changes are therefore somewhat dated. However, the energy saving potential as arrived by best practice comparison for some selected industries are given in Table 7.18 (Bhattacharya and Cropper 2010). However, Sanstad et.al (2006) on the other hand estimated using an econometric model the autonomous energy saving technical change for the same period of 1973-94 for most of the energy intensive industries. These showed such energy saving to have been positive for most of them excepting iron and steel and glass the annual average rate of technical progress being 1.96% per annum. All these results show that they had been taking place some progress in the direction of improving efficiency in energy use in the industrial sector 1970's. These results also indicate the scope of further greening of the process of Indian development through rise in energy efficiency in the industrial sector.

Table 7.18: Specific Energy Consumption compared with Best Practice for Selected Industries

Industry	India Best Plant/Process	India Other Plants/Average	Global Best Practice	Potential of Savings %
Aluminum Energy Usage: NALCO				
Alumina	25.1	32.3	20.2	-
Aluminum (Electricity)	52.2 – 56.0	55-65	45	-
Final Energy	86	86-100	65.2 – 81.9	5 – 35
Cement Dry Process				
Total Energy Usage	3.4	4.0	3.06	23.5
Iron and Steel				
Total Energy Usage	-	35.47	19.12	46.0

Source: Bhattacharya and Cropper, 2010.

It may be pointed out in this context Yang (2005) reviewed the industrial energy efficiency policies implemented in India during the decades since 1980s to conjecture about the major factors which has been contributing to rising energy efficiency. These have been (a) disclosure of a company level energy performance related information and data, (b) establishment of Energy Management Centre under the Ministry of Energy, introduction of the Energy Conservation Act resulting in the setting up of the Bureau of Energy Efficiency, a statutory body under the Ministry of Power for growth and promoting energy efficiency, (c) Electricity Act of 2003, (d) liberalization of trade and industry through tariff reduction, delicensing of investment and removal of price and output control to induce industrial competitiveness both at home and abroad, (e) energy price reforms to guide energy efficiency for inducing international competitiveness, (f) introduction of energy auditors and energy standards as mandatory, etc. However, all these reform measures have not as yet all been fully implemented nor have they led to the realization of full impact on the energy efficiency performance. There appears to be no substantive rigorous empirical assessment of impact of these policies on industrial energy efficiency available also.

In view of the financial resource limitations, the capital structure of the Indian economy has always represented a mix of plants, equipment and various types of building and other structures of varied ages and technologies of a wide range of vintages. Old and substandard plants with zero book value of capital assets are co-existing with modern highly efficient equipment and infrastructural constructs embodying some of the latest technologies. Although industry receives most of the attention because of its large share in the total energy consumption, the non energy sectors of agriculture, transport, lighting, building etc. have substantive scope of saving energy by modernization of the machinery, equipment and infrastructure of the concerned sectors. Table 7.19 shows some of these potentials for selected end uses where savings are supposed to be substantial as per the experts' assessment. For the realization of these potentials it is important to remove the barriers to the adoption of energy conserving measures and standards as already listed above in this section.

Table 7.19: Energy Saving Potential in Infrastructure

Intervention	Sector	Potential Energy Savings (in %)
Various motors, drives capacitors, etc. for energy intensive industries like steel, cement, aluminum, glass, etc. building	Cross-cutting	10 to 20
Lighting	Commercial/industrial/institutional	50 to 60
Efficient Pumpset	Agriculture	30

Source: Suki Lenora, 2010.

7.3.3 Energy Conservation in Transport Sector

Transport service is a basic infrastructural service which is a universal necessity and it requires energy as the prime driver for any mode of its railway, roadway, airways and water ways. It is worth noting a few points of concern relating to the pattern of growth of India's transport sector and its energy use. The GDP elasticities of the freight and the passenger traffic were estimated by the Expert Committee on the Integrated Energy Policy of the Planning Commission (Planning Commission 2006a) to be 1.0 and 0.8 respectively implying high growth of freight and passenger traffic service with high GDP growth. The challenge of environmental sustainability of the growing transport sector and its greening arises due to the non-substitutability of oil in road transport and the growing share of road traffic in the total traffic in India. The fuel efficiency of rail traffic service is substantially higher for both passenger and freight tariff. The energy saving potential by just the shifting of goods traffic from road to rail has been assessed to be 80%. In a case study of comparative modal efficiency between the road and the rail for selected railway sections and the competing highway sections for intercity transport of freight and passenger, Sengupta (2010) estimated the energy saving to be 89% for every tonne km. of freight traffic for rail with electric traction in plain terrain (New Delhi-

Mughalsarai section) and 83% for rail with diesel traction in similar terrain (Lucknow-Gorakhpur section). For the passenger traffic in passenger km, the extent of similar savings is 33% for the rail electric traction and 41% for the rail diesel traction in the same rail-road sections. It has also been found that rail mode has a substantive social cost advantage over the road mode which was estimated to be Rs. 1.68 per passenger kilo meter (pkm) and Rs. 2.50 per tonne kilometer of freight traffic in terms of 1997-98. However, while the per capita passenger transport service and the freight traffic intensity of GDP have substantively increased over time, unfortunately the share of the relatively unsustainable mode of road increased in passenger traffic from 64% in 1971-72 to 87% in 2006-07 and the same in freight traffic increased from 31% in 1971-72 to 62% in 2006-07 inspite of such potential advantages when externalities are internalised. This has caused serious pressure on oil demand resulting in both the problem of energy security and environmental pollution.

Urban transport, on the other hand, is the single largest source of urban air pollution in India causing substantive health damage from the emissions of CO_2, HC, NOX and PM10, the last one having the most damaging effect in value terms. With high economic growth, industrialization, urbanization and motorization of the economy, some cities in India are experiencing explosive growth in private automobile ownership resulting in rise in the share of the private transport in the total urban passenger traffic. The oil usage and road space requirement per passenger km being lower for public transport because of the higher passenger loading factor, the substitution of the private transport by public transport can substantively reduce the pressure on oil consumption and emissions. The recent growth of India's middle class due to rising urban income and educational opportunities and the decision of the government to expand all highways and upgrade rural roads would tend to push the share of road passenger traffic and that of private transport upwards implying higher environmental pressure and higher health cost due to automotive pollution. This does not however mean that we should not expand or upgrade our road system, but only points to the important challenge that greening of urban transport will pose.

In the context of assessment of impact of automotive pollution Sengupta and Mandal (2005) estimated the saving of health cost for 35 urban agglomerations to be substantive for the upgradation of the quality of motor gasoline and HSD undertaking appropriate investment for refinery upgradation. The study used the health cost parameters from the study of Delucchi for US cities (Delucchi 2000 and Delucchi et.al 1999) with appropriate adjustments for population density, income and purchasing power parity for the Indian condition. Since automotive pollution is the single largest source of urban air pollution, Murty and Gulati (2004) estimated the benefit of reduced air pollution in terms of willingness to pay using a generalized method of hedonic property prices as well as hedonic travel cost, to be also significant for being noted in this context. The energy savings potential of the urban transit which is the major energy consuming and polluting sector of the urban economy has been assessed to be as high as 67% (see Suki 2010).

All these studies have warranted the policy of raising of the share of the railway in particularly the freight traffic, that of the share of the public transport in urban traffic, and also upgrading the quality of fuel and the standards of vehicular emissions for the environmental sustainability of transport development, conservation of eco-capacity of the urban ecosystem and greening of the urban development process.

7.3.4 Residential Sector

The energy consumption of India's residential sector will substantively grow with the growth of per capita income and population growth in future. As already noted that a large part of residential energy requirement is supplied from the traditional unclean biomass fuel, and many of such households have no access to the reliable supply of electricity. While there is substantive scope of energy saving by way of substitution of inefficient unclean fuel by cleaner modern fuel, there is also the substantive problem of energy poverty whose removal would tend to raise the spending and use of commercial energy by the Indian households. As the green development intends to combine the conservation of eco-capacity with equitable sharing of the benefit of growth and resources of the nature, this would involve the challenge of combining energy efficiency with the provision of clean modern fuel for at least lighting and cooking to meet the basic minimum. We came back to this issue in next section where we first clarify the concepts of energy transition and energy poverty and then return again to the discussion of how to best combine the energy conservation and access to basic minimum of clean energy for the households.

7.3.5 Efficiency in Electricity Supply

As per the energy balance of 2005, a share of 82% of primary commercial energy resources was converted into final energy in the forms of electricity and petroleum products and the balance 18% of the primary resource –mostly coal and natural gas had direct final use in various industries. Again a share of 60% of primary commercial energy supply is converted into the specific form of electricity for being used in the various non energy sector. As electricity is likely to further penetrate the various sectors of the Indian economy by replacing the direct use of fossil fuels for greater end use efficiency, the share is projected to go up to 68-70% for an 8% rate of growth of GDP for sectoral approach of estimation of the impact of growth on energy consumption and carbon emission (see Sengupta 2010). This projection in fact presumes the rise of share of electricity in the total final use of energy to go up from the base of 23.78% in 2005 to 40% in 2031 with sectoral details as indicated in Table 7.20.

Table 7.20: Growth of Share of Electricity in the Total Final Energy Use

Items	Overall economy	Industry	Agriculture	Transport	Other Services	Residential
Share of Electricity in 2005	23.78	24.36	57.74	2.3	40.84	26.09
Target Share of Electricity in 2031	40.00	43.46	81.13	3.71	75.27	44.0

However, substantive part of the primary energy resource which is to be converted to meet the final energy demand in the form of electricity, is lost in the conversion process itself which has been 69% in 2008 as per the IEA Energy Balance data for India. Again, a substantial part of gross electrical energy generated in India is lost in auxiliary consumption, transmission and distribution before reaching the final user (see Table 7.21). The estimate of such losses has been about 30% of gross generation in 2008.

Table 7.21: Electrical Energy Balances of India

Years	PENEL mtoe	CONV.-LS %	Aux-Loss-%Gen	T&D-Loss-%BB	Total Less as % of Fuel Energy	FNLELC-mtoe
1971	18.66	69.40	5.69	16.36	76.15	4.45
1975	24.25	69.53	23.66	0.02	76.74	5.64
1980	33.32	69.22	24.89	0.03	76.89	7.70
1985	50.97	68.20	23.96	2.75	76.69	11.88
1990	70.10	64.49	7.79	19.05	74.02	18.21
1995	108.74	66.97	7.42	18.54	75.55	26.59
2000	152.76	68.35	7.06	27.35	79.24	31.71
2005	191.28	68.57	6.87	24.76	78.51	41.10
2008	231.55	69.17	6.57	24.98	78.39	51.74

Source: IEA - Energy Balances of Non-OECD Countries, Different Volumes.

While electricity is a high quality clean fuel used widely across every segment of the economy and society because of its much higher efficiency in final end use compared to other fuels for doing the required work, the power sector causes substantial material and energy loss and pollution in the process of its generation, transmission and distribution. The total energy loss a share of throughput energy has been of the order of 78.4% in 2008 in India. The economization of such losses is of critical importance for the supply side efficiency improvement in the power sector.

While the rising share of electricity in final energy use will accelerate its pace of generation, this would involve emission of air pollutants and arising of solid waste which tend to erode eco-capacity. While the use of electricity does not cause any pollution at the end use location, any use of electricity by a consuming sector would cause generation of pollution at the location of the electricity plant and in their neighbourhood and also in the mines/oil – gas fields in the case of fossil fuels. However, the higher efficiency of electricity to do a given work compared to that of the primary fuels in their direct use would imply both the integrated energy use of the final consumer sector including the share of the power, and the corresponding integrated pollution load to be lower for the substitution of the direct use of other fuels by electricity. Besides, the direct use of energy through electricity would also localise a large part of pollution to the power generating stations compared to widely dispersed arising of pollution reducing possibly both the number of people exposed to pollution at the places of energy production and energy use together. However, this geographic redistribution of pollution load would lead to the emergence of more of large point sources of pollution with higher ambient concentration. Besides, the global and regional externalities of energy use like the effects of global warming or acid rain are often the same irrespective of how geographically pollution is distributed.

As the environmental pressure of electricity generation and use would thus be dependent on the supply side efficiency, savings potential of energy in this energy producing sector would be determined by the possible rise in conversion efficiency of thermal plants, choice of low carbon fuel mix and the reduction of the auxiliary loss and the transmission and distribution loss of power. As about 70% of gross electricity was generated in coal fired power plants, conversion efficiency of such plants are quite important determinant of supply side efficiency in the electrical energy supply in India. Persson et. al (2007) reported the average efficiency of coal fired Indian power plants to be 29% in the years of nineties. Indian coal fired generating units have been mostly sub-critical, whose efficiency can at most be 35 to 38%. The efficiency falls with higher ash of coal and lower heat content. Indian power grade coal has high ash content ranging between 25% and 45% and consequently has as low calorific value as 4000 kcal/kg. Import of low ash coal with higher calorific value and use of washed power grade coal can raise the conversion efficiency which needed appropriate coal import policy and coal washing policy to permit such measures. However even with washing, the use of washed coal in a plant located more than 1000 km from pithead has been prohibited for raw coal with ash higher than 34%, for reasons of high cost as well as high environmental pressure particularly if the plants are located in urban or sensitive areas. Rising coal price in the international market of coal is also eroding the benefit of lowering of coal import tariff as brought out by economic reforms and taking away incentive for raising efficiency of generation units by improving coal fuel quality by beneficiation.

However, higher capacity utilization (PLF) of generation unit, replacement of old boilers by new ones and improved management practices can improve the efficiency of such coal thermal units. This may warrant privatization of generation sector and introduction of greater competitiveness in this subsector after the unbundling of the state electricity boards under the power sector reforms process in the interest of raising such conversion efficiency. However, the experience of power sector reforms cannot as yet conclusively establish which part of power sector reforms would help to what extent in raising the conversion efficiency of boiler-turbine units of coal thermal plants. However, given the comparative performance analysis across units and regions, one may expect raising the conversion efficiency of coal thermal generation from a level of 27% on average as in 2005 to 35% in 2031 to be quite achievable.

Gas fired power generating units have accounted for increasing the share of newly generating capacities since the introduction of economic reforms in India. The average thermal conversion efficiency has been about 46% for such plants in 1998 in India comparing favourably with most of the other countries like South Korea or UK. Most of the new gas plants had been however combined cycle gas turbines in which pass out gas of the first cycle of gas turbine is used to raise steam in boiler to drive a stream turbine, the two cycles together enabling the achievement of a maximum efficiency of 60%. However, there is a trade off between this energy efficiency with cost efficiency. Sathaye and Phadke (2006) find the cost of a unit energy to be 5.48 cents for CCGT as against 3.10 cents for coal plants thus. The adoption of CCGT can be effected only if there is a carbon premium for competing with coal fired units. There have also been other newly developed clean technologies like integrated gasification combined cycle coal technology, pulverized fluidized bed combustion and also biomass based integrated gasification combined cycle technology which can achieve higher thermal efficiency with low carbon emission. While the deployment of such technologies are of crucial importance, high initial capital cost and lack of proven reliability in Indian operating condition pose to be the major barriers to entry. However, the overcoming of such barriers is an important challenge which India needs to face to successful in the interest of dynamics of green development in India. (Bhattacharya and Cropper 2010).

In any case in view of the above observations it would be quite realistic to assume conversion efficiency of 45% for natural gas on the average in 2031, while the same can be taken to be 38% for oil fired units and 70% for all hydro wind or solar or other technologies. Apart from raising conversion efficiency, the efficiency on the supply side can be also augmented by reducing auxiliary losses from 6.8% on the average for all types of plant technologies to 5%, and the transmission and distribution losses from 25.8% in 2005 to 15% in 2031. The power sector reforms are supposed to provide an enabling legal and institutional framework so that the unbundled generating and distributing companies can work efficiently following commercial principle of efficiency and the regulatory commissions can rationalize power tariff structure in India. However, the persistence of political interference in tariff fixation and cross subsidization of power for agriculture and household sectors are standing in the way of power conserving technologies both in end use non energy sector and in the energy conservation in the supply side of the power sector.

7.4 Energy Poverty

7.4.1 Energy Poverty: Concept and Measurement

As energy equity has to be an important consideration for green energy planning, it is important to define energy poverty and understand its relationship with energy transition and income poverty. While the issues of income distribution and poverty have received adequate attention in the literature of development economics, the issue of inequality in the distribution of energy consumption and energy poverty which have important bearing on human development have not attracted similar attention. There exists however some literature on energy poverty in which attempts have been made on the measurement of energy poverty by defining energy poverty line or otherwise (see Foster et. al 2000, Pachauri et. al 2004, Reddy 1999). Foster et. al 2000 defines fuel poverty line as the average energy consumption of all households whose over all per capita consumption expenditure level falls within + or – 10% range of the official expenditure poverty line. Pachauri et. al (2004) have tried to estimate the poverty line by assessing the amount of energy required by a household directly to meet a vector of basic needs. However, the total quantity of end use energy requirement (or energy poverty line) would be a function of the kinds of energy carriers they have access to for meeting these needs. In a two dimensional characterization of the poverty line, they estimate the amount of final energy required to meet the basic needs of the various energy services for each combination of energy carriers. Once the energy poverty line is defined for each such combination, the poor can be identified depending on their access to energy carriers and the actual amount of end use energy consumption. The distribution of individual households according to access to energy carriers and amount of energy consumption would thus yield the energy poverty ratio and characterize in fact the state of energy adequacy for the household sector. They have also studied further the changes in this distribution over time and have found out the determining factors behind such changes to derive policy conclusions.

Reddy 1999 also took an engineering approach to energy poverty line as the end use energy required per capita to meet the basic needs assuming LPG as the energy carrier for cooking and electricity for lighting. In this paper we define energy poverty with respect to the deprivation of access to clean energy carriers of electricity for lighting and hydrocarbons for cooking as primary fuel. Energy poverty is defined in this paper without any reference of quantity of consumption for these two major energy services of the households separately. A household would be lighting energy poor if the principal lighting fuel is not electricity. Similarly a household would be energy cooking if its principal cooking fuel is not petroleum fuels of LPG/Kerosene. A household may use some electricity or LPG/Kerosene, but in such inadequate amount that they are not described as principal fuel for the purpose by the households. Since such data on response to querries on principal fuels are available in the NSS – household consumption survey, it is not difficult for estimating energy poverty ratio for India as data are readily available. It is thus intimately connected with energy transition as it only requires shift to superior energy carriers of electricity for lighting and LPG and Kerosene for cooking as principal fuel for energy services.

As energy poverty is defined in terms of access to energy carriers as associated appliances, it will be determined by both income of the households on the demand side and the availability of the energy carriers and the required appliances and technology on the supply side. It will therefore be dependent among others on the income distribution for which we can take the distribution of per capita household consumption expenditure as a representative. Given the definition of the national poverty line, the poverty ratio of an economy is also function of the distribution consumption expenditure of the households. Since both the probability of a household chosen at random being poor by income and energy criteria would depend on its per capita consumption expenditure, there would exist a macro level relationship between income poverty and mean per capita consumption expenditure of a growing economic system on the one hand, and an Engel's function type positive micro level relationship between the probability of a household being energy poor and its own consumption expenditure on the other. For the usual functional nature and property of consumption expenditure distribution of households, a rise in mean per capita consumption expenditure is therefore expected to reduce both income (expenditure) poverty ratio at macro level and the probability of a given household being energy poor at the micro level, the latter resulting in the reduction of the over all energy poverty ratio as well as the macro level.

In respect of the question whether the removal of income poverty would be enough for removing energy poverty, the answer would obviously depend on the interactive result of the consumption expenditure elasticity of the two relationship – one at the macro level behaviour of poverty ratio with mean consumption expenditure and the other of the micro level behaviour of accessibility to superior energy carrier with respect to such expenditure. There is no a priori reason to suppose that at any stage of development, the level or the pace of reduction of energy poverty would be higher or lower than the income poverty and therefore that the reliance on policies on income poverty removal should be sufficient for providing the household clean energy security.

7.4.2 Energy Poverty of the Household Sector in India

As per our concept of energy poverty here, the state of energy transition in the household sector matters most directly for the well-being of the people of a country. It should be noted that the share of household sector in the total final commercial energy has been 16.7% in 2005, while its share in the total primary energy use (including biomass has been 34% in the same year being the largest sectoral share in the economy followed by the share of industry at 31%. The poor of India as well as those of the world in fact suffer from energy poverty due to the lack of access to modern energy services like electricity, or to clean cooking fuel like LPG (Birol 2007, Barnes and Toman 2006). About 1.6 billion people in the world have no electricity connection in their homes. Again about 2.5 billion people (i.e. 40% of world's population) have to rely on the biomass of fuel wood, dung-cake and agricultural residue without any conversion for meeting their cooking needs. The share of the traditional fuel consisting of fuel wood, dungcake, agricultural wastes etc, still constitutes to be around 30% of the total primary energy supply of the Indian economy. A major part - 90% of such non-commercial energy resources is used by the households for meeting its cooking needs only. In India with 71.5 % of its people living in villages, 84% of the rural households and 23% of the urban households have had to primarily depend on biomass for cooking as per the NSSO Survey 61st. round for 2004-05. For the lighting need, 45.1% of the rural households and 7.7% of the urban households are denied access to any reliable supply of electricity either due to income poverty or due to the lack of adequate investment in energy infrastructure. (NSSO 2007).

In the Indian context it is further important to have a glimpse of the regional disparities in the development indicators including energy consumption to appreciate the challenges ahead in the context of equitable growth with special reference to the household energy consumption. The tables 7.22-7.25 show the state wise distribution of the households per 1000 people by primary energy source for lighting and cooking for the rural and the urban sectors separately (based on NSSO 2007) and how such distribution varies across the states with the level of household income or consumption expenditure and the poverty ratio. These tables show how the people of the poorer states are being left behind in enjoying higher quality of life by way of access to and affordability of efficient commercial fuel. These cross section observations also broadly correspond to the hypothesis of upward movement along energy ladder with development. Besides, these data of the tables also point to the big challenge which the country has to face in the coming years if the transition from traditional to commercial fuel and within commercial increasingly to cleaner and more efficient fuels like electricity is to be completed within a medium term horizon of 5 to 10 years as government of India is targeting. This is particularly important because the removal of income poverty need not imply removal of energy poverty to similar extent as the access to cleaner fuel may pose a constraint from the supply side in many parts of rural India.

Table 7.22: Distribution of Households per 1000 by Primary Source of Energy Used for Cooking for each major State (Rural India)

State	Poverty ratio	MPCE*	61st Round (July 2004-June 2005)				
			No cooking arrangement	Firewood and chips	Dung cake	LPG	Others including kerosene, coke & coal
Andhra Pradesh	11.2	529	36	803	1	144	16
Assam	22.3	491	-	924	0	69	7
Bihar	42.1	377	2	498	334	17	149
Chhattisgarh	40.8	384	13	923	24	15	25
Gujarat	19.1	539	43	734	8	105	110
Haryana	13.6	780	9	564	192	191	44
Jharkhand	46.3	384	10	828	10	14	138
Karnataka	20.8	459	17	897	-	65	21
Kerala	13.2	915	19	791	0	182	8
Madhya Pradesh	36.9	397	5	907	38	38	12
Maharashtra	29.6	513	17	749	3	149	82
Orissa	46.8	360	15	797	58	29	101
Punjab	9.1	765	4	314	333	242	107
Rajasthan	18.7	534	0	941	3	51	5
Tamil Nadu	22.8	544	29	809	-	134	28
Uttar Pradesh	33.4	481	3	667	265	48	17
West Bengal	28.6	508	9	733	36	43	179
All India	28.3	559	13	750	91	86	60

Note: * MPCE = Monthly Per Capita Consumption Expenditure
Source: NSSO, 2007.

Table 7.23: Distribution of Households per 1000 by Primary Source of Energy Used for Cooking for each major State (Urban India)

State	Poverty ratio	MPCE	61st Round (July 2004-June 2005)				
			No cooking arrangement	Firewood and chips	Kerosene	LPG	Others including coke & coal
Andhra Pradesh	28	838	55	300	70	566	6
Assam	3.3	871	64	272	47	606	12
Bihar	34.6	573	21	189	27	539	224
Chhattisgarh	41.2	815	26	375	30	495	74
Gujarat	13	918	39	144	138	623	56
Haryana	15.1	940	15	142	69	729	46
Jharkhand	20.2	811	71	123	13	427	366
Karnataka	32.6	850	88	237	136	529	10
Kerala	20.2	1062	70	484	8	437	2
Madhya Pradesh	42.1	744	13	381	32	545	28
Maharashtra	32.2	945	58	138	159	633	11
Orissa	44.3	623	64	372	65	358	141
Punjab	7.1	1091	38	80	132	703	47
Rajasthan	32.9	793	29	386	43	513	29
Tamil Nadu	22.2	889	72	219	175	533	1
Uttar Pradesh	30.6	705	18	263	45	561	112
West Bengal	14.8	925	59	125	112	461	242
All India	25.7	1052	49	217	102	571	61

Source: NSSO, 2007.
Note: * MPCE = Monthly Per Capita Consumption Expenditure

Table 7.24 Distribution of Households per 1000 by Primary Source of Energy Used for Lighting for each major State (Rural India)

State	Poverty ratio	MPCE	61st Round (July 2004-June 2005)		
			Kerosene	Electricity	Others
Andhra Pradesh	11.2	529	157	840	3
Assam	22.3	491	695	303	2
Bihar	42.1	377	894	101	5
Chhattisgarh	40.8	384	366	619	15
Gujarat	19.1	539	196	802	2
Haryana	13.6	780	91	897	12
Jharkhand	46.3	384	736	260	4
Karnataka	20.8	459	137	862	1
Kerala	13.2	915	201	794	5
Madhya Pradesh	36.9	397	300	692	8
Maharashtra	29.6	513	234	762	4
Orissa	46.8	360	681	315	4
Punjab	9.1	765	20	955	25
Rajasthan	18.7	534	519	472	9
Tamil Nadu	22.8	544	153	846	1
Uttar Pradesh	33.4	481	749	240	11
West Bengal	28.6	508	654	342	4
All India	28.3	559	444	549	7

Note: * MPCE = Monthly Per Capita Consumption Expenditure
Source: NSSO, 2007.

Table 7.25: Distribution of Households per 1000 by Primary Source of Energy Used for Lighting for each major State (Urban India)

State	Poverty ratio	MPCE	61st Round (July 2004-June 2005)		
			Kerosene	Electricity	others
Andhra Pradesh	28	838	48	949	3
Assam	3.3	871	137	862	1
Bihar	34.6	573	259	738	3
Chhattisgarh	41.2	815	67	932	1
Gujarat	13	918	27	958	15
Haryana	15.1	940	33	955	12
Jharkhand	20.2	811	127	871	2
Karnataka	32.6	850	41	959	0
Kerala	20.2	1062	65	930	5
Madhya Pradesh	42.1	744	34	964	2
Maharashtra	32.2	945	39	957	4
Orissa	44.3	623	186	813	1
Punjab	7.1	1091	2	978	20
Rajasthan	32.9	793	103	895	2
Tamil Nadu	22.2	889	54	946	0
Uttar Pradesh	30.6	705	142	844	14
West Bengal	14.8	925	125	873	2
All India	25.7	1052	71	923	6

Note: * MPCE = Monthly Per Capita Consumption Expenditure
Source: NSSO, 2007.

7.4.3 Removal of Barriers to Energy Poverty and Energy Conservation in the Household Sector

While energy poverty removal would contribute to higher well-being of the people, the replacement of traditional carbon neutral fuels for lighting and cooking by electricity and petroleum fuel which are carbon intensive would put upward pressure on total CO_2 emissions. This would imply priority need for greater share of eco-space in the earth's environment for carbon emission for the sake of energy equity. However, as India has also to keep its commitment of low carbon growth the replacing modern and efficient fuels and appliances have to be energy conserving in nature. Thus the policies of removing energy poverty along with household energy conservation would require that barriers to both energy conservation as well as to switch to clean fuel based modern technologies are removed.

While the cleaner fuels are more efficient in terms of useful energy per unit of heat input, these fuels are often found to be more expensive for use when we consider both the costs of appliances and fuel as per market prices. If the saving in energy cost is not enough to make the pay back period low the fuel switch is not acceptable to many households. However, people agree to switch to cleaner fuel due to greater convenience in use i.e., for low user's cost. This inducement is of greater effect as the income of the people rises, the discount rate of the future declines and the cut off pay back period as acceptable for switch increases. Table 7.26 shows levelised annual cost for the use of a fuel and cost of useful energy for varying fuel efficiency.

Table 7.26: Cost of Use of Cooking Fuels as One Moves up Along an Energy Ladder

Cooking Option	Efficiency %	Fuel Price Rs.	Annual Amortized Cost	Total levelised cost per unit of useful energy
LPG	60	17.5 per litre	3164.7	702
Kerosene	35	8.5	2405.7	701
Wood Stove	10	1 per kg.	1506.6	627

Source: Bhattacharya and Cropper, 2010; Reddy, 2003.

In order to reduce this payback period government uses the fuel subsidy as inducement for the use of superior fuel substituting for the inferior good fuels. However, analysis of NSSO consumption pattern has shown that it is the effect of higher income which is more important in determining fuel switch to a superior one and in fact more effective in reducing the subjective discount factor than other factors like subsidy or prices.

The subsidies for kerosene and LPG when distributed through the public agencies have often been wasteful and misdirected. The benefit of LPG subsidies is appropriated mostly by the middle class and the non poor, while kerosene subsidy is relatively better targeted towards poor. However, kerosene distributed through the PDS is often illegally diverted to automotive uses whenever kerosene price is lower than the diesel prices. Besides, while subsidized and low prices would induce some switch to cleaner fuel, its low price would act against energy conservation. Nevertheless one has to admit that kerosene has best competed as clean fuel with wood fuel to replace it.

However, the government of India had also introduced the National Programme of Improved Chullah (NPIC) to promote a relatively cleaner cook stove with efficiency of 30% to replace traditional stove of 10% efficiency. While the pay back period of investment for such a device was found to be quite small (Reddy 2003, Reddy and Balachandra, 2006) and the indoor air pollution involved was much less, the market penetration of this device was found to be very slow. The policy of subsidy to such stove producer and top-down approach of its introduction and promotion took away all incentives to the stove producer to take care of user's preferences when designing and marketing stoves, and also inhibited any efforts to innovate and produce other improved model of stoves. The NPIC proved to be a complete failure as it did not take off, nor the improvement in efficiency over the traditional chullah was always significant. There had been also the initiative of renewable energy cooking device – solar cooker – which also faced similar fate as it was never preferred over LPG or kerosene stoves. As in the case of wooden cook stoves, the subsidy policy for such solar cooker did not induce stove producer to take account of consumer's preference in designing the cooker. The reliability of the device under Indian weather condition and working condition failed to make it an attractive option. (Bhattacharya and Cropper 2010, Pohekar and Ramachandran 2006).

The electrical energy for lighting is however a more efficient and less costly option per unit of Lumen than kerosene lamp. The battery operated electricity for lighting is however more costly than kerosene because of high battery cost. However, there is substantive scope of energy saving switching on to efficient device of Compact Fluorescent Lamp (CFL) from either incandescent Lamp or kerosene lamp. The pay back periods of such switches are quite short of around a year in spite of high cost of the lamp, while the life of such lamp is much longer. However, the major reasons for slow penetration of such CFLs has been high price of the device, uncertainty over the quality of the lamp and lack of warranty and finally lack of awareness about the merit of these lamp devices.

It is important to note that the higher income classes of Indian households will have increasing share of energy consumption for a variety of energy services other than cooking and lighting involving the use of a range of other appliances and devices – two of which are going to be of immediate high importance – refrigeration for household purpose and air conditioner for space cooling. MCNeil (2005) estimated the energy saving by switching from the existing models of such appliances to high efficiency models between 2010 and 2020 can save 45% of energy per unit of the device with pay back period of within 3 years and result in a total saving of 77 million tonne of oil equivalent energy representing a net present value of consumer's benefit of US $ 1.3 billion for Indian households. For air conditioners switching to models of energy efficiency rating (EER) of 10.2 from a lower level of 9.0 would involve a payback period of less than 3 years. The pay back period would sharply rise to 20 years if the switch is from an EER of 9.0 to that of 12.8 although such switches would save a total of 23 mote energy in India in the time horizon 2010 to 2020 representing a present value of saving of US $ 1.2 billion. (Bhattacharya and Cropper, 2010).

There are further studies by M.Mc Niel et.al (2005) Reddy (2003) and Reddy and Balachandra (2006) on the implicit saving potential of all such energy saving devices or appliances for various energy services in India. There may however be an argument that all such energy savings potential if realized, may have some rebound effect of higher absolute energy consumption in India. However, no empirical studies exist which can be used as a test for the validity of such hypothesis for the same level of development.

Finally, the pace of greening the energy development through the energy conservation will depend partly on the rate of diffusion of such technologies. While the rate of adoption of a new technology depends on the cost of the new device, the cost of use or price itself depends on the scale of its deployment, i.e., on the cumulative application. As consumer's of a device are heterogeneous, they receive different types of benefit from a technology. With cumulative adaptation of a technology the awareness about the application also increases and the positive externalities of the public good of information regarding the technology induces further adoption at a faster rate. If now the benefits of adoption across consumers are normally distributed such dynamics of adoption will show an S-shaped curve as being followed. However, it is both the higher energy price and lower capital cost which would induce faster adoption or diffusion of any energy conserving technology. If the rate of discount or lower capital cost be of greater importance for faster adoption, it would imply that people are myopic having high discount rate. However, if India can grow fast and people's discount rate goes down as their propensity to saving increases, the barriers to diffusion would be slackened over time. While some interest concession or investment benefit for lowering capital cost of energy conserving devices would be important for the initial deployment of a device or technology, both dynamic externalities of adoption and that of lowering of discount rate by higher level of development would take care of faster diffusion of technology in the long run.

However, information about the life cycle benefit of energy conservation, resolution of any agency problem in technology adoption (like landlord investing in energy conservation and tenants pay energy bill working as a disincentive for such investments being resolved by appropriate pricing of housing service), energy standard enforcement, energy labelling rational pricing would further help in accelerating the rate of technology diffusion. Both the development and access to new energy conserving technologies require continuous R&D investment in such area as well as international cooperation for the transfer of the concerned technologies. More empirical research is also needed to understand the process of diffusion of energy conserving technology as determined by different economic, technical and institutional factors and policy initiatives.

7.5 Environmental Implications of the Projection of Energy Requirement by the Expert Committee of Integrated Energy Policy

7.5.1 Methodological Approach and Results: Aggregate Economy

What is the future prospect of green development of the energy sector of India particularly in view of the recent acceleration of GDP growth which reached the annual average rate of 8.6% from 2005-06 to 2009-10 and high growth commitment of India in the interest of faster removal of income property? It is important to see what is the environmental implication of 8 to 9% annual GDP growth under alternative conditions of resource use for making the development process as sustainable and eco-capacity conserving as possible. The report of the Expert Group of Integrated Energy Policy of the Planning Commission has presented some of these results which we review here in short.

The long term projections of energy requirement of an economy targeting such inclusive growth and of the absolute environmental pressure caused by such a growth process would be based on a complex set of factors comprising the future rate of growth of GDP, change in sectoral structure of the economy, population growth, growth of urbanisation and transport infrastructure, the pace of replacement of non commercial energy by commercial energy, the pace of energy conservation through improved energy efficiency and the change in fuel mix. The inclusiveness of the growth would further require the removal of energy poverty along with income poverty as the two may not be synonymous as we have already discussed. The Expert Committee of the Planning Commission on the Integrated Energy Policy (Planning Commission 2006) has provided the projection of the total energy requirement for an inclusive growth of the Indian economy at the GDP growth rate of both 8% and 9%, assuming some normative GDP elasticity of the total primary commercial energy requirements which is alternatively taken to be constant and falling over time as experienced in the post economic reform era. As per the falling elasticities, the report has indicated a consistent set of projections of the total gross electricity generation and capacity requirements, fuel/technology wise generation mix, energy resource needs for power, direct non-power requirement of coal, oil and natural gas, household's requirement of biomass fuels and finally arrive at the projections of requirements of total primary energy resources, total primary commercial energy resources and non-commercial energy resources with fuel wise break-up with environmental implications.

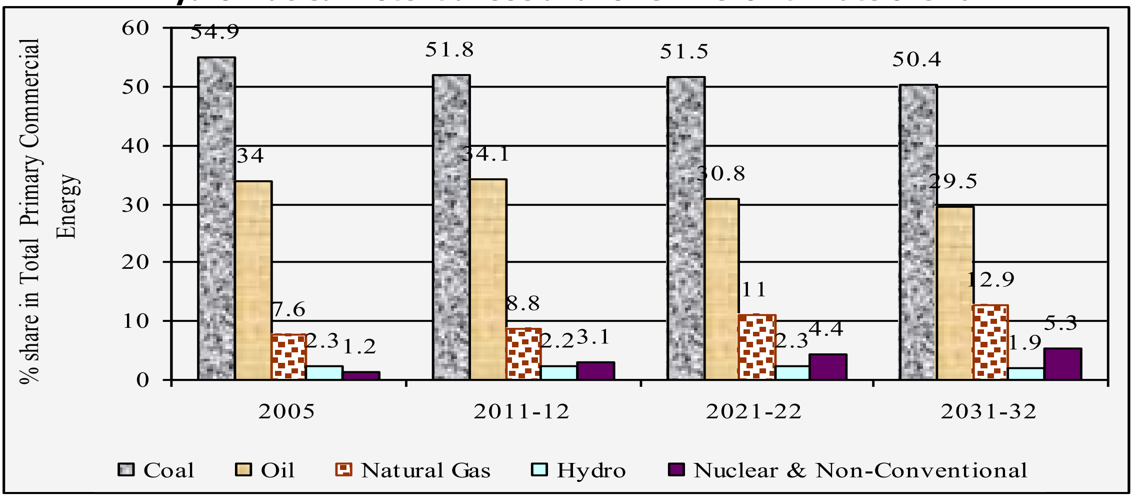
The Integrated Energy Policy Committee used the results of a multiperiod, multisector linear programming model of cost optimization to simulate alternative energy supply scenarios given the potential availability of energy resources and of the spectrum of technologies for India over the planning horizon up to 2031-32. As electricity uses more than fifty percent of the primary commercial energy resources in 2005 and offers substantive scope of fuel substitution, and as the transport sector is the dominant consumer of oil and a major source of urban pollution, the model was used to solve for the least cost fuel and technology choice for a number of alternative policy option scenarios having alternative implications in respect of pressure on the ecosystem. These options are designed to reduce the adverse environmental externalities in alternative ways while meeting the given requirements of energy services in the different sectors of the economy for supporting the macroeconomic growth targets and keeping in view such sector specific issues at the same time. These scenarios were designed to generate the extreme points of feasible solutions of supply and use of various energy resources by way of introduction of alternative sets of policy induced constraints on resource use. However, the underlying model used to simulate the projections of energy requirement does not appear to factor in explicitly any monetized value of the adverse effects of negative environmental externalities of use of the different fuels. (Planning Commission 2006), but it either constrains some resource use or forces some of the eco-conserving options irrespective of cost considerations.

If there is no other policy compulsion and if no costs of externalities are considered, the coal based development of the energy sector was found to be the least cost option for supporting the targeted growth as per the results. However, the concern for weakening the link between the growth of GDP and the energy use and that between the energy use and the pollution arising induced the consideration of the options of forcing full development of hydro, maximisation of use of nuclear potential, the use of gas to generate 16% of electrical energy (where natural gas is supplemented by coal bed methane and in –situ coal gasification), demand side management to reduce electricity demand by 15% , the attainment of higher conversion efficiency of thermal power generation to 38-40% from the pre-existing level of 36% for 500 MWE plants, rise of railways' share in freight traffic from 32% to 50%, increase of fuel efficiency of motor vehicles by 50%, and forced utilisation of the renewable potentials to the extent of 3000 MW of wind power, 10,000 MW of solar power, 50,000 MW of biomass power, 10 Mt of bio-diesel, and 5 mt of ethanol by 2031-32. The extreme points were generated by certain combinations of these options in policy space and given in the report. It is one of the extreme point solution which forces the maximum use of the nuclear potential, the entire domestic hydro potential of 1,50,000MW and the use of gas for 16% of gross power generation (i.e., maximum use of the potential of conventional commercial carbon free and gas resources) which generated the solution and provides the basis of energy requirement calculation in the long run as mainly highlighted in the report.

As per this scenario the fossil fuel, and particularly coal, will remain the dominant primary energy resource for India over the time horizon upto 2031-32 (see Figure 7.4). The share of coal declines from 54.9% in 2005 to 50.4% in 2031-32 which is not a major fuel switch over more than 25 year horizon. The share of fossil fuel is shown to be at almost 95% of the total primary commercial energy in 2031-32 as per this scenario. However, the share of traditional biomass energy resource is projected to go down to 9.1% over the same time horizon from the approximate share of 28% in 2005. While the shares of hydro and natural gas in the total primary commercial energy would grow respectively from 1.2% and 7.6% in 2005 to 1.9% and 12.9% in 2031-32. Their respective shares in electricity generation would also move correspondingly. This implies the possibility of no significant de-linking between the growth of GDP and that of energy, and the rigidity of fuel mix not permitting significant decarbonisation. It is in fact the energy resource endowment of a country which primarily drives the fuel mix of a country.

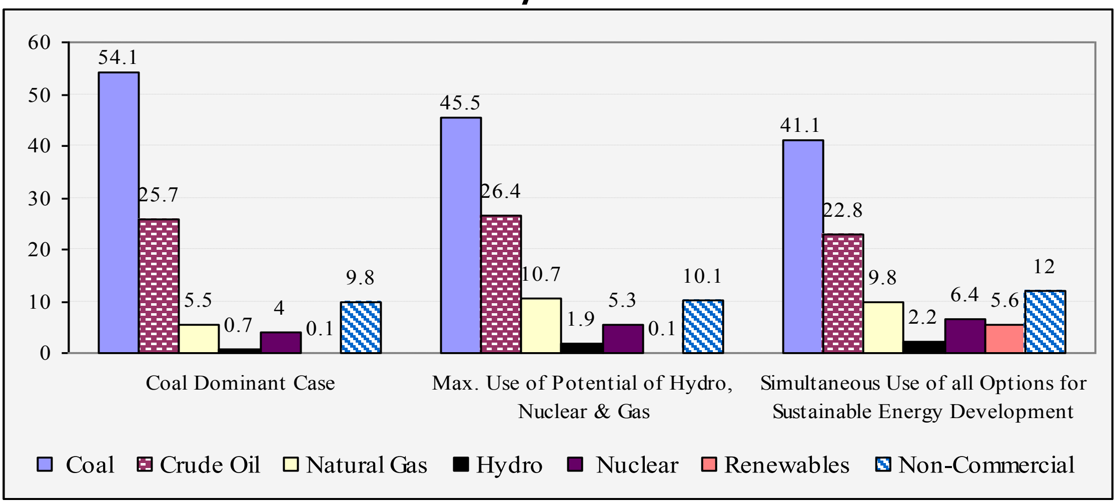
There has also been an extreme point solution generated by the model used by the committee which is based on the consideration of all the policy options together to make a maximum use of all the potential of clean energy resources in power generation including renewables and that of the potential of demand side management, including that of the transport sector. Figure 7.5 provides the comparative solution of the three scenarios of coal based development, maximization of use of the potential of conventional clean resources and the most environmentally clean policy option for 8% rate of GDP growth for the planning horizon upto 2031-32.

Figure 7.4: Projected Primary Commercial Energy Requirement for Maximum Hydro-Nuclear Potential Use and for GDP Growth Rate of 9%



Source: Based on Planning Commission, 2006.

Figure 7.5: Energy Resource Mix for 8% GDP Growth in 2031-32 for different Policy Scenarios



Source: Based on Planning Commission, 2006.

However, as neither the full social cost of supply has been considered to internalize the costs of environmental externalities nor the issues of energy poverty and energy security have any explicit weight in the formulation of the model and generation of scenarios, none of them can be characterized as the social welfare maximizing solution. However, they all provide good basis for the evaluation of alternative strategies for environmental control.

It is important to notice that the dependence of India on coal in 2031-32 will remain 51% in electricity generation and its share in the total primary energy resources will remain over 41% in the total primary energy mix even as per the best environmental scenario among the options as indicated in Figure 7.5. The gas resource is to be used only for peaking power even when it is forced as an option. The capacity utilisation of hydro power is found to be low because of the low availability of water resources. However, the total energy need as per the environmentally best option would reduce the requirement of the total primary energy resources by 21%, that of primary commercial energy by 19% and that of coal and oil by 38% and 28% respectively in 2031-32 vis-à-vis the coal dominant option. The CO_2 emission is correspondingly expected to go down by 35% in the terminal year vis-à-vis the least cost coal dominant option. The CO_2 emission is projected to grow from the prevailing level of 1 billion tonne per year as in 2005 to 5.5 billion tonne as per the high coal development scenario and 3.9 billion tonne as per the most environmentally conserving scenario. Even with all these energy sector developments, India's per capita carbon emission would be in the range of 2.6 to 3.6 tonnes of CO_2 while the same for the US and the World on the average had been 20 tonnes and 4.5 tonnes respectively in 2004. The expert group report also provides the implications of arising of other pollutants like SO_2, NOX, TSP, etc. for these alternative scenarios (Planning Commission 2006).

Among the various policy options for environmental sustainability, various studies have shown that the demand side management for efficiency improvements are economically the most attractive option (Garg et. al 2003). The fuel switching for the changes of energy mix pose greater challenges. The hydropower development would require the resolution of problems relating to water rights, resettlement and rehabilitation of the people affected by the project and environmental degradation of the kind discussed in an earlier section. Similarly nuclear energy maximisation in the thorium-uranium cycle requires the success of materialisation of import of Light Water Resources (LWRs). The latter requires removal of the political constraint of sanction on India by the Nuclear Suppliers' Group for the supply of uranium and nuclear power plant. The competitiveness of gas for justifying 16% share depends again on the price of gas being less than U$ 2.27 per MMBtu (i.e. equivalent to $ 45 per tonne of competing imported coal as assessed in 2006 by the Committee). The high cost option of the non-conventional renewables would not provide more than 5.6% of the total primary energy requirement even with the maximum mobilisation of these resources with an appropriate policy support. This is of course in tune with the worldwide projections of its share. For any gap in meeting any of these challenges posed by resource switching, the shortfall of the consequent energy supply will have to be met by coal for ensuring the security of high growth (Planning Commission 2006).

7.5.2 Future Projection of Energy Requirement of the Household Sector and the Fuel Mix

So far as the household sector is concerned the Expert Committee of the Planning Commission projected the requirements of the sector with fuel-wise break up – commercial and noncommercial- for the growing household expenditure in the future upto 2031-32 horizon as per 8% and 9% GDP growth rate. While these future projections used the pattern of spending on the total energy and on the individual fuels by the households as obtained from the data of the NSS 55th round of 1999-2000 (NSSO, 2001), they factored in the independent target of providing electricity to all by 2009-10, as a part of the inclusive growth programme. The impact of the Rajeev Gandhi Viduytikaran Yojana (RGGVY) for the purpose was taken into account in the demand assessment for the years beyond 2010, which assumed that the released kerosene for lighting due to electrification of homes will be used for cooking by the households in order to climb upwards along the energy ladder. Table 7.27 shows the projected demand for energy items by the households assuming the provision of electricity to all by 2009-10.

Table 7.27: Projected Demand for Fuels by the Households for 9% GDP Growth Rate (in mtoe)

Year	Fuel Wood & Chips	Dungcake	Kerosene	LPG	Electricity	Total
2000	79.62	29.61	10.07	6.42	8.43	134.45
2011	88.00	31.16	13.16	27.36	33.63	193.31
2021	97.67	30.28	13.71	44.72	59.35	245.73
2031	102.41	28.78	13.59	53.05	76.95	274.78

Source: Planning Commission, 2006.

Table 7.27 clearly shows a decline in the share of biomass fuel source to decline from 81.24 % in 2000 to estimated figures of 61.64% in 2011-12, 52.07% in 2021-22 and 47.7% in 2031-32. What is thus important to notice is that the relatively lower income-earning households will have to depend in a significant way on biomass for their energy need in spite of 9% growth and thrust on inclusiveness. This implies that the energy poverty cannot be fully removed even over the time horizon 2031-32 and there will be considerable continued pressure on Indian forests since the absolute quantity of fuel wood required is projected to increase at the annual average rate of 0.8% per annum.

In view of this role of fuel wood over the long run time horizon there is the requirement of further commercialization and market development for fuel wood subject to the environmental regulation in order to reduce the collection time of such biomass by Indian rural women. Even on the basis of such optimistic scenario of growth and electrification, the climbing along the energy ladder for a majority of rural population would be slow in India. As a result a more proactive policy thrust than the BAU trend in policies is imperative to ensure that electricity can meet the lighting need and the adverse externalities and user's cost of biomass fuel are at least further reduced than what the projections of the Expert Committee imply.

7.5.3 Prospects and Policies of Low Carbon Economic Growth

In another study on the prospect and policies for low carbon economic growth of India, Sengupta (2010) made long run predictions of final energy and primary energy resource demand and their CO_2 emission implication for 8% growth of Indian economy. The future prediction was based on econometric models of sectoral final energy consumption behaviour with respect to variation in real energy prices faced by the sector, level of sectoral activities or value added, fuel mix particularly the rate of penetration of electrical energy in the total final energy use. In case relationships estimated for any sector showed statistical insignificance or too much over estimation of energy requirement or energy saving in the long run based on the extrapolation of the results on elasticities of energy use, the basic prediction models have been changed in the study to be one of simple prediction based on the extrapolation of the trend rate of decline of final energy intensity of the sectoral GDP. The study also made assumptions on the supply side efficiency improvement in electricity along the line of the Planning Commission Expert Committee's report. Sengupta (2010) gives the results of projection of final energy and primary intensities of GDP and CO_2 emission intensities of GDP at the sectoral and aggregate level based on alternative assumptions, growth rate, energy prices and technological policy intervention for the penetration of electricity based on the demand elasticities and supply side efficiency parameters as obtained. For the base case of 8% growth of GDP and no price change and the business as usual trend of electricity penetration. All these show the decline of final energy intensity of GDP at sectoral and aggregate level between 2005 and 2031. At the aggregate level it shows a decline of final energy intensity of GDP from 6.5 gm/Rs. to 4.9 gm/Rs. – a decline of 25%. The macro level aggregate primary energy intensity was accordingly projected to decline from

13.3 gm/Rs. in 2005 to an intensity in the range of 8.6 to 9.7 gm/Rs. In 2031 without any change in real price of energy in future, and in the range of 5.2 to 8 gm/Rs. in the same terminal date 2031. With the rise in real energy price faced by each sector increasing at 3% compound rate per annum. The decline of such primary energy intensity would on the other hand be of lower order from 13.3 gm/Rs. to somewhere in the range of 9.2 to 10.6 gm/Rs. in the same terminal date in the case of no price change but by lowering of the growth rate to 6% per annum.

The prediction on the basis of such models based past data of the period 1971 to 2005 further shows that the CO_2 intensity of GDP in India would drop in the range of 29 to 38% in the time horizon upto 2031 over the base year of 2005 for 8% growth rate but no real price change of energy under alternative assumptions of technical change. The study further shows how rising real energy prices at the rate of 3% per annum may lead to the drop in CO_2 intensity of GDP in the range upto 41 to 61% in the year 2031-32 over the same base year. The lowering of the growth rate to 6% keeping prices unchanged on the other hand, would in fact ensure only lower decline in CO_2 intensity of GDP over the same time horizon. It is thus reassuring to find that lowering of growth is not necessary for lowering CO_2 intensity of GDP, while the using of pricing as a tool for energy conservation would be of higher effectiveness for lowering the CO_2 intensity of GDP. Table 7.28 and 7.29 provided the aggregate projections of CO_2 emission for the 8% growth under alternative pricing regime and the declining of CO_2 intensity of GDP over the planning horizon in 2005 to 2031.

Table 7.28: Projection of CO_2 Emissions (mt.)

Details	8% Gr No Price Change Sc1B	8% Gr Technology Sc1C	8% Gr With Price Change Sc2B	Sc3B
2005	1083	1083	1083	1083
2011	1523	1552	1452	1479
2021	2910	2726	2532	2442
2031	5553	4920	4597	4016
Future Growth Rate of CO_2	6.62	5.84	5.76	5.18
GDP Elasticity	0.831	0.733	0.72	0.85

Source: Sengupta, 2010.

Table 7.29: Projection of CO_2 Intensity of GDP (gms/Rupee) and Per capita CO_2 (tonnes)

Details	8 % growth with no price change	8% growth with 3 per cent price rise	6% GDP growth rate and no price range
2005	41	41	41
2021	30-32	23-28	16 – 24
2031	25.4 – 29	16 – 25.4	27 – 31
% drop 2021	22 – 27	32 – 44	17 – 24
% drop 2031	29 – 38	41 – 61	24 – 34
Per capita CO_2 (tonnes) -2031	3.4 – 3.6	2.1 – 3.2	2.4 – 2.8

Source: Sengupta, 2010.

7.6 Policy Conclusions

The Integrated Energy Policy Committee Report of the Planning Commission's projection of the total energy requirement and the supporting optimal supply for 8% growth rate under alternative assumptions of technology, fuel choice and energy conservation had implied the total CO_2 emission to vary in the range of 3.9 billion tonne to 5.5 billion tonne. As results of the two study are not much at variance, it is in fact a robust conclusion that India would be able to substantively weaken the CO_2 emission – growth linkage by reducing the CO_2 intensity of GDP in the coming decades. This would however require pro-active departure from the business as usual trend of primary energy conservation in the following areas.

(1) Energy conservation for irrigation in agriculture, service sector and the household sector should be of high priority in the energy policy agenda for influencing the demand side of the market. Raising efficiency of pump sets and lighting devices in all sectors and that cooking stoves and utensils should attract priority. As discussed above, barriers need to be removed for switching to the use of refrigerators and air-conditioner of higher energy efficiency rating as discussed in the paper. Solar hot water system and solar cook stoves deserve to be promoted by removing the barriers to their adoption. The introduction and enforcement of energy efficiency standard related information and greater awareness of consumers, trust on the reliability of such certification and labeling are of crucial importance for the diffusion and adoption of energy conserving devices and technologies.

(2) Rationalization of energy prices and using pricing as a tool for conservation are imperatives, but taking any recourse to the deceleration of growth rate would be not so for making the economy low carbon.

(a) Energy pricing need to be depoliticized for energy conservation and the greening of development. Electricity tariff should be remunerative enough to ensure economic viability of both generation and distribution investment. All cross subsidization need to be removed. For the energy security of the households and particularly the poor, there can be a life line rate of subsidized tariff for the subsistence consumption of 30 units of electricity per household while the rates should be progressively structured providing for cross subsidization across small and large consumers on the basis of progressive taxation principle. Similarly blanket subsidization of all consumption of LPG and kerosene should be abolished to induce conservation and provision of life line supply of kerosene or cooking gas of an amount of 6 kg. may be made as recommended by the Integrated Energy Policy Committee at subsidized rate per household for targeted consumers. Such targeted consumers should be required to buy such entitlement on the production of some debit or smart card introduced for the purpose of target group identity like universal identity card as being introduced.

(b) Time of the day tariff need to be introduced for moderating the system's load factor and improving the system's PLF. Suppliers of power co-generators to the grid should also be procured by utilities as per some time of the day differentiated tariff principle for improving system's efficiency.

(3) In the industrial sector energy audit and a reward-cum-penalty system for improving upon or making for deficiency from a bench mark of specific energy consumption fixed for such purpose need to be introduced for promoting energy and resource efficiency. Promotion of greater competitiveness of industrial production by the liberalisation of trade, tariff and industrial investment through the economic reforms process need to pay specific attention to the consideration of material and energy resource efficiency. The tax reforms like the introduction of GST should also keep in view of the issue of resource efficiency as well.

(4) The royalty or rental rates of search energy resources should be fixed rationally so that the finally energy price truly reflect the scarcity of the concerned eco-resource scarcity.

(5) There should be modal switch from road to rail particularly for freight traffic for reducing petro-diesel consumption. Fuel efficiency standards need to be enforced and energy efficiency labeling need to be introduced for inducing greater fuel efficiency of all kinds of road vehicles.

(6) In urban transport public rapid transit needs to be promoted and developed and made attractive to induce switch from private to public transport and conserve energy and decongest urban traffic.

(7) Efficiency of coal fired and gas fired generation units need to be improved to raise the conversion efficiency which is a cheaper option than augmenting supply by new capacities based on fossil fuel or renewables.

(8) The loss on account of transmission and distribution need to be substantively reduced from 26% to 15% which is achievable by stopping theft of power, strengthening the system of evacuation and distribution of power and the all India system of grid for transportation of power.

(9) Technological initiatives are important for not only developing new energy conserving technology in the non energy sector, but also for the introduction of the carbon free technologies (like wind, solar or hydel) for power generation or carbon neutral renewables like bio-liquid fuels for transportation. Capital

subsidies for such new technologies should be replaced subsidy linked with output of electricity by the use of new renewable resources.

(10) Assessment of potential of minihydels and the identification of potential sites for the estimate of its potential which is likely to be enhanced.

(11) To extend the network of wind turbines, these may be allowed to be set up in agricultural fields.

(12) The assessment of use of waste land for biodiesel cultivation should be carefully made and adequate caution has to be taken in deciding land use pattern for bio-diesel or bio-ethanol cultivation so that food security concern does not conflict with energy security. It is therefore important to find ways of raising the yield of jatropha oil per hectare, or introduce other plant species for such oil production.

(13) Ethanol production may be encouraged more through the use of celluloric materials, sweet sorghum and raising yield of sugarcane to enhance the availability of byproduct molasses from the juice processing activity which would used for alcohol or ethanol production.

(14) Electricity generation by way of wood and bio-waste gasification in family sized biogas plant by the use of such gases for electricity generation or thermal water heating can save use of fossil fuel for the same purpose. A vast potential exists of converting biomass into clean gas fuel for use as carbon neutral and renewable fuel from green source.

(15) Among the fossil fuel the abundant coal resources should not be wasted, but utilized by clean coal technologies as discussed in a preceding section which will significantly reduce the environmental pressure and damage.

(16) The use of imported gas resources and use of heavy oil or oil sand by modern technology of extraction in clean way can significantly reduce the pressure of eco-scarcity in the form of limitation of oil supply. India needs to resolve the geo-political problem of the region so that she can significantly enhance the supply of particularly gas in the region from the neighbouring region.

(17) India needs to resolve the global as well as internal political problem regarding nuclear cooperation with countries of the in nuclear suppliers group so that she can import light water reactor and uranium to be able to develop the fast breeder reactors at the earliest and utilize her vast thorium resources by developing thorium-uranium cycle of power generation.

(18) Development of entrepreneurship for proactive initiatives in the supply of the new technologies is an imperative. Fast deployment of new technologies is a critical requirement for reducing its cost and making it competitive.

(19) Government needs to innovate appropriate fiscal-monetary and other policies for the realisation of the points made above. The policies should target the development of appropriate market conditions for the purpose in each case.

(20) India must assert that if green development is to combine the prevention of erosion of eco-capacity with removal of poverty, she would required to stick to its high growth commitment, but minimize the environmental damage by enforcing as may options as possible for resource conservation or higher energy and material resource efficiency and by changing resource-mix or fuel mix in the context of energy sector development.

(21) India should implement sustainable resource and income accounting system as the framework of SEEA of the SNA 1993 of UN, and to monitor the environmental cost of any growth process and erosion of value to arrive at the true measure of income and accumulation of wealth – wealth being conceived in the most comprehensive sense of all kinds of environmental and non-environmental resources.

(22) In order to reduce the environmental cost of growth, India will in fact require to continue to investment in R&D in both technology development for enhancing resource efficiency and also in economic research in the valuation of the natural and the human capital for better monitoring greenness of growth and development.

(23) In these days of globalization there is also the necessity of pooling global resources of knowledge and technology by developing appropriate international cooperation for market development and developing an intellectual property rights regime which would facilitate technology transfer for economizing the cost of greening the development process.

Although India is recently indicating its openness to the idea of voluntarily committing to a GHG emission cap to make global initiative of collective action more effective she will have to make at the same time to sustained efforts to impress upon the rest of the world the legitimacy of her rights to emission for equitable sharing of the capacity of the global environment as sink for carbon emission. It is for the removal of the income poverty, generation of employment and the elimination of energy poverty there would be legitimate requirement of certain allocation of ecospace for her carbon emission. India's argument for carbon emission rights and demand for space in the global ecosystem has not ever been advanced for the adoption of the western style of life for her people, but for the removal of the socially unsustainable disparities in the patterns of energy consumption. India is already on a low carbon growth path or a green development path. She of course needs to do more to ensure that the same growth can be attained with even lower environmental stress and erosion of eco-capacity and at the least cost of greening the process of development.

Chapter 8

OTHER GREEN INITIATIVES – ENVIRONMENTAL TAX REFORMS AND GREEN BUILDINGS

8.1 Need and Scope for 'Green' Fiscal Reforms in India

India is presently embarking upon a major reform of indirect taxes. The current system taxes goods and services separately where goods are taxed by both the central (CenVAT) and state (State VAT) governments with overlapping tax bases and taxation of services (barring a few) are with the centre (service tax). This system is characterized by certain inadequacies which include cascading between central and state taxes and also between goods and services, multiple tax rates and inter-state sales tax that fragments the all-India market.

The proposed Goods and Services Tax (GST) by integrating taxes like CENVAT, State VAT, service taxes and a host of other taxes into a single tax with a uniform rate across goods and services aims at eliminating cascading and other inadequacies present in the current system of taxes.

The need for environmental taxes (eco-taxes) on polluting inputs and outputs over and above the core uniform GST rate arises from the fact that many polluting goods are currently taxed at a higher effective rate (taking both the centre and the state taxes). However, the uniform GST that is called for will bring down the effective tax rates on these goods and would not differentiate between polluting and non-polluting goods. This will lead to more pollution. Hence, it is important that before designing the new tax system, environmental considerations are taken on board so that any future changes in GST are not called for.

8.1.1 What can we learn from the experiences of developed countries?

The use of market based instruments to control damages to the environment is not new. Since the 1990s, developed countries, especially the European countries have levied taxes on carbon, fuel, waste disposal in landfills and other emission sources to control pollution and meet environmental targets. It is therefore helpful to learn from the experiences of developed countries that are aware of the benefits and costs of levying taxes with environmental objectives. Experiences relating to the different types of taxes levied, revenue generating potential of such taxes, the subsequent usage of the additional revenue and more importantly the impact of such taxes on the economy and the environment can guide policy makers in designing a tax system that integrates eco-taxes within its overall framework of taxes.

It has been observed that most of the countries adopting Environmental Tax Reforms (ETRs) have been successful in bringing about improvements in environmental quality. Additionally, the revenue from such taxes has been used to reduce other distortionary taxes and in some cases re-invested in improving the environmental quality.

Some main issues relating to the successful design and implementation of eco-taxes that draws on the experiences of developed countries with an already existing environmental tax framework such as UK, Germany, Sweden, Canada and New Zealand are briefly discussed here.

What is taxed?

Since the primary objective of environmental taxes is to bring about a reduction in environmental damages from different polluting sources, existing eco-taxes have targeted three main areas that are major contributors to pollution: (a) transport, in the form of differential taxation on vehicles based on fuel efficiency and congestion charges such as the one in place in London; (b) energy, where fuels which feed into energy generation are taxed; and (c) waste and use of natural resources, where pollution, waste disposed and exploitation of natural resources is taxed so that an industry that is more polluting or is more natural resource intensive ends up paying a higher amount in taxes (refer Table A.1).

How much revenue can eco-taxes raise?

Revenues raised from environmental taxes have ranged from 4-14 percent of total tax revenues in different countries. Korea and Turkey are among the highest, their eco-tax revenues contributing about 10-12% of their total tax revenues. UK, Germany and Sweden generated around 6% of revenue from eco-taxes as a percentage of total tax revenues in 2007.

As a percentage of GDP, the revenues from eco-taxes have ranged between 1-5%, Denmark generating the highest revenue as percent of GDP (4-5%) followed by Netherlands and Italy. UK, Germany and Sweden generate about 2.5 -3% of GDP from eco-tax revenues whereas Canada and New Zealand generates only 1-1.5%.

The major contributors to raising revenue are energy taxes and transport fuel taxes in particular. There is a predominance of consumption based taxes on household and transport whereas taxes on direct pollution and pollution causing industries are almost completely ignored.

Revenue from eco-taxes has been reducing over the years. This decline is almost entirely due to the reduction in energy tax revenue. Although it would be incorrect to interpret the fall in revenue as resulting from increased efficiency, evidence shows that the fall in revenue is due to a fall in the consumption of transport fuels.

How should the eco-tax revenue be utilized?

Revenue raised through eco-taxes is mainly utilized in three ways:

- the revenue is given back to the public through reductions in distortionary taxes, such as taxes on labour and capital;
- revenue is used to subsidise the use of green technology or promote investments in environmental management; and,
- revenue is earmarked for specific purposes such as, transport and transport fuel taxes being earmarked for road infrastructure.

What has been the impact of eco-taxes?

Following from the discussion above, it is clear that the full impact of any tax depends on what is taxed and how exactly the revenue raised is spent. The experiences of developed countries suggest that eco-taxes have positive impacts on the environment. Although the impact on the economy, in terms of GDP and employment are small, it is still positive. On the other hand, some taxes such as transport fuel taxes are argued to be regressive. There are mixed results in the incidence of taxes.

Transport taxes have led to a shift in consumer preferences towards cars with low emissions rating which in turn has led to an increase in fuel efficient cars. Evidence also suggests that taxes such as air duty have lowered demand for leisure flights. Local transport taxes have reduced congestion to a great extent. A decline in carbon emissions is also associated with transport taxes.

Fuel and energy taxes have had a significant effect in reducing fuel consumption and hence a reduction in emissions of greenhouse gases (GHGs)like carbon dioxide (CO_2) and methane (CH_4). CO_2 emissions have declined owing to fuel taxes in several countries like Sweden, Denmark and Germany. Taxes and levies such as the Climate Change Levy (CCL) in the UK has led to a decline in the demand for energy and energy taxes elsewhere have spurred innovations in the use of environment friendly fuels such as biomass. Taxes on waste and natural resources have led to a reduction in wastes dumped and a reduction in water extracted.

8.1.2 Lessons for India

Direct and Indirect Taxation of pollution

The main taxes that are relevant for India are transport fuel tax, coal tax and pollution taxes on industries such as iron and steel, oil refineries, fertilizer, sugar and cement. Transport fuel tax is the center piece of environmental taxes in developed countries. While considering fuel tax, it is import to analyze the incidence of taxes. Studies on incidence of fuel taxation in India have shown that it may not be regressive. However, experience from UK and Canada show mixed results regarding the incidence of the tax and hence it should be carefully evaluated. Also, the effective tax rate on fuels is quite high in India and taxing it further is debatable. However, the tax rate should not be reduced while moving to a GST rate.

Another major environmental problem corresponds to the pricing of coal. International experience in coal taxation has not been very widespread. The price of coal is substantially lower in India than in other countries. Since most emissions from India can be attributable to coal, it makes a case for levying environmentally motivated taxes on coal. India has already introduced a Rs. 50 per ton cess on coal.

Production based taxes (taxes on polluting industries and direct pollution) are ignored in the international scene. Taxes on polluting industries are important to shift to cleaner methods. However, it is important to identify polluting industries and tax them for effective pollution abatement. Most polluting industries have a high effective tax rate currently which should not be reduced under the GST regime.

Other issues in designing a system of eco-taxes in GST

- The introduction of GST presents India with the perfect opportunity to integrate eco-taxes with the overall tax structure. This can be done in two ways. One, a cess can be charged on top of the GST rate for polluting goods and two, input tax could be made non-rebatable for polluting goods.
- Regarding implementing eco-taxes in a federal setup, the centre should be given the responsibility to tax those pollutants whose externality is felt at the national or global level. Local pollutants should be the responsibility of the State.

- The revenues can be either used to reduce the overall rate on other goods and services or spent on improving the environmental quality depending on the precise needs of the country.

8.2 Green Buildings

While green buildings may on the face of it appear as a clear developed country priority area for green economy intervention, a couple of factors may necessitate careful attention to this sector in Indian context: (a) vast demand supply gap in residential housing would lead to intense activity in the coming decades; and (b) significant employment potential and feedback effects that this crucial sector has in Indian economy.

8.2.1 Integrating the Climate agenda and Development Agenda

In spite of the growing urgency in dealing with climate change, most developing countries have far more pressing problems and development concerns to address, that they would prefer to ignore climate change for a while. Additionally the developing countries have had a very little share in historical contributions and would not be willing to reduce emissions now when they are on a development path. However, countries need not choose between addressing development and climate change but can address both simultaneously.

In most developing countries, a large percentage of buildings or dwelling structures are made of materials which are not durable and in many cases, housing supply is far short of the housing demand. Alleviation of slums as one of the Millennium Development Goals is gaining prominence. In such a situation, meeting the demand for improved housing conditions for the poor, associated with ripple effects is seen as an important development strategy. With a little more effort, policies and investment if directed in the right direction, most of these buildings can easily be 'greener' thereby cost-effectively addressing climate change without having a separate agenda for mitigation. For a developing country, this little extra effort to go green would not only reduce future emissions but more importantly build an adaptive capacity to withstand any adverse effects of a changing climate. Green buildings in the context of sustainable development needs to be interpreted as a tool for adaptation with mitigation as an important co-benefit.

From a policy perspective, politicians of developing countries would not prefer to project the fact their emissions are going down as a result of a fall in energy consumption. It is here, where the complementarities between mitigation and adaptation needs to be stressed. Green buildings in developing countries should not be encouraged just as a mitigation tool but mainly as a development cum adaptation tool. The government should act as a major player in increasing investments and directing efforts to this end.

8.2.2 Enabling Green Buildings in India

India has adopted a national green rating system called GRIHA (Green Rating for Integrated Habitat Assessment) tailored to her geographic and climatic conditions. It was conceived by TERI and developed jointly by the Ministry of New and Renewable Energy to help people assess the environmental performance of a building over its lifecycle against certain nationally acceptable benchmarks.

However, as outlined in Table 8.1 there are still a lot of barriers in adopting green buildings coming from all the stakeholders involved: reluctance from home owners, risk-averseness attitude and information asymmetry of construction firms, lack of financing from institutions and lack of incentives and investment from government. To strengthen the Green building movement, first and foremost, these different stakeholders should be brought together and these barriers should be addressed simultaneously. A top-down approach, where policies influence financing decisions and hence affect consumer decisions would work better in the case of buildings. The government and municipalities should play a key role in policy making, enacting legislations, and providing an enabling environment. Incentives should be given to financial institutions and property owners in such a way that more financing comes from the private sector and the property owners would prefer green buildings. This way, incentives from government should influence financing and consumer decisions, and enable the green movement.

A new initiative called Eco-Housing aided by the USAID and implemented by the International Institute for Energy Conservation (IIEC) is being adopted by the Pune Municipal Corporation (PMC). The program aims at promoting green building practices by demonstrating the benefits of sustainable construction to various stakeholders and by developing a five star rating mechanism based on several assessment criteria. Most importantly, the program design includes supporting policy changes, the engagement of stakeholders, financial and fiscal incentives, development of performance assessment tools and capacity building activities all of which are crucial in enabling the adoption of green buildings. The project has successfully engaged several public and private sector housing finance institutions to develop specific housing mortgage products for Eco-housing. Bank of Maharashtra and ING Vysya are offering an interest-rate subsidy for eco houses and other financing institutions like HDFC and SBI also are set to launch similar products. The municipality has proposed upto 50% property tax rebate for consumers. The program has also resulted in a unique public-private partnership by setting up of the Sustainable Technology Building Center (STBC) which aims at training and capacity building of professionals and removing institutional and market barriers resulting in successful program expansion.

There are important lessons to be learnt from this program and the crucial thing would be to scale up the program to promote sustainable construction practices throughout the country. The government should also act as a leader in adopting green practices for constructing government buildings and also in social housing and slum rehabilitation schemes which would go a long way in inducing the private sector to go green.

Table 8.1 Costs, Benefits and Barriers for Green Buildings

Stakeholder	Costs	Benefits	Barriers
Construction firm	Incremental cost towards Architectural and Engineering design	New business opportunity	1)Information asymmetry regarding green practices, codes and standards and green guidelines 2) Lack of Incentives: developers may not find it profitable to increase energy efficiency 3)Conservative nature of construction industry: voluntary adoption of new technologies is low
Owner	Bears the incremental cost	Financial Benefits Huge operational and maintenance savings due to 1)Energy savings (40-45% less energy) 2)Water savings(20-30% less water)	1)Lack of incentives-low priority for energy-efficiency 2)Split Incentives 3)High Upfront Costs 4)Lack of access to capital 5)Information asymmetry regarding where to turn, whom to trust and what to buy 6) High Transaction Costs 7)Short planning horizons but long pay-back periods 8)Risk aversion: uncertainty about green property value 9)Framing and discounting problems 10)Serving the loans as there is no direct return

Stakeholder	Costs	Benefits	Barriers
Occupant		Health benefits Reduces deaths due to poor indoor air quality Reduces illness rate by providing better interior quality Productivity benefits Improved indoor environmental quality(more fresh air, daylight) enhances productivity	1)Inadequate information on current energy consumption 2)Lack of awareness about benefits of energy efficiency
Society		Environmental Benefits Value of Emissions Reduction (Highest mitigation potential at low cost) Resource Conservation Value of reduced waste generation Social benefits Increase Adaptive capacity Alleviate living conditions of poor and slum inhabitants Energy Security Decrease Energy Poverty	1)Lifestyle and behavioral status-quo 2)Lack of awareness that green buildings will enhance quality of life 3)Externalities: no one internalizes the consequences of their actions
Government	-Incremental cost in enforcing green techniques -Cost of implementing policies, enabling financing environment and capacity building -Cost of technology transfer, development and dissemination	-Combating climate change – achieving emission reduction targets -Achievement of MDG : slum clearance -Reduction of operational costs and subsidy costs	1) No incentives for the property owner, businesses and financial institutions 2) Lack of appropriate instruments (like tax rebates) 2)Lack of appropriate Policies, Legislations and Laws 3)Weak Monitoring Mechanisms 4)Lack of institutions that oversee the market and coordinate transactions among different actors 5)Lack of investment and financial support from the government

Stakeholder	Costs	Benefits	Barriers
Workforce	Cost of undergoing training to acquire new 'green skills'	<u>Economic Benefits</u> Huge Employment effects : Direct, Indirect and Induced jobs	1)Lack of 'green skilled' workforce 2)No proper training institutes and guidelines 3)Absence of certification mechanisms which distinguishes skilled from non-skilled workers is a disincentive to undergo training
Other Businesses	Increased expenditure on R&D, product development and promotion	-New business opportunity -Positive impact on research, innovation and business development	1)Green Products Industry: unwilling to invest in R& D to develop energy-efficient appliances simply because there is no demand and they are uncertain about market conditions 2) Businesses lack expertise and know-how regarding the science and techniques of energy-efficiency 3) Utilities: operating under outdated regulatory system creates disincentives to pursue cost-effective energy eficiency
Funding institutions (FIs/Banks/International Aid agencies)			1)Reluctance to fund individual building projects -Risk-averseness attitude: uncertainty regarding how the customer will pay back the loan as there are no direct returns for the customer(only indirect returns in the form of energy savings) -High risks and low returns 2)Reluctance to fund large-scale building projects because of building specific challenges: -'long tail' of building projects: large no of small opportunities -Multiple Stakeholders, Building diversity leading to high transaction costs -economically not attractive: Low CER yields (for CDM funding)

Source: Balasubramaniam and Viswanathan, 2010.

Chapter 9

SUMMARY AND CONCLUSIONS

The World Commission on Environment and Development characterized a development process to be sustainable if it ensures such use of resources of all kinds – man made capital, natural capital and human capital – in the current period that the present generation would leave behind an endowment of resources for the next generation that can allow the latter access to the same opportunities and amenities of life. This definition has been quite broad, but its prime focus has been on the intergenerational equity, and not on the intra-generational and distributional equity, particularly the ones relating to the removal of poverty and destitution. Secondly, this definition of sustainability is based on the substitutability between the ecological capital and the man-made / knowledge capital and therefore relied on the concept of weak sustainability, not that of a strong one. The technological optimism based on the experience of the huge technical progress of the twentieth century has been the basis of this presumption that any adverse ecological effects of erosion of capital can be offset by the development of knowledge and man made capital. Although Rio 1992 and Johannesburg 2002 earth summits followed mainly the World Commission's concept of sustainable development while deliberating on the global issues relating to environment and development, there has been the following twin experiences in the global development process in the last 20 years.

(a) There has been the persistence of poverty and deprivation in Afro-Asian developing countries with the gap between the rich and the poor of the world growing over time.

(b) There has been substantive erosion of capacity of the ecosystems which has brought such irreversible changes in the different regions that their adverse effects could not be fully offset by the growth of other types of capital and development of technology. This has adversely affected the flow of eco-services of nature, primary productivity of common property resources of societies and therefore the livelihood and economic conditions of the poor and the marginalized section of population.

As a consequence of the above there has been a switch from the concept of sustainable development to that of green development by the UN for the future deliberation and choice of development strategy to solve the major global developmental issues. The thrust of the green development has therefore been on the following twin objectives:

(a) Removal of poverty and destitution and addressing intra-generational equity issues; and

(b) Conservation of ecological capacity of the earth or of the ecosystems to ensure the sustained supply of eco-services.

Prevention of erosion of eco-capacity due to any irreversible change would contribute to the conservation of common resources of the society – an important source of livelihood of the poor. The objectives (a) and (b) have thus important complementarities.

Having discussed various green economy initiatives in some crucial sectors of Indian economy, this final chapter presents a brief SWOT – Strengths, Weaknesses, Opportunities and Threats – analysis of the green economy concept and supplements it with an overview on the international negotiations on green economy.

9.1 Green Economy – SWOT Analysis

India's strengths, weaknesses, opportunities and threats with regard to green economy can be summarized as follows:

Strengths

- Stable economy with handsome growth
- High savings rate and population dividend
- Presence of clear policy making mechanism at national and state level
- Significant public-private partnership in various sectors that could incentivize businesses to become more sustainable
- Strong emphasis on renewable resources and increasing energy efficiency – for example, many initiatives taken by the Bureau of Energy Efficiency and other organizations
- Vibrant and strong network for capacity building
- Vibrant private sector that is taking on its own various green initiatives – for example, Indian Green Building Council had a significant role in building capacity and promoting the uptake of green building principles

Weaknesses

- Persistent poverty, inequality and unemployment
- Uneven growth across regions leading to stress on the federal structure

- Rapid urbanization leading to severe stress on infrastructure and ecosystems
- Slowing agricultural growth and stagnant rural economy
- Too diverse focus on meeting sustainable development goals – for example, policies try to promote almost all renewables with separate program for each resource
- Rapidly growing construction sector contributing to growing carbon emissions
- Heterogeneous institutions and multiple stakeholders often leading to conflict of interests and stalling operationalization of policies

Opportunities

- Young and educated population could spur green entrepreneurialism
- Strong social network could provide necessary cushion to absorb shocks
- Growing emphasis in south-south networking could provide ample scope for sharing of green knowledge and usher greater trading opportunities among the developing countries
- Strong base of quality education can be further developed to build stonger links with business community

Threats

- Continuing global economic slowdown could relegate priority to the green economy initiatives and policies world over as well as in India
- Status-quo thinking on sustainability by the national and state governments can inhibit out-of-the-box thinking needed in the green economy context
- Rising resource scarcity including the global geopolitical pressures pertaining oil resources could derail the green thinking and green initiatives
- The global climate change and the associated extreme impacts could pose distinct danger to the green economic thinking.

9.2 Enabling International Environment

In a fundamental sense, the new notion of 'green economy' is intimately linked with the concept of 'sustainable development' as the latter is viewed as development that is economically efficient, socially equitable, and environmentally sustainable. What the notion of green economy does is to make the economic, equity, and ecological dimensions of the concept of sustainable development more direct and explicit. However, since many developing countries view the excessive carbon focus of the green economy initiative as another attempt to put limits on their reliance on carbon generating energy resources, they tend to have reservation on the new initiative. As a result, the green economy concept is not creating the same level of consensus across countries as the concept of sustainable development.

If green economy initiative is to achieve consensus across countries, it should be conceived broadly to go beyond simple carbon focus. While green economy is necessary to achieve sustainable development, it is not sufficient as there are other important conditions that are to be met collectively by both rich and poor countries. When developed countries have preempted global carbon space, it is not equitable to expect the developing countries to limit their carbon emission. This is particularly so when technology transfer is blocked through Trade-related Intellectual Property Rights regime and financial flow for green investment is limited for economic and technical reasons. There is also a need for considerable reduction in agricultural subsidy in developed countries and open their trade regime for products from developing countries. The principle of common but differentiated responsibility should be accepted so that rich countries bear a major share of responsibility.

The carbon-based green economy approach is relevant for advanced countries, which have obviously achieved higher living standard, better income distribution, and energy self-sufficiency. These countries find the green economy initiatives as a necessary part of the program for economic stabilization. But, from the perspective of developing and emerging countries such as India, green targets, especially in terms of carbon emission targets, can be real constraint. This is particularly so in the absence of technology transfer, international investment, and development aid. Also, these countries have the additional responsibility of catching up with the developed countries in terms of living standard and income distribution. Therefore, in their long-term interest, developing countries such as India should approach green economy initiatives from the larger perspective of sustainable development, where green initiatives are coupled with open trade regimes, free international flow of technology and investment, and more equitable sharing of international carbon space.

India could cooperate in international collective action on GESDPE based on principles endorsed by UN bodies such as right to development, fair entitlement to global commons, and common but differentiated responsibilities of states according to their respective capabilities. Specifically, India could highlight the following areas of concern – not only from national perspective but also to facilitate meaningful dialogue on GESDPE:

- GESDPE should not open door for green protectionism. As the stage of development, national circumstances, policy priorities and capacities – both technical and financial – differ among countries any attempt at harmonization of "green" standards and use the standards as basis of trade barriers like trade restrictions and border tax adjustments should be resisted;

- Distorting agricultural subsidies in OECD must be eliminated in a time bound manner to ensure agricultural goods exporting developing countries to enhance their export opportunities and receive "fair" agricultural prices to incentivize them to in invest in agriculture;
- There is asymmetry between treatment of traditional/ indigenous knowledge and modern scientific knowledge and between biological and other resources. The IPRs are private rights while traditional knowledge and biological resources are under open access common property regimes. Country of origin, consent of suppliers of biological resources and traditional knowledge and evidence of benefit sharing must be made mandatory for registration of patents based on traditional knowledge and biological resources in all countries to avoid biopiracy and ensure that the guardians of traditional knowledge and biological resources are rewarded for sustainable use of the resources;
- Based on the principle of common but differentiated responsibilities of states according to their respective capabilities, developed countries must compensate developing countries for the "stock burden" of greenhouse gas accumulation and incremental costs of providing other global public goods like biodiversity;
- Developed countries must provide environmentally sound technologies, including green and climate-friendly technologies, at concessional prices to developing countries;
- An institutional mechanism for R&D, collaborative research between developed country and developing country partners on location –specific problems facing developing countries, and technology adaptation and diffusion especially to micro, small and medium enterprises is needed. One such activity is ecologically sustainable green revolution; and
- As some of the investment programmes e.g., restoration of natural capital, adoption of low carbon technologies like solar energy and carbon capture and storage, involve high upfront costs and as capital costs are relatively higher in many developing countries compared with developed countries, creation of a funding mechanism for green investment by way of loans at fair rates would accelerate investment in green infrastructure activities.

REFERENCES AND BIBLIOGRAPHY

Amarasinghe, U.A, T. Shah, H. Turral, and B.K. Anand (2007a): *India's Water Future to 2025-2050: Business-as-usual Scenario and Deviations*, Research Report No: 123, International Water Management Institute, Colombo, Sri Lanka.

Amarasinghe, U.A., T. Shah, and O.P. Singh (2007b): *Changing Consumption Patterns: Implications on Food and Water Demand in India*, Research Report No: 119, International Water Management Institute, Colombo, Sri Lanka

Anand Sudhir and A. Sen (2000): "Human Development and Economic Sustainability", *World Development*, Vol. 28, No. 12.

Anand,S., V.Talyan, R.P.Dahiya and P.Vrat (2006): Assessment of Nitrous Oxide Emission from Fertilizer Application in India, *The 2nd Joint International Conference on Sustainable Energy and Environment (SEE 2006,)* 21-23 November 2006, Bangkok, Thailand.

Baland, J.M., P. Bardhan, S. Das, D. Mookherjee, and R. Sarkar (2006): Managing the Environmental Consequences of Growth: Forest Degradation in the Indian Mid-Himalayas, Paper Presented at the Indian Policy forum 2006, at NCAER, New Delhi.

Barnes, D.F. and M.A. Toman (2006): "Energy, Equity and Economic Development" in Lopez R. and M.A. Toman (eds.), *Economic Development and Environmental Sustainability*, Oxford University Press.

Benbi D.K, V.K.Nayyar and J.S.Brar (2006): Green revolution in Punjab: the impact on soil health*, Indian J. Fertil.* 2: 57–66.

Benbi, D.K. and J.S.Brar (2009): A 25-year record of carbon sequestration and soil properties in intensive agriculture, *Agronomy for Sustainable Development*, 29: 257–265

Bharadwaj, Tongia and Arunachalam (2006): "Whither Nuclear Power", *Economic and Political Weekly*, March 25, 2006.

Bhattacharya, Soma and Maureen L. Cropper (2010): 'Options for Energy Efficiency in India and Barriers to their Adoption: A Scoping Study', Discussion Paper No. 10 - 20, Resources for the Future, April.

Bhattacharyya, P and G. Chakraborty (2005): "Current Status of Organic Farming in India and other Countries", Indian Journal of Fertilizers, Vol. 1 (9): pp.111-123.

Birol F. (2007): "Energy Economics: A Place for Energy Poverty in the Agenda?" in *The Energy Journal*, Vol. 28, No. 3.

Brookes, G. and P.Barfoot (2010): Global impact of biotech crops: environmental effects, 1996-2008, *AgBioForum, 13(1): 76-94.*

Burney,J.A., S.J. Davis, and D.B. Lobell (2010): Greenhouse gas mitigation by agricultural intensification, *PNAS*, 107(26): 12052–12057.

Central Water Commission (CWC) (2009): *Water and Related Statistics*, New Delhi.

Charyulu, D.K. and S. Biswas (2010): "Economics and Efficiency of Organic Farming *vis-à-vis* Conventional Farming in India", Working Paper No. 2010-04-03, Indian Institute of Management, Ahmedabad.

Daly Herman E. and Farley J. (2004): *Ecological Economics, Principles and Applications*, Washington D.C. Island Press.

Delucchi M A (2000): "Environmental Externalities of Motor Vehicles used in the US" in *Journal of Transport Economics and Policy*, Vol. 34, No. 2.

Delucchi M A and D Mc. Cubbin (1999): "The Health Cost of Motor Vehicle emissions – Related Air Pollution" in *Journal of Transport Economics and Policy*, Vol. 33, No. 3." LBNL-41845. Lawrence Berkeley National Laboratory.

Drinkwater, L.E., P. Wagoner, and M. Sarrantonio (1998): Legume-based cropping systems have reduced carbon and nitrogen losses, *Nature*, 396:262-265

Follett, R. F. (2001): Soil management concepts and carbon sequestration in cropland soils. *Soil and Tillage Research,* 61: 77–92.

Follett, R.F., S.R. Shafer, M.D. Jawson, and A.J. Franzluebbers (2005): Research and implementation needs to mitigate greenhouse gas emissions from agriculture in the USA, *Soil and Tillage Research*, 83: 159–166

Foster V, J.P. Tre and and Q. Wodon (2000): "Energy Prices, Energy Efficiency and Fuel Poverty", unpublished paper of the Latin America and Carribbean Regional Studies Program, World Bank.

Francis,G., R. Edinger and K. Becker (2005): "A concept for simultaneous wasteland reclamation, fuel production, and socio-economic development in degraded areas in India: Need, potential and perspectives of *Jatropha* plantations", *Natural Resources Forum,* 29: 12–24.

Garg Ashish, Manisha Gulati and Nachiketa Tiwari (2010): "Moving Towards Low Carbon Economy, The Need for Renewable Energy Solution: Part- I Renewable Energy in India: Capability, Challenges, and Prospects" in *India Infrastructure Report 2010, Infrastructure Development in a Low Carbon Economy*, by 3i- Network, Infrastructure Development Finance Company, Oxford University Press, New Delhi.

Garg, A., P.R. Shukla, and M.Kapshe, M. (2006): "The sectoral trends of multigas emissions inventory of India", *Atm. Environment*, 40 (24): 4608-4620.

Garg, Amit, P.R. Shukla, Debyani Ghosh, Manmohan Kapshe and Rajesh Nai (2003): "Future GHG and Local Emissions for India: Policy Links and Disjoints", *Journal of Mitigation and Adaptation Strategies for Global Change*, Vol. 28, No. 1.

Government of India (GOI) (2010): India: Greenhouse gas emissions 2007, Indian National Network for Climate Change Assessment, Ministry of Environment and Forests, Government of India.

GoI (2009): *Road Transport Year Book 2006-07*, Transport Research Wing, Ministry of Shipping, Road Transport and Highways, Government of India, New Delhi.

GOI (2007): *Report of the Working Group to Advise Water Quality Assessment Authority on the Minimum Flows in the Rivers*, Central Water Commission, Ministry of Water Resources, New Delhi, July.

GOI (2000): *Annual Report-1999-2000*., Ministry of Water Resources, New Delhi.

GOI (2000): *Wastelands Atlas of India*. Department of Land Resources and National Remote Sensing Agency, Ministry of Rural Development, Government of India, New Delhi.

GOI (1995): *Report of the Committee on Private Sector Participation in Major and Medium Irrigation Projects*, Ministry of Water Resources, New Delhi.

GOI (1999): *Report of the National Commission on Integrated Water Resources Development,* Ministry of Water Resources, New Delhi.

GOI (1992a): *Report of the Committee on Pricing Irrigation Water*, Planning Commission, New Delhi.

GOI (1992b): *Model Bill to Regulate and Control the Development of Groundwater*, Ministry of Water Resources, New Delhi.

Grace P R, M.C. Jain and L.W.Harrington (2002): Environmental concerns in rice-wheat system, in *Proceedings of the International Workshop on Developing Action Programme for Farm level Impact in Rice-Wheat system of the Indo-Gangetic Plains* held during 25-27 September 2000 at New Delhi, India. Rice-Wheat Consortium paper series 14, New Delhi, India. pp. 99-111.

Gunatilake, H. (2011): "India: Study on Cross-sectoral Implications of Biofuel Production and Use", Final Report of TA 7250-IND Submitted to the Department of Economic Affairs, Ministry of Finance, Asian Development Bank, Manila, The Philippines.

Gupta, R. K., R.K.Naresh, P.R.Hobbs, and J.K.Ladha (2002): Adopting Conservation Agriculture in Rice-Wheat Systems of the Indo-Gangetic Plains- New Opportunities for Saving on Water. Paper presented at the "Water wise rice production workshop", 5-10 April 2002, IRRI, Philippines.

Gupta, RK, M.L.Jat, and S.K.Sharma (2005): Resource conserving technologies for water savings and enhancing productivity. in *Proceedings of the National Symposium on efficient water management for eco-friendly sustainable and profitable agriculture*, December 1-3, 2005, New Delhi, p 181-182.

Gutierrez, A.P., J.J.Adamczyk Jr., S.Ponsard, C.K.Ellis (2006): Physiologically based demographics of Bt cotton–pest interactions II: temporal refuges, natural enemy interactions. *Ecological Modelling,* 191: 360–382.

Helmers, G.A., M. R. Langemeier, and J. Atwood (1986): An economic analysis of alternative cropping systems for east-central Nebraska, *American Journal of Alternative Agriculture*, 1:153-158.

Holdren, J.P. (2007): Final Report to the William and Flora Hewlett Foundation from the Woods Hole Research Center, Phase I of a Project on "Linking Climate Policy with Development Strategy in Brazil, China, and India" (Woods Hole, MA: Woods Hole Research Center, 15 November 2007), pp. 198, 319.

International Energy Agency (IEA) (2010): *Energy Balances of Non-OECD countries*, OECD, Paris.

IEA (2010): *World Energy Outlook*, OECD, Paris.

Intergovernmental Panel on Climate Change (IPCC) (2007): Climate Change 2007: Fourth Assessment Report. Synthesis Report, Cambridge University Press, Cambridge.

Janakarajan, S. (1993): "Economic and Social Implications of Groundwater Irrigation: Some Evidence from South India", *Indian Journal of Agricultural Economics*, 48(1).

Jat M L and Pal S S. (2000): In-Situ decomposition of rice straw using cellulose-degrading fungi in a typic Ustochrepts of Indo-Gangetic plain under rice-wheat system, In *Proceedings of National Symposium on Agronomy: Challenges and Strategies for the new millennium* held during November 15-18, 2000 at Gujrat Agricultural University, Junagadh.

Jat, M.L., Pal, S.S., Shukla, L., Mathur, J.M.S. and Singh, M. (2004): Rice residue management using cellulolytic fungi and its effect on wheat yield and soil health in rice-wheat cropping system. *Indian Journal of Agricultural Sciences*. March, 2004.

Johnson, J. M.-F., A.J.Franzluebbers, S.L.Weyers and D.C.Reicosky (2007): Agricultural opportunities to mitigate greenhouse gas emissions, *Environmental Pollution,* 150: 107-124.

Kakodkar, Anil (2004): Nuclear Energy in India-retrospect and Prospects, *An International Journal of Nuclear Power*, Vol. 18, No. 2-3.

Kauppi, P., and R. Sedjo (2001): Technological and economic potential of options to enhance, maintain, and manage biological carbon reservoirs and geo-engineering, pp. 303–341, Chap. 4 in *Climate Change 2001: Mitigation*. Cambridge University Press, New York.

Khor, M. (2011): 'Risks and Uses of the Green Economy Concept in the Context of Sustainable Development, Poverty and Equity', Research Paper No. 40, South Centre, Geneva, July.

Kouser, S. and M. Qaim (2011): Impact of Bt cotton on pesticide poisoning in smallholder agriculture: A panel data analysis, *Ecological Economics,* doi:10.1016/j.ecolecon.2011.06.008

Kumar, K.S. Kavi (2008): "Use of Solid Fuels in Indian Households", *ENVISAGE* – Newsletter of ENVIS Centre on Environmental Economics, Vol. 5(3), October.

Ladha J.K, D.Dawe, H.Pathak, A.T.Padre, R.L.Yadav, B.Singh, Y. Singh, P.Singh A.L.Kundu, R.Sakal, N. Ram, A.P.Regmi, S.K.Gami, A.L.Bhandari, R.Amin, C.R.Yadav, E.M.Bhattarai, S. Das, H.P.Aggarwal, R.K.Gupta, P.R.Hobbs (2003): How extensive are yield declines in long-term rice-wheat experiments in Asia? *Field Crops Research,* 81:159–180.

Ladha J.K., H.Pathak, T.J.Krupnik, J.Six, C.van Kessel (2005): Efficiency of fertilizer nitrogen in cereal production: retrospect and prospects. *Adv Agron*, 87:85–156

Ladha, J.K., J. Hill, R.K. Gupta, J. Duxbury and R.J. Buresh. (eds). (2003): Improving the productivity and sustainability of rice-wheat systems: issues and impact. *ASA Spec. Publ.* 65. ASA, Madison, WI. USA.

Lal R. (2004): Soil carbon sequestration in India, *Climatic Change,* 65: 277–296.

Lal, R. (2007): Carbon management in agricultural soils, *Mitigation and Adaptation Strategies for Global Change*, 12(2): 303-322.

Lee, D.R. (2005): Agricultural sustainability and technology adoption: issues and policies for developing countries, *American Journal of Agricultural Economics* 87, 1325–1334.

Lele, S., and L. Venkatachalam (2006): "Assessing the Socio-Economic Impact of Changes in Forest Cover on Watershed Services" in J. Krishnasamy, S. Lele R. Jayakumar, eds., *Hydrology and Watershed Services of the Western Ghats (India): Effects of Land Use and Land Cover Change*, New Delhi: Tata McGraw-Hill.

Lipper, L. and R.Cavatassi (2003): Land use change, carbon sequestration and poverty alleviation, *ESA Working Paper No. 03-13*, Agricultural and Development Economics Division, The Food and Agriculture Organization of the United Nations, Rome, www.fao.org/es/esa.

Lotter, D.W. (2003): Organic agriculture, *Journal of Sustainable Agriculture,* 21(4): 59–128.

Maene, L.M. (2000): Efficient Fertilizer Use and its Role in Increasing Food Production and Protecting the Environment, 6th AFA International Annual Conference 31 January - 3 February 2000, Cairo, Egypt.

Maggio, G. and G. Caccida (2009): A Variant of the Hubbert Curve for World Oil Production Forecasts, *Energy Policy*, Vol. 37, Issue No. 11, pp. 4761-4770.

Mahajan, A. and R.D. Gupta (2009): *Integrated Nutrient Management in a Sustainable Rice-Wheat Cropping System*, Springer.

Mahdi1 S.S., G. I. Hassan, S. A. Samoon, H. A. Rather, S.A. Dar and B. Zehra (2010): Bio-Fertilizers in Organic Agriculture, *Journal of Phytology* 2(10): 42-54

Malik, R.P.S. (2009): "Energy Regulations as a Demand Management Option: Potentials, Problems, and Prospects", in R. M. Saleth, ed., *Promoting Irrigation Demand Management in India: Potentials, Problems, and Prospects*, International Water Management Institute, Colombo, Sri Lanka.

Malik, RK, Gupta, RK, Singh, CM, Yadav, A, Brar, SS, Thakur, TC, Singh, SS, Khan, AR, Singh, R, and Sinha, RK. (eds.) (2005): Accelerating the adoption of resource conservation technologies in rice-wheat systems of the IGP. *Project Workshop Proceedings*, June 1-2, 2005, CCSHAU, Hisar

Mall, R.K., Akilesh Gupta, Ranjeet Singh, R.S. Singh, and L.S. Rathore (2006): "Water Resources and Climatic Change: An Indian Perspective", *Current Science*, 90(12): 1610-1626.

McNeil, M., M. Iyer, S. Meyers, V. Letschert and J.E. McMahon (2005): "Potential benefits from Improved Energy Efficiency of Key Electrical Products: The Case of India", LBNL-58254, Lawrence Berkeley National Laboratory.

Meadows, D.H., Meadows D.L., Randers, J. (1992): *Beyond the Limits*, Chelsca Green Publishing Company, Vermont.

Murty M N and S C Gulati (2004): "A Generalized Method of Hedonic Prices: Measuring Benefits from Reduced Urban Air Pollution", Institute of Economic Growth, New Delhi.

Narain, Vishal (2009): "Water Rights System as a Demand Management Option: Potentials, Problems, and Prospects", in R. M. Saleth, ed., *Promoting Irrigation Demand Management in India: Potentials, Problems, and Prospects*, International Water Management Institute, Colombo, Sri Lanka.

Narayanamoorthy, N. (2009): "Water Saving Technologies as a Demand Management Option: Potentials, Problems, and Prospects", in R. M. Saleth, ed., *Promoting Irrigation Demand Management in India: Potentials, Problems, and Prospects*, International Water Management Institute, Colombo, Sri Lanka.

Nashawi, Ibrahim Sani, Adel Molallah and Mohammed Al-Bisharah (2010): Forecasting World Crude Oil Production Using Multicyclic Hubbert Model, *Energy Fuels*, Vol. 24, Issue No. 3, pp. 1788-1800.

National Council of Applied Economic Research (NCAER) (2008): *Economic Impact of Interlinking Rivers Programme*, Revised Final Report, New Delhi.

National Sample Survey Organization (NSSO) (2007): *Energy Sources of Indian Households for Cooking and Lighting,* 2004-05, Report No. 551(61/1.0/4), NSS 61st Round.

NSSO (2001): *Report of NSS 55th Round Survey: Energy used by Indian Households* 1999-2000.

Nel, William P. and Christopher, J. Cooper (2009): Implications of Fossil Fuel Constraints on Economic Growth and Global Warming, *Energy Policy*, Vol. 37, Issue No. 1, pp. 166-180.

Nelson, G., R.Robertson, S.Msangi, T. Zhu, X.Liao and P.Jawajar (2009): Greenhouse Gas Mitigation: Issues for Indian Agriculture, *IFPRI Discussion Paper 00900*, Environment and Production Technology Division, International Food Policy Research Institute, Washington, D.C.

Niles, J.O., S. Brown, J. Pretty, A. S. Ball and J. Fay (2002): Potential carbon mitigation and income in developing countries from changes in use and management of agricultural and forest lands, *Philosophical Transactions of the Royal Society of London A*, 360: 1621-1639.

Organization of Economic Cooperation and Development (OECD) (2011): *Towards Green Growth*, OECD Publishing, Paris.

Pachauri S and D Spreng (2004): "Energy Use and Energy Access in relation to poverty", *Economic and Political Weekly*, January 17, 2004.

Pachauri S, A. Mueller, A. Kemmler and D Spreng (2004), " On Measuring and Energy Poverty in Indian Households", *World Development*, 2004.

Pandey, D.N. (2007): Multifunctional agroforestry systems in India, *Current Science*, 92(4): 455-463

Parikh, J., K.S. Parikh and V. Laxmi (2005): Lack of Energy, Water and Sanitation and its Impact on Rural India, 2005 in Parikh K.S. and R. Radhakrishna (eds.), *India Development Report, 2004-05*, Oxford University Press, New Delhi.

Parikh, Jyoti K. and K.S. Parikh (1977): Mobilisation and Impacts of Biogas Technologies, *Energy,* Vol. 2.

Pattanayak, S. (2004): "Valuing Watershed Services: Concepts and Empirics from South East Asia", *Agriculture, Ecosystems and Environment*, 104(1): 171-84.

Paustian, K., J.M.Antle, J.Sheehan and E.A.Paul (2006): Agriculture's role in greenhouse gas mitigation, Pew Center on Global Climate Change, Arlington, Virginia, USA.

Paustian, K., J.Six, J., E.T.Elliott, and H.W.Hunt (2000):. Management options for reducing CO_2 emissions from agricultural soils. *Biogeochem*. 48, 147–163.

Pemsl, D.E., A.P.Gutierrez, H.Waibel (2008): The economics of biotechnology under ecosystem disruption. *Ecological Economics,* 66, 177–183.

Persson T. A., C. Colpier and U. Azar, "Adoption of Carbon Dioxide Efficient Technologies and Practices": An analysis of sector specific convergence trends among 12 nations", *Energy Policy*, Vol. 35 (5).

Pimental, D. (2006): Impacts of organic farming on the efficiency of energy use in agriculture, *State of Science Review*, The Organic Centre.

Planning Commission (2008): Eleventh Five Year Plan (2007-2012), Oxford University Press, New Delhi.

Planning Commission (2006): *Integrated Energy Policy: Report of the Expert Committee*, New Delhi.

Pohekar, S.D. and M. Ramachandran (2006): "Multi-criteria Evaluation of Cooking Devices with Special Reference to Utility of Parabolic Solar Cooker (PSC) in India", *Energy* 31:1215-27.

Pretty, J. and R. Hine (2001): Reducing food poverty with sustainable agriculture: a summary of new evidence, SAFE Research Project, University of Essex, Wivenhoe Park, UK.136 p.

Pretty, J.N., A.S.Ball, L.Xiaoyun and N.H.Ravindranath (2002): The role of agriculture and renewable-resource management in reducing greenhouse-gas emissions and increasing sinks in China and India, *Philosophical Transactions of the Royal Society of London A*, 360: 1741-1761.

Ramana, M.V. (2007): Discussions: Economics of Nuclear Power Subsidies and Competitiveness, *Economic and Political Weekly*, Vol. 42, Issue No. 2, pp. 169-171.

Ramana, M.V., Antonette D'sa and Amulya, K.N. Reddy (2005): Economics of Nuclear Power from Heavy Water Reactors, *Economic and Political Weekly*, Vol.40, Issue No. 17, pp. 1763-1773.

RBI (2009): *Handbook of Statistics on the Indian Economy 2008-09*, Reserve Bank of India, Mumbai.

Reddy A. K. N (1999): Goals, Strategies and Policies for Rural Energy", *Economic and Political Weekly*, Vol.34 (49).

Reddy, B.S. (2003): "Overcoming the Energy Efficiency Gap in India's Household Sector", *Energy Policy* 31(11):1117-27.

Reddy, B.S. and P. Balachandra (2006): "Dynamics of Technological Shifts in the Household Sector – Implications for Clean Development Mechanism", *Energy Policy* 34(16):2586-99.

Romeis, J., A.S.Shelton, G.G.Kennedy, (Eds.) (2008): Integration of Insect-Resistant Genetically Modified Crops within IPM Programs. Springer, New York.

Roshetko, J.M., M.S.delos Angeles, and K.Warner (2002): Smallholder Agroforestry Systems as a Strategy for Carbon Storage, Paper presented at International Symposium on Forest Carbon Sequestration and Monitoring, November 11-15, 2002, Taipei, Taiwan.

Roy, Uttam K., M. Roy, S. Saha (2008): "Mass-Industrialized Housing to Combat Consistent Housing Shortage in Developing Countries: Towards an Appropriate System for India", XXXVI IAHS World Congress on Housing, November, Kolkata.

Saleth, R. M., and M. Thangaraj (1993): "Distribution Pattern of Lift Irrigation in India: An Analysis by Hydro-geological Regions", *Economic and Political Weekly*, 28(39).

Saleth, R.M. (1996): *Water Institutions in India: Economics, Law, and Policy*, Commonwealth Publishers, New Delhi.

Saleth, R.M. (2007): "Water Rights and Entitlements in India", in John Briscoe and R.P.S. Malik, eds., *Handbook of Water Resources in India*, The World Bank and Oxford University Press, New Delhi.

Saleth, R.M., and A. Dinar (2004): *The Institutional Economics of Water: A Cross Country Analysis of Institutions and Performance*, Edward Elgar, Cheltenham, UK.

Saleth, R.M., ed. (2009): *Promoting Irrigation Demand Management in India: Potentials, Problems, and Prospects*, International Water Management Institute, Colombo, Sri Lanka.

Sandhu, H.S., S.D.Wratten, and R.Cullen (2010): Organic agriculture and ecosystem services, *Environmental Science and Policy,* 13:1-7.

Sandhu, H.S., S.D.Wratten, R.Cullen, and B.Case (2008): The future of farming: the value of ecosystem services in conventional and organic arable land. An experimental approach. *Ecological Economics,* 64: 835–848.

Sanstad, A.H., J. Roy, and J.A. Sathaye (2006): "Estimating energy-augmenting technological change in developing country industries." *Energy Economics* 28(5-6): 535–38.

Sathaye, J., and A. Phadke (2006): "Cost of electric power sector carbon mitigation in India: international implications." *Energy Policy* 34(4): 1619–29.

Sathaye, J., L. Price, S. de la Rue du Can, and D. Fridley (2005): "Assessment of energy use and energy savings potential in selected industrial sectors in India." LBNL-57293, Energy Analysis Department Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, August.

Schaldach R., J.A.Priess and J.Alcamo (2011): Simulating the impact of biofuel development on country-wide land-use change in India, *Biomass and Bioenergy*, 35: 2401-2410.

Schneider U.A.and P.Kumar (2008): Greenhouse Gas Mitigation through Agriculture, *Choices,* 23(1):19-23.

Schumacher, K., and J. Sathaye (1998): "India's iron and steel industry: Productivity, energy efficiency and carbon emissions." LBNL-41844, Lawrence Berkeley National Laboratory.

———. (1999a): "India's aluminum industry: productivity, energy efficiency and carbon emissions", LBNL-41845, Lawrence Berkeley National Laboratory.

———. (1999b): "India's cement industry: Productivity, energy efficiency and carbon emissions." LBNL-41842, Lawrence Berkeley National Laboratory,.

———. (1999c): "India's fertilizer industry: Productivity and energy efficiency." LBNL-41846, Lawrence Berkeley National Laboratory.

———. (1999d): "India's Pulp and Paper Industry: Productivity and Energy Efficiency." LBNL-41843, Lawrence Berkeley National Laboratory.

Sengupta, Ramprasad (2010): *Prospects and Policies for Low Carbon Economic Growth of India*, National Institute of Public Finance & Policy, New Delhi.

Sengupta, Ramprasad and R. Singhal (2010): Biofuels and Energy Security of India, Paper Presented at IGC-ISI India Development Policy Conference, Indian Statistical Institute Delhi Centre, New Delhi, 20 – 21st December.

Sengupta, Ramprasad and S. Mandal (2005): Health Damage Cost of Automotive Air Pollution: Cost Benefit Analysis of Fuel Quality Upgradation for Indian Cities, Working Paper No. 37, National Institute of Public Finance and Policy, New Delhi.

Shah, T. (1993): *Groundwater Market and Irrigation Development: Political Economy and Practical Policy*, Bombay: Oxford University Press.

Singh Y., A.Dobermann, B.Singh, K.F.Bronson and C.S.Khind (2000): Optimal phosphorus management strategies for wheat-rice cropping on a loamy sand, *Soil Science Society of America Journal,* 64: 1413–1422.

Smakhtin, V., and M. Anputhas (2008): *An Assessment of Environmental Flow Requirements of Indian River Basins*, International Water Management Institute, Colombo, Sri Lanka

Srinivasan, M.R., R.B. Grover and S.A. Bhardwaj (2005): Nuclear Power in India, *Economic and Political Weekly*, Vol.40, Issue No. 49, pp. 5183-5188.

Stern, Nicholas (2008): "The Economics of Climate Change", Richard T. Ely Lecture, *American Economic Review*, 98(2), 1-37.

Stolze M. and N.Lampkin (2009): Policy for organic farming: rationale and concepts, *Food Policy*,

Streets, D.G., K.F. Yarber,J.-H. Woo, and G.R.Carmichael (2003): Biomass burning in Asia: annual and seasonal estimates and atmospheric emissions, *Global Biogeochemical Cycles,* 17(4): 10-1 to 10-20.

Suki Lenora (2010): "Drivers of Energy Efficiency Industries", in *India Infrastructure Report 2010, Infrastructure Development in a Low Carbon Economy*, 3i-Network, Infrastructure Development Finance Company, Oxford University Press, New Delhi.

Tewari, D.N. (1995): Agro forestry for increased, productivity, sustainability and poverty alleviation, International Book Distributors, Dehradun.

Thakur, S. (2005): Economics of Nuclear Power in India: The Real Picture, *Economic and Political Weekly*, Vol. 40, Issue No. 49, pp. 5209.

Timsina, J. and D.J.Connor (2001): Productivity and management of rice-wheat cropping systems: issues and challenges. *Field Crops Research* 69: 93-132.

Ugarte, Daniel G. De La Torre, C.M.Hellwinckel and J.A.Larson (2004): Enhancing Agriculture's Potential to Sequester Carbon: A Framework to Estimate Incentive Levels for Reduced Tillage, *Environmental Management,* 33, (Supplement 1): S229–S237.

United Nations Environment Programme (UNEP) (2010): *Green Economy: A Brief for Policymakers on the Green Economy and Millennium Development Goals*, Nairobi

UNEP (2011): *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication*, Nairobi, www.unep.org/greeneconomy.

Velthuijsen J W and E Worrel (1999): "The economics of Energy" in van den Bergh, Jeroen C J M, *Handbook of Environmental and Resource Economics*, Edward Elgar.

Watson, R. T., I.R.Noble, B. Bolin, N.H. Ravindranath, D.J. Verardo and D.J. Dokken, (eds) (2000): *IPCC Special Report on Land Use, Land-Use Change and Forestry. A special report of the Intergovernmental Panel on Climate Change.* IPCC Secretariat, World Meteorological Organisation, Geneva, Switzerland. (Available from http://www.ipcc.ch/.)

Welsh, R. (1999): The Economics of Organic Grain and Soybean Production in the Midwestern United States, Henry A. Wallace Institute for Alternative Agriculture, Washington.

World Bank (2009 & 2010): *World Development Indicator* (2009, 2010), Washington DC: World Bank.

World Commission on Environment and Development (WCED) (1987): *Our Common Future*, New York: Oxford University Press.

World Health Organization (2006): *Fuel for Life*, Geneva.

Yang, M. (2006): "Energy efficiency policy impact in India: Case study of investment in industrial energy efficiency", *Energy Policy*, 34 (17) : 3104 – 114.

Appendix A

Table A1. Eco-taxes – Summary of International Experience

Country	Tax	Objective	Description
Taxes on Energy			
UK	Climate Change Levy (CCL)	To encourage energy efficiency	Charged on business use of energy such as natural gas, electricity, LPG and solid fuels. Different rates for different fuels.
	Fuel Duty	To reduce number of trips made by car	Tax levied on fuels based on emissions.
Germany	Energy Tax	To encourage energy efficiency	Tax charged on tax rate on mineral oil for fuel, gas and heating oil, coal and electricity.
Sweden	Carbon Tax	To reduce carbon emissions	Levied on oil, coal, natural gas, liquefied petroleum gas, petrol and aviation fuel in domestic traffic.
	Sulphur Tax	To reduce sulphur emissions	Levied on liquid fuels, coal and fuel oil according to the sulphur content.
Canada	Fuel Tax	To encourage use of efficient fuels	Fuel is subject to the GST/HST, the federal excise tax, provincial taxes and provincial sales taxes. Hence, tax rates differ among provinces.
	British Columbia's Carbon Tax	To reduce emissions of CO_2, methane and nitrous oxide	Levied on the purchase and use of fossil fuels such as gasoline, diesel, natural gas, heating fuel, propane, coal, etc based on emissions of CO_2 equivalent.
Taxes on Waste and Natural resources			
UK	Landfill Tax	To reduce externalities associated with waste disposal	Charge levied on landfill site owners and can be passed on to consumers via higher prices

	Aggregates Levy	To reduce externalities associated with aggregates extraction	Tax levied on quarry operators and other organizations that commercially exploit aggregates. Different rates for active and inactive wastes.
	Water Abstraction Charge	To cover the costs they incur in water resource management	Levied on businesses that extract and use over ground, underground or tidal water sources
New Zealand	Waste Levy	To provide both an incentive to avoid waste, along with funding to help develop waste minimisation infrastructure	Charged on waste disposed at disposal facilities
Mexico	Water Abstraction Charge	To encourage efficient use of water	Different rates for specific types of uses of water. Rate also determined by the relative scarcity or abundance of an area's water resources
	Pollution Charges	To reduce discharge of polluting effluents	Different rates for different contaminants and for different types of water bodies to which effluent is discharged.

Transport Taxes			
UK	Vehicle Excise Duty (VED)	To encourage purchase of low emission cars	Annual tax on road vehicles based on the emissions rating of the vehicles.
	Air Passenger Duty (APD)	To reduce the number of times a person flies	Levied on airlines based on the number of passengers flying domestically or internationally from UK airports.
	London Congestion Charge	To reduce level of congestion in Central London	Charged on any vehicle entering or parking in the charging zone between 7 am and 6.30 pm on a weekday.
	Taxation of Company Cars	To reduce emissions by company cars	Company cars are allocated a cash value on which company car drivers are liable to pay income tax and employers are liable to pay Class 1A National Insurance Contributions (NICs).
Germany	Vehicle Tax	To reduce CO_2 emissions from road traffic	Tax based on cylinder capacity of vehicle, over which EURO 2 per gram of CO_2 emissions per kilometre (g/km) is charged if those exceed a threshold of 120 g/km.
Sweden	Vehicle Excise Duty (VED)	To reduce CO_2 emissions from road traffic	Duty comprises of a base charge of 360 SKR plus a CO_2 charge of 15 SKR per gram of CO_2 exceeding 100 grams per kilometre (g/km).
Canada	Vehicle Tax	To encourage purchase of low emission cars	Federal excise tax on automobiles based on the weighted average fuel consumption rating of the vehicle.

MSE Working Papers

Recent Issues

- * Working Paper 60/2011
  Discount Rate for Health Benefits and the Value of Life in India
  K.R. Shanmugam
- * Working Paper 61/2011
  Evidence on Changes in Time Varying Volatility around Bonus and Rights Issue Announcements
  Madhuri Malhotra, M. Thenmozhi and Arun Kumar Gopalaswamy (forthcoming)
- * Working Paper 62/2011
  Patterns of Labour Market Insecurity in Rural India: A Multidimensional and Multivariate Approach
  Padmini Desikachar and Brinda Viswanathan
- * Working Paper 63/2011
  Determinants of Child Morbidity and Factors Governing Utilisation of Child Health Care: Evidence from Rural India
  Anindita Chakrabarti
- * Working Paper 64/2012
  Arsenic Contamination in Water: A Conceptual Framework of Policy Options
  Zareena Begum I
- * Working Paper 65/2012
  Learning and Capability Acquisition: A Case Study of the Indian Automobile Industry
  Madhuri Saripalle
- * Working Paper 66/2012
  Poverty, Human Development and Health Financing in India
  Brijesh C. Purohit
- * Working Paper 67/2012
  Corporate Governance and Product Market Competition
  Ekta Selarka
- * Working Paper 68/2012
  Basel l and Basel ll Compliance: Issues for Banks in India
  Sreejata Banerjee
- * Working Paper 69/2012
  The Distributional Impacts of Climate Change on Indian Agriculture: A Quantile Regression Approach
  Chandra Kiran B Krishnamurthy
- * Working Paper 70/2012
  Efficiency of Raising Health Outcomes in the Indian States
  Prachitha J. and K. R. Shanmugam

---

* Working papers are downloadable from MSE website http://www.mse.ac.in
$ Restricted circulation

MSE Monographs

* Monograph 10/2010
  Economic Instruments for Environmental Management: International Best Practies and Applicability to India
  D.K.Srivastava Dr K.S. Kavikumar , and C.Bhujanga Rao
  With inputs from Dr Bodhisattva Sengupta, Dr Brijesh C. Purohit, Ms Asha Mariam Abraham, Ms Ishwarya
* Monograph 11/2011
  Taxation of Goods and Services in India
  D.K.Srivastava and C.Bhujanga Rao
* Monograph 12/2011
  Coping with Pollution: Eco Taxes in a GST Regime
  D.K. Srivastava, K.S. Kavi Kumar and C. Bhujanga Rao,
  with inputs from Brijesh C. Purohit and Bodhisattva Sengupta
* Monograph 13/2011
  Recent Bouts of Inflation in India: Policy Paralysis?
  T.N. Srinivasan
* Monograph 14/2011
  Impact of Fiscal Instruments in Environmental Management through a Simulation Model: Case Study of India
  D.K. Srivastava and K.S. Kavi Kumar, with inputs from Subham Kailthya and Ishwarya Balasubramaniam
* Monograph 15/2012
  Environmental Subsidies in India: Role and Reforms
  D.K. Srivastava, Rita Pandey and C. Bhujanga Rao, with inputs from Bodhisattva Sengupta
* Monograph 16/2012
  Integrating Eco-Taxes in the Goods and Services Tax Regime in India
  D.K. Srivastava and K.S.Kavi Kumar
* Monograph 17/2012
  Monitorable Indicators and Performance: Tamil Nadu
  K. R. Shanmugam
* Monograph 18/2012
  Performance of Flagship Programmes in Tamil Nadu
  K. R. Shanmugam, Swarna S Vepa and Savita Bhat
* Monograph 19/2012
  State Finances of Tamil Nadu: Review and Projections
  A Study for the Fourth State Finance Commission of Tamil Nadu
  D.K. Srivastava and K. R. Shanmugam
* Monograph 20/2012
  Globalization and India's Fiscal Federalism: Finance Commission's Adaptation To New Challenges
  Baldev Raj Nayar
* Monograph 21/2012
  On the Relevance of the Wholesale Price Index as a Measure of Inflation in India
  D.K.Srivastava and K.R.Shanmugam
* Monograph 22/2012
  A Macro-Fiscal Modeling Framework for Forecasting and Policy Simulations
  D.K.Srivastava, K.R.Shanmugam and C. Bhujanga Rao