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Sustainable Development: The Journey from Rio (1992) to Rio+20 and Beyond

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ABSTRACT

Rio-1992 conference gave widespread visibility of the concept of sustainable development (SD), developed by Brundtland commission (1983-1987) and defined Sustainable Development as the development which meets the needs of the present generation without compromising with the necessities of the future generations and proclaimed 27 principles for its implementation. This concept developed as the present model of unlimited growth in a limited resource based environment is not the right answer to the complex of the problem that every country faces. This concept placed environmental management in a position to address the environmental impacts of developmental projects so that the environment is protected for the present and future generations. Brundtland Commission considered population control, food security and energy supply as critical components of sustainability. Since the Rio-1992 summit, and adoption of Agenda-21 by the global community, most of the countries including India have set sustainability as a key goal for their development.

It is generally accepted that the four pillars of sustainable development are the environmental, social, economic, and technological wellbeing, especially green technology. To achieve SD, different management systems are adopted. The defining aspects of SD are: population control, energy use, increasing productivity, water resource conservation, biodiversity conservation, development of science & technology, and technology transfer.

Our modern way of living is based on unsustainable consumerism. The energy source from fossil fuels puts tremendous adverse pressure on environment, and our activity reduces biodiversity, which provides us food, shelter material, raw material for medicines, gases for survival, ecosystem services like recycling of water and other materials.

The Rio+20 (2012) emphasised Green Economy, which includes all aspects of SD but emphasizes on the adoption of Green Technology. Indicators of green economy are (i) CO_2 productivity-demand & production based,(ii) Non-energy material productivity (manufacturing) by material group, (iii) measures of natural resource stock. The essence is using green technologies in manufacturing and other sectors so that the GHG load to the environment is substantially reduced to lessen the effect of climate change.

The world population is rising and predicted to reach 9 billion by 2050. Most of this growth will take place in developing countries. With huge population increase, there will be enormous pressure on the resources .The world will face several challenges in health care, food and energy security, and fresh water availability. India accounts for the largest proportion of malnourished children in the world and exhibits very high variability; on one hand we have high GDP growth rates, a big pool of scientific manpower, a large middle class, malls, global retail chains, expanding multi-millionaires, and on the other hand huge number of people under poverty, unemployment and debt, with limited access to health facility and education, and most of them live rural areas and slum areas of urban centres.

Sympathizing will not solve the problem and something beyond sympathizing has to be done. The business group and the people having an assured high income must consider contributing to a fund for national welfare of the deprived people. The Corporate Social Responsibility (CSR) is another option, which can be made mandatory. Massive awareness for population control is to be created. More incentives are to be given for opting birth control options so that population growth is brought down to less than 1% at the earliest.

There is increased need of energy in the agriculture, industrial and service sectors. Modern way and standard of living demand more energy for unsustainable consumerism, transport, increased construction work and other aspects of human use. Biomass forms important component of energy source for rural India and about 360 million people depend upon biomass as energy source. India produces 300 million Mg of sugarcane annually and bagasse can be used to produce butanol on a large scale.

To lessen the effect of climate change, algae can be used as efficient GHG sequesters. Algae require non-agriculral land, fresh water pond and shallow marine areas (brackish water, saline break water, saline shallow coastal areas etc) for their mass cultivation. About 1 million ha of wasteland is available for algal cultivation. Arresting climate change will require transforming the Indian economy from a high carbon to low carbon and no carbon energy base. The GHG sinks such as forest, is shrinking due to fragmentation and by anthropogenic interference. Soil is getting eroded; marine ecosystem getting polluted and they require conservation measures. Soil biodiversity is an important source of C-sink. These aspects have been discussed in this paper and a conceptual model for GHG sink study has been suggested. Food and nutritional security linking to Indian situations, particularly to Indian rural livelihood options, animal resources and other alternate technologies to increase productivity has been discussed.

Key Words: Sustainable Development; Green Economy; Green Technology; Our Common Future; Livelihood Options; GHG Sink; Soil Biodiversity; Food and Nutritional Security; Energy Security.

INTRODUCTION

Stockholm conference on 5th June 1972 lead to the establishment of UN Environment Programme and emphasized on protection of environment for the future. The World Commission on Environment and Development, established in 1983 under the chairmanship of Dr.Gro Brundtland brought out its report 'Our Common Future' in 1987.The report highlighted on poverty, depletion of natural resources faster than exploitation, deterioration of environmental quality and quality of life. These recommendations lead to the organization of the Earth Summit in Rio de Janeiro in Brazil in June 1992 (Rio-1992), which gave widespread visibility of the concept of sustainable development (SD). Sustainable Development is defined as the development which meets the needs of the present generation without compromising with the necessities of the future generations (Brundtland Commission 1987).

In 14th century, sustainable forestry was practiced, based on the principle of not cutting down more trees than the growth rate for replacement allowed. The forests were to be used in such a way that future generations would have just as many advantages as the present generation does. In India the concept is very old and linked to Vedic times. The Rio-1992 conference further proclaimed 27 principles for adoption to achieve SD by the different nations. The principles centered on the fact human beings are at the centre of concerns for sustainable development; and the states have the sovereign right to exploit their own resources pursuant to their own environment within the ambit of the International Laws. The right to development must be fulfilled so as to equitably meet development and environmental needs of present and future generations; and environmental protection (EP) is an integral part of Sustainable Development. Poverty eradication is indispensable requirement for SD & all states and all people to participate in the process and the least developed and environmentally vulnerable states shall be given special priority. Global partnership is to be promoted to conserve, protect and restore the health and integrity of the Earth's ecosystem. Countries to reduce and eliminate unsustainable patterns of production and consumption and adopt appropriate demographic policies to achieve SD. Countries to strengthen endogenous capacity-building for SD by improving scientific and technological knowledge transfer of technologies including new and innovative technologies. Countries shall enact effective environmental legislation & develop environmental standards and to support open international economic system. Countries shall develop national law regarding liability and compensation to the victims of pollution and other environmental damage and should co-operate to discourage relocation and transfer of substances and activities to other states that cause severe environmental degradation & harmful to human health processes and to encourage public awareness. Internalization of environmental costs and application of the general principle that the polluting industry shall pay the cost of remedial measures without distorting international trade and investment. Environmental Impact Assessment (EIA) shall be used as a national instrument for developmental projects. Countries shall immediately notify other countries of any natural disaster or other emergencies that are likely to produce sudden harmful effects on the environment of those states. International community to help countries so afflicted. Women and youth shall be encouraged to actively participate in environmental management & development to achieve SD and for global partnership. Indigenous people & their communities and local communities and their knowledge and traditional practices should be recognized by all countries and their identity, culture are to be protected. The environment & natural resources of people under oppression, domination and occupation shall be protected. Warfare is inherently destructive of SD and hence countries shall respect international law to protect the environment in times of armed conflict. Peace, development and EP are interdependent and indivisible. Countries shall resolve all their environmental disputes peacefully and in accordance with the Charter of UN and to cooperate in good faith and in the spirit of partnership in the fulfillment of the Declaration, international law to achieve SD.

This concept developed as the present model of unlimited growth in a limited environment is not the right answer to the complex of the problem that every country faces. It also means redistribution of resources as it will reduce inequalities. Redistribution may include technology transfer, financial aid and compensation to prevent environmental degradation, resource conservation etc. Environmental management is the key to address environmental impacts of developmental projects so that the environment is protected for the present and future generations. Since the Rio-1992 summit, and adoption of Agenda-21 by the global community, most of the countries including India have set sustainability as a key goal for their development. The four pillars of sustainable development are the environmental, social, economic, and technological wellbeing, especially green technology and the different management systems are adopted to achieve SD. (Figure 1 and 2)

Figure 1. Pillars of Sustainable Development

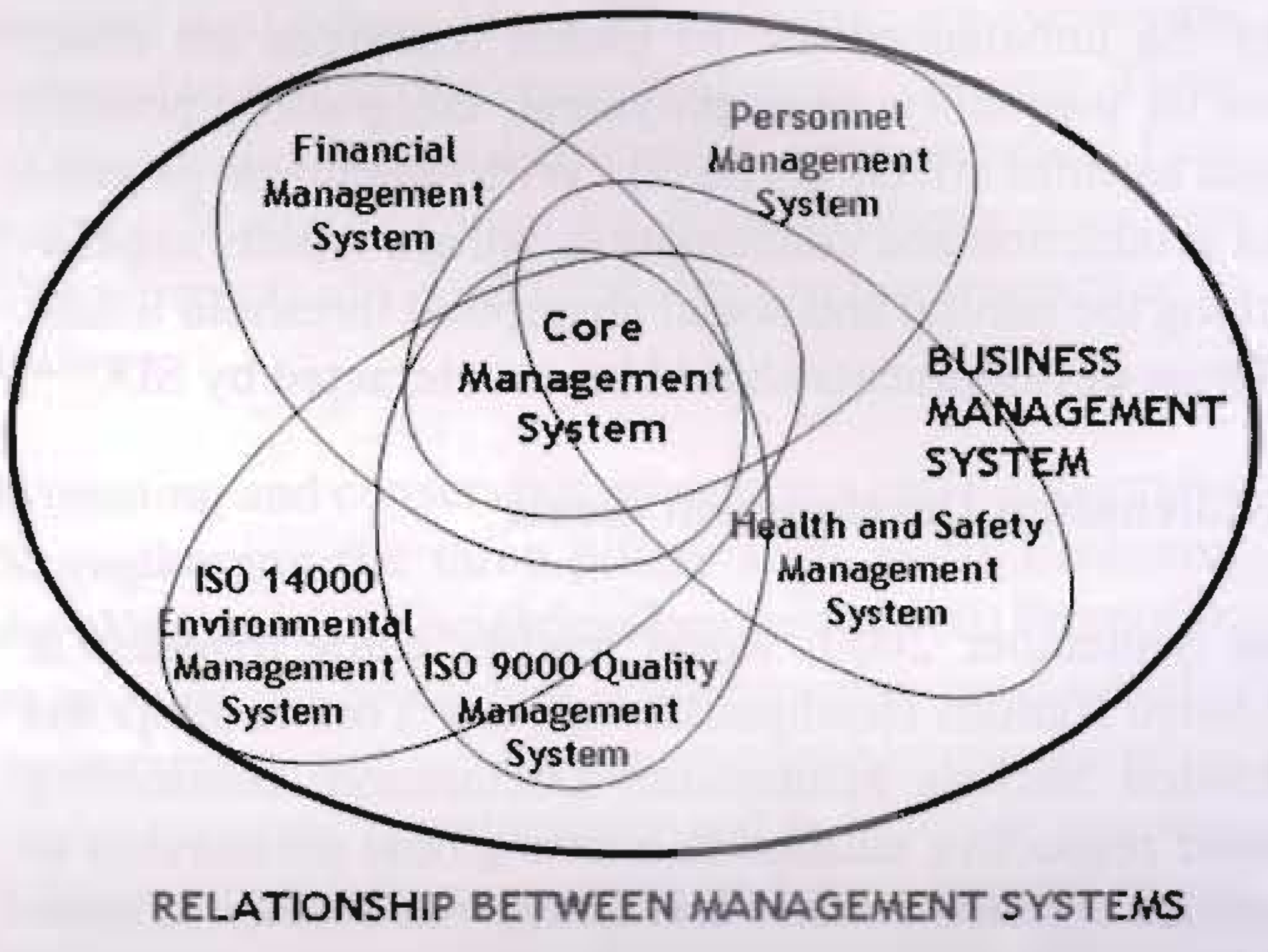

Figure 2. Relationships between management systems to achieve Sustainable Development

The follow-up conference in Johannesburg, South Africa in 2002 provided opportunity to review the actions taken and benefits made and to review the different aspects of resource utilization and conservation. Biodiversity conservation received top priority. Besides, the important issues such as energy use, climate change and its effect on developmental projects, food security, etc and future of mankind was very much focused.

The theme for the World Environment Day on 5 June 2012 was 'Green Economy-Does it include you? This was also the theme of sustainable development. The defining aspects are: Population control, Energy use, increasing productivity, Water resource conservation, Biodiversity conservation, Development of Science & Technology and Technology Transfer. Our modern way of living is based on unsustainable consumerism. The energy source from fossil fuels eats away puts tremendous adverse pressure on environment, and human activity reduces biodiversity, which provides us food, shelter material, raw material for medicines, gases for survival, other ecosystem services like recycling of water and other materials – something like legendary Indian poet Kalidasa, before being blessed by the goddess of learning was cutting the tree branch sitting over it. Virtually all earth's ecosystems have been significantly transformed through human activities and the changes have been more rapid during last hundred years as the population grew faster and migration to urban centres became a necessity due to lop-sided development and management. The social repercussions of the unbalanced use of global resources are clear: social inequality, unemployment, emigration, poverty and harmful effects on health. With our current patterns of production and consumption, we are rapidly approaching the natural and social absorption threshold limits. These developments should be counteracted by SD.

Millennium Development Goals

In September 2000, world leaders came together at United Nations Headquarters in New York to adopt the United Nations Millennium Declaration, committing their respective nations to a new global partnership to reduce extreme poverty and setting out a series of time-bound targets - with a deadline of 2015 - that have become known as the Millennium Development Goals. Eight issues were included. These are (i) to end poverty and hunger; (ii) to provide universal education; (iii) to promote gender equality; (iv) to care for child health; and (v) maternal health; (vi) to combat HIV/AIDS; (vii) to promote environmental sustainability; and (viii) global partnership. These aspects of human development are also intrinsically linked to SD.

In India about 400 million children enroll in primary school, about 50% drop out by reaching class eight to support family income, and only 17% study after class 12. Among the weaker sections of the society (scheduled tribe and scheduled caste), the dropout rates are much higher. India accounts for the largest proportion of malnourished children in the world. India exhibits very high variability; on one hand we have high GDP growth rates, a big pool of scientific manpower, a large middle class, malls, global retail chains, expanding multi-millionaires, and on the other hand huge number of people under poverty, unemployment and debt, with limited access to health services and education (TOI 2012).

Sympathizing with the situation does not solve the problem and something beyond sympathizing has to be done. The business group and the people having an assured high income must consider contributing to a fund for national welfare of the deprived people. Besides the Corporate Social Responsibility (CSR) is to be made mandatory. Massive awareness is to be created, and further incentives are to be given for opting birth control options. The population growth in India is to be brought down to less than 1% at the earliest.

HUMAN POPULATION GROWTH

The world population is rising (Table 1) and predicted to reach 9 billion by 2050. Most of the population increase will take place in developing countries and there will be enormous pressure on the resources. The world will face several challenges in health care, food and energy availability etc (Dash, 2012). The demographics of India indicate that it is the second most populous country in the world, with over 1.21 billion people (Census 2011), more than a sixth of the world's population. Already containing 17.5% of the world's population, India is projected to be the world's most populous country by 2025, surpassing China, its population exceeding 1.6 billion people by 2050. Its population growth rate is 1.41%, ranking 93rd in the world. India has more than 50% of its population below the age of 25 years and more than 65% are below the age of 35 years. It is expected that, in 2020, the average age of an Indian will be 29 years, compared to 37 for China and 48 for Japan; (Census 2011). The situation has started creating huge socio-ecological problem, which is to be addressed properly if we like to survive as a nation with dignity.

Table 1. World Human Population Growth since 10,000 B.C. (based on Bhende 2010, www.google.com/population/en.wikipedia.org)

B.C / A.D.	Population (estimated)	Growth (%)	Doubling Time (yr)
10,000 B.C.	5 million	negligible	
5000 B.C.	10 million	negligible	
1 AD	250 million	<0.1	many centuries
1000 AD	350 million	<0.1	
1500 AD	450 million	0.1	
1600 AD	500 million	0.1	1600
1700 AD	600 million	0.2	
1800 AD	1000 million	0.3	200
1900 AD	1500 million	0.5	
1930 AD	2000 million	1.0	130
1960 AD	3000 million	2.0	
1975 AD	4000 million	1.8	45
1987 AD	5000 million	1.7	
1999 AD	6000 million	1.5	
2011 AD	7000 million *	1.3 (India 1.41)	
2030 AD	8000 million		
2050 AD	9000 million**		

* India: >1210 million, Census 2011; ** India : >1600 million

RIO-1992 to RIO+20-2012

After the United Nations Conference on Climate Change (Durban, South Africa) in November-December 2011, the United Nations organised in Rio, Brazil another conference, termed as Rio+20 in 2012. At Rio, 191 countries came together to debate and prepare a consensus document, 'The Future We Want'. Indian effort was for 'common but differentiated responsibility'. Rio Earth Summit-1992 had the buzzword Sustainable Development, which had a link to the Brundtland Commission's 1987 report 'Our Common Future', and in Rio+20 - 2012, the buzzword was Green Economy as a tool for sustainable development goals.

UNEP defines Green Economy as 'improved human well-being and social equity, while significantly reducing environmental risks & ecological scarcity'. Organization for Economic Cooperation and Development (OECD) proposes 25 indicators to define green economy-from biodiversity to measures on the objective and subjective dimensions of environmental quality, leading to greener economic growth and opening new sources of growth. Headline indicators are (i) CO_2 productivity-demand and production based, (ii) non-energy material productivity by material group, (iii) measures of natural resource stock. The essence is using of green technologies in manufacturing and other sectors so that the GHG load to the environment will be substantially reduced to mitigate the effect of climate change. The focus was also on Institutional framework.

GREEN ECONOMY

Besides sustainable development and poverty eradication, the objectives of the conference was (i) to secure renewed political commitment for sustainable development ;(II) to assess the progress and identifying the remaining gaps in the implementation of the outcomes of major summits on sustainable development' ;(iii) to address new and emerging challenges.

The UNEP advocates adopting renewable energy technologies, energy efficient buildings and equipments, low-carbon public transport systems, clean energy vehicles, proper waste management with recycling facilities. Green investments will enhance new sectors and new technologies which will the main resources for economic development and for the future growth. The green economy is the pathway to achieving sustainable development and eradication of poverty. The environment is an 'enabler' of economic growth and societal well-being. Many terms, which are synonyms, are used to explain the concept of green economy. These terms are: Ecological Economics; Environmental Economics, Welfare Economics, Buddhist Economics, etc. The prospects of Green Economy can be summarized as follows:

Protecting and conserving ecosystems and biodiversity, Strengthening the three pillars such as (i) Economic development, (ii) Social development and (ii) Promoting environmental protection, Discouraging unsustainable consumption and practicing sustainable consumption. Green economy, productivity and sustainable consumption are mutually supportive and may require macro and micro interventions that may require change in policy and regulatory framework, investments and business operations. This may induce behavioral change in the society,

Eradication of Poverty:
About 70% of India's population live in villages and about 50% of them depends upon biodiversity such as agriculture, forest products, animal husbandry, fishing and biodiversity based cottage industry for their livelihood. In view of this, biodiversity conservation and management to get value added products for poverty eradication is important. Economic wealth measured in terms of High Gross Domestic Product (GDP) is often linked to overexploitation of resources and causing environmental pollution. Green economy aims to increase to basic services and infrastructure for alleviation poverty and helping in the overall improvement of quality of life.

Green economy and Green Technology should generate employment. New avenues such as renewable energy, new building retrofits for energy efficiency, public transportation, organic agriculture and vermi-technology, reclamation of degraded lands and forests, recycling and reuse of waste materials etc. These practices are expected to provide economic benefit, employment benefit and environmental benefits.

Financial Incentive:.
The green economy policies may involve public-private partnerships as an economic instrument. This may involve public finance and fiscal measures, utilization of public expenditure on productive research and development, inclusion of environmental costs on goods and services, promoting purchange of green products

and services, putting levies on pollution, and providing incentives on tax amount to industries for adopting green technology, strengthening legal framework. Governments can adopt appropriate policies depending upon the capability of the country to promote green investment

Benefits of Green Economy:
It will generate clean environment by minimizing waste generation, reuse, recycling etc, provide security for getting clean water, renewable energy (energy security), change manufacturing philosophy, quality of transportation, and food security etc. For example about 70,000 Mg per year of plastic products are recycled in USA generating about 69 million dollars. In USA recycling of about 6.1 million Mg of urban waste in five years has generated more than 1.6 billion dollars. Recycling of wastes instead of land filling or incinerating reduced about 412,000 Mg of carbon dioxide emission (Paribesh Samachar 2012).

With the background of Rio-1992 to Rio+20-2012, I wish to discuss mainly two issues, namely (i) Energy use, energy security and climate change and where do we stand? and (ii) Food and nutritional security in the context of Indian situation.

ENERGY SOURCE AND USE

Energy is the key for survival, continuance and for sustainable development. There is increased need of energy in the agriculture, industrial and service sectors. Modern way and standard of living demand huge energy from unsustainable consumerism, transport facilities and increased construction work and other aspects of human use. Excessive consumerism (Figure 3) is a factor in global warming and resource depletion. Patterns of consumption, food habits and recycling processes have influenced growth in energy demand and green house gas (GHG) emissions. The specific GHG emissions from food production and processing are much lower in developing countries, including India, than in developed countries.

Solar energy is abundantly available but we have not been able to trap it as per our need because of many reasons. The recent thrust is to utilize the renewable resources to address the GHG load in the atmosphere and environmental degradation.

India's Energy Source

Our energy sources are: thermal- coal and lignite, gas or liquid fuel, diesel, nuclear and renewable such as hydroelectric, and wind (http://en.wikipedia.org).

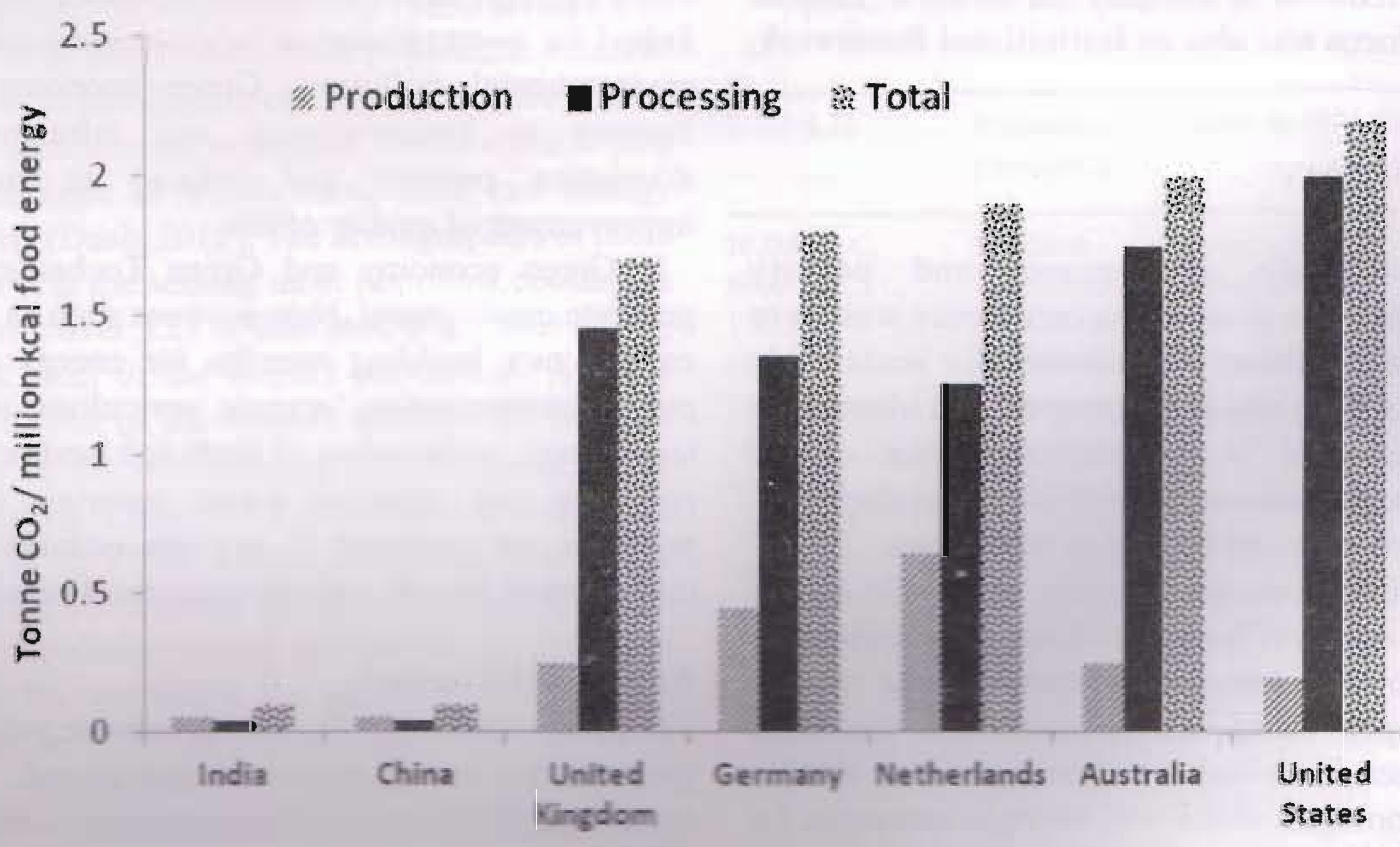

Figure 3. CO_2 emissions from the food sector from field (Production) to table (Processing) excluding cooking (from TERI analysis)

Table 2 Source of energy generating materials and % of total energy consumption (from Dash 2012)

Source of Material	% of the total energy consumed
Coal	42
Oil	24
Combustble Renewables and Waste (including biomass)	24
Natural Gas	07
Wind, Solar, Geothermal, and Hydro-electric	02
Nuclear	01

About 73% of our energy source (about 170,000 MW in 2012) is fossil fuel. Table 2 shows energy consumption in India in 2009 (Dash 2012).

Thermal power plants, especially of coal and lignite based are not environment friendly as these plants generate huge amount of carbon dioxide (green house gas) and pollutants such as SO_2,NOx,COx,SPM, Fly and bottom ash, metallic dust, etc. About 120-150 million Mg of fly ash is generated annually in India (Jain 2010). The ash utilization is only about 40% in cement industries, brick making road construction, forest soil fertilization, and in agriculture etc. Hence it is a huge problem for their disposal.

One estimate (Paribesh Samachar 2010) shows that the pollution load from 1 MW Indian coal based thermal power generation amounts to generation of: ~19 Mg of CO_2 (GHG), >136 kg of SO_2, >7 Mg of fly ash and 60 kg of particulate matter per day. Since about 120,000 MW electricity is generated from thermal source, the annual pollution and carbon dioxide load on the environment is huge; i.e., 832.2 million Mg of CO_2, 5.956 million Mg of SO_2, 306.6 million Mg of fly ash, and 2.628 million Mg of particulate matter. The GHG load and load of pollutants from other industries is not included in this calculation.

About 42,000 MW of renewable energy and nuclear energy are generated at present. There is now a policy shift for energy generation by government of India keeping international commitments as per Durban negotiations and Rio+20. More stress is being given to renewable source of energy, especially solar, wind, biomass gasification and nuclear in 11^{th} plan and 12^{th} plan and onwards for reduction of green house gas emissions, reduction in pollution load and for conservation of resources (Prime Minister's eight missions including the solar and energy efficiency missions 2009). Huge investment is required to harness more renewable energy and nuclear energy. Indigenous technology development and appropriate technology transfer mechanism, collaboration of public sector-private sector etc are required in the present juncture of this transition (CSE 2010).

Energy Consumption in India

Globally, India was the fourth largest energy consumer in 2009 and because of huge population and recent industrialization, the demand has been rising constantly. Renewable such as biomass including agriculture waste constitute 24 % of the energy consumption (Table 2). However per capita electrical energy consumption is only about 700 units per year compared to about 2600 units at international level in industrially developed countries (CSE 2010). The quality of physical standard of living of people depends upon the availability of clean efficient energy. Energy equity', where every human being is assured of sufficient means of clean and sustainable energy services for achieving decent living standards is important requirement for every nation. India has 640 districts, and about 6, 40,867 villages. Out of this, about one lakh villages do not have electricity supply till today. It is expected that during this plan all villages will have electric supply. One estimate (Prayas Energy Group 2009) shows that in India 45 % of population do not have electricity connection at home, 33% use about 50kWh per month, 11% use 50-100kWh and only 1% use > 100kWh of electricity per month (Figure 4). Source of energy use is linked to green house gas generation and climate change.

Bio-Energy (Renewable) Resources

Biomass from agricultural and horticulture produce, agricultural and horticulture wastes after processing can be incinerated under controlled conditions so that energy is produced and GHG emission is reduced considerably. Forestry products are the resources for bio-energy generation. Besides jatropa plantation, neem forestry and algal resources can be used to sequester GHG.

India has 55.37 million ha of wasteland and the total potential area for future cultivation is 32 million ha. Figure 5 shows various types of wasteland in the country with their potential for cultivation (Dash 2012).

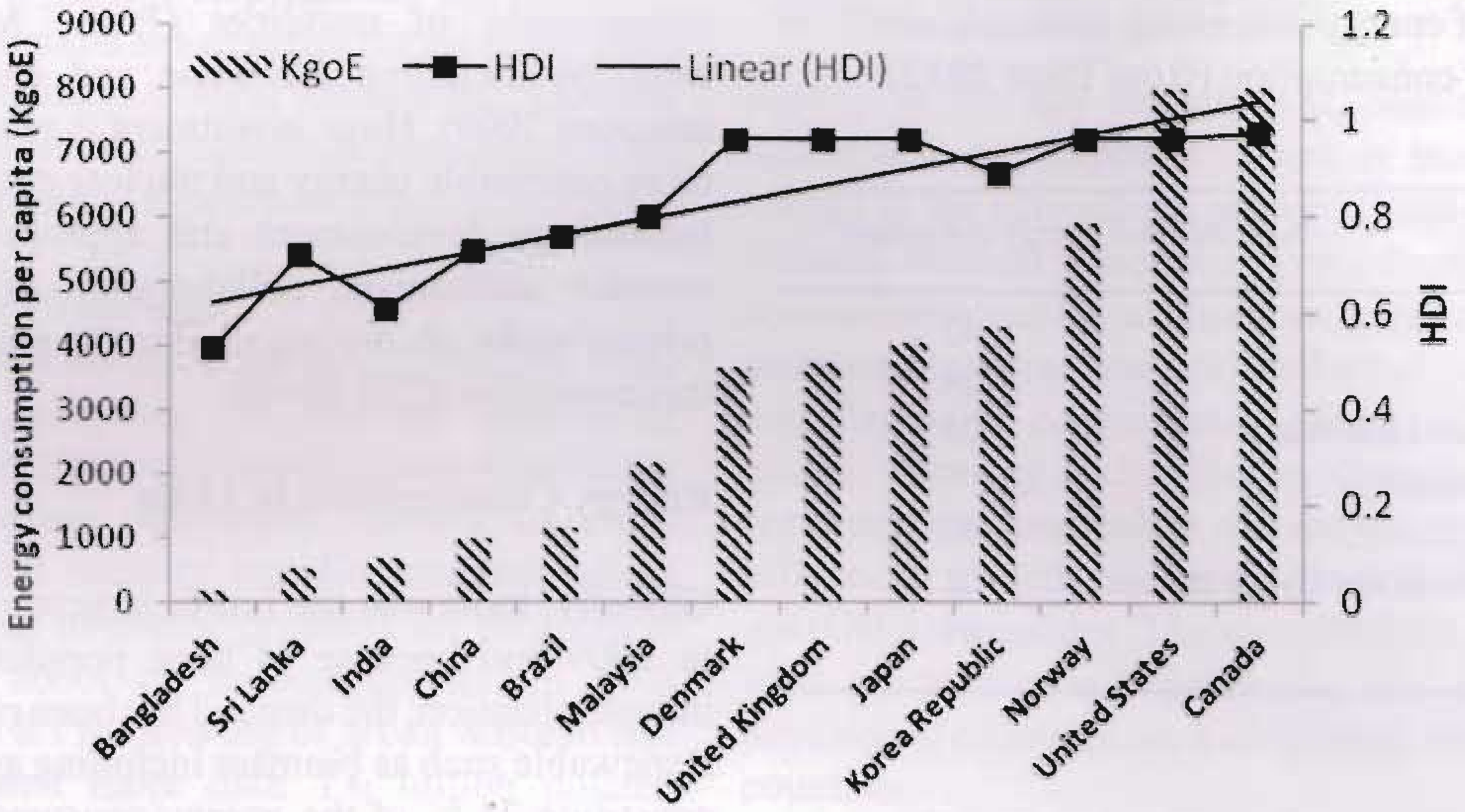

Figure 4. Energy consumption per capita (source: www.google.com)

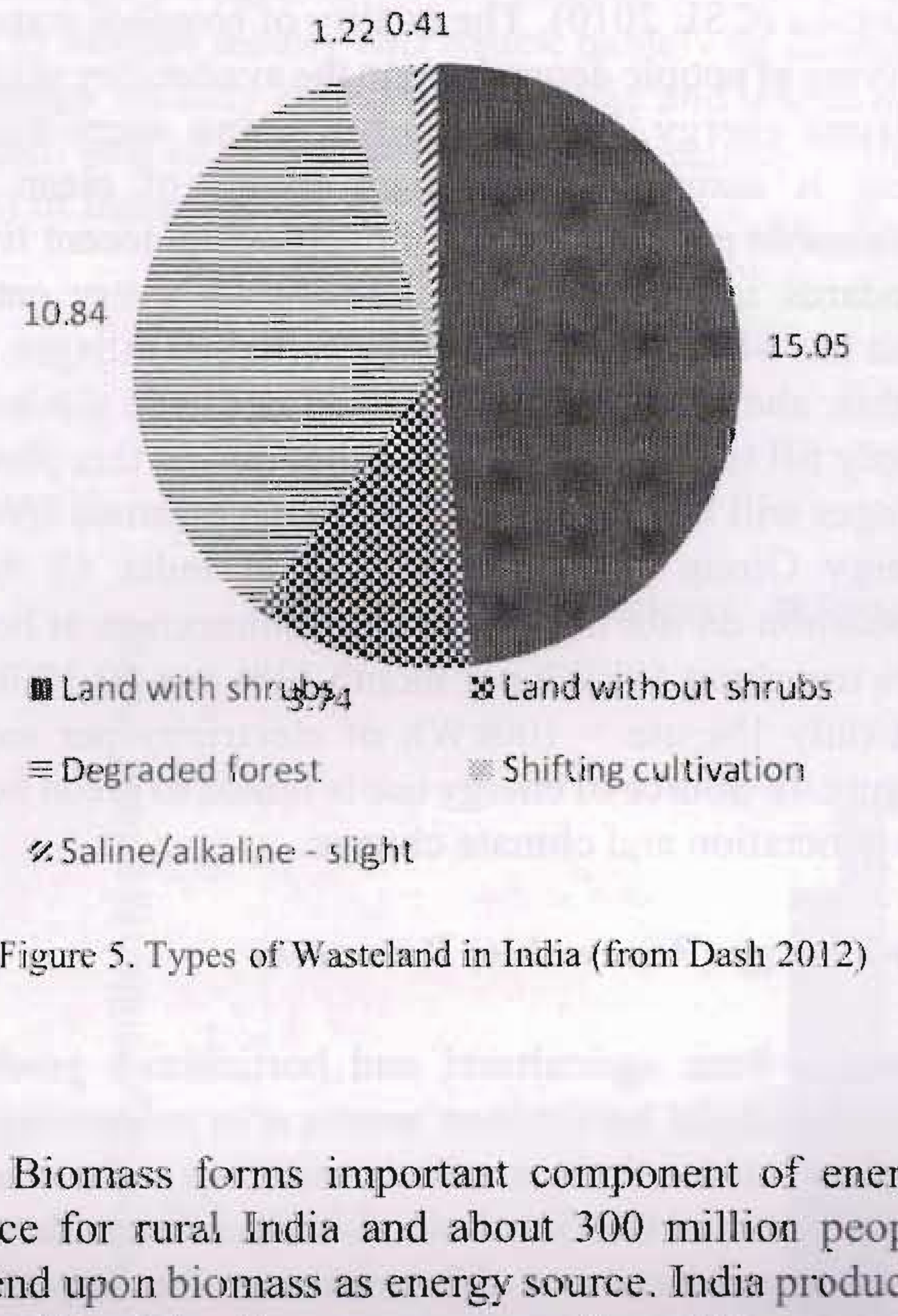

Figure 5. Types of Wasteland in India (from Dash 2012)

Biomass forms important component of energy source for rural India and about 300 million people depend upon biomass as energy source. India produces 300 million Mg of sugarcane annually and Bagasse can be used to produce butanol on a large scale. Biomass energy for rural India project is an US $8.62 million project supported by Global Environment Facility (GEF) through UNDP, India-Canada Environment Facility, Government of India and Government of Karnataka.

This project will provide socio-economic and environ-mental benefits. (Dash 2012). Energy from biomass gasification sources should be vigorously promoted.

Algae can be used as efficient GHG sequesters. Algae require non-agriculral land, fresh water or shallow marine areas (brackish water, saline break water, saline shallow coastal areas etc) for their mass cultivation. Algae are better GHG sequesters than land plants. About 1 million ha of wasteland is available for algal cultivation. Besides the brackish water lake like Chilika can be utilized for microalgae (sea weed) cultivation. Shallow coastal region in east coast can also be used for algal culture and to sequester GHG. Algae can be used for carbohydrate and protein source as cattle feed and for agar-agar preparation. Sea weed(algae) grown in seacoast ponds enriched with thermal power plant flue gas may produce net primary production of 20 g per sq. meter per day ,which amounts to 73 Mg NPP per year per ha(amounts to ~ 438 ton CO_2 per ha per year).These efforts will help to neutralize GHG emissions to some extent. Fresh water algae and soil algae can also sequester GHG. Research in this discipline will be profitable for the country ((Times of India news 2010).

Arresting climate change will require transforming the Indian economy from a high carbon to low carbon and no carbon energy base. High carbon base include coal and petroleum. Low carbon base is corn oil, Jatropa oil, Biomass gasification. No carbon base is: Solar, wind, hydroelectricity, hydrogen and Nuclear. For sustainable development and to prevent climate change, switching over to eco-friendly energy source on a large scale is urgently required to address the call of the earth. This is important for sustainable practices and involves green technology. The alternative energy source should get top priority (solar, wind, biomass-gasification, nuclear etc). In a country with an average of 250 clear, sunny days a year, such systems have proven viable and cost-effective. The efficiency of conversion of sunlight into electrical energy is up to 15-20 percent at the current level of knowledge of photosensitive materials and technologies. New advances in nanotechnology and molecular biology hold the promise of a breakthrough in the future. Powerful new methods of nanoscale fabrication, characterization and simulation – using tools that were not available as little as five years ago – create new opportunities for understanding and manipulating the molecular and electronic pathways of solar energy conversion.

The National Energy Generation Policy

The national policy is now to gradually increase renewable as energy although coal will occupy the main source of energy for few more decades because of our huge deposits. New technology is now available to convert coal to gas and this technology if it becomes cost-effective, will be used in near future South-African Company is engaged in such a project at Talcher, Odisha. At present 42,000 MW of energy is produced from renewable and it is expected that by 2020, this will increase to 70,000 MW. The PM's office has announced that by 2015, India will save about 5% of annual energy consumption and nearly 100 million tonnes of CO2 emissions annually.

CLIMATE CONTROL POLICIES (KYOTO PROTOCOL 1997)

In 1997, the global community met in Kyoto in Japan to work out mechanism for controlling Green House Gas (GHG) emissions. According to the mandate of this Protocol, termed as *Kyoto Protocol*, all countries were grouped into two categories. Those consuming energy above the global average mostly the industrially advanced countries such as European countries, USA, Canada, Japan, Australia, and Russia, are called Annex-1 countries (Developed) and the rest are called Non-Annex-1 countries (Developing). According to Kyoto Protocol, Annex-1 countries were to bring down their GHG emissions to less by 5.2 % average from the base level of 1990 keeping in mind their economic development, population growth, etc. If for some reason they are not in a position to bring down the emission to below 1990 level, they are allowed to go and reduce the GHG emission in the developing countries where the efficiency of energy consumption is also lower and there is a need to consume more energy for ensuring their development. Any reduction made in the specific green house gas emissions can be considered as being reduced in the respective country providing the monetary benefit.

Any organization or industry in the Non-Annex-1 country reducing the GHG emissions can trade those emissions with the Annex-1 countries. The Kyoto Protocol further stipulated that the time period allowed for GHG emission reduction commences from January 2000 and ends up by 2012. The accounting for Annex-1 countries began from 2008 and ends up with 2012 (first crediting period). The C-trading process is controlled by the respective governments and the UNO. To reduce the global warming potential (GWP) from the GHG, industries can undertake any of the following CDM projects: Increase in methane gas (biogas) consumption, Increasing the use of biomass in place of fossil fuel for energy generation, Fuel switching from coal to biomass (biomass gasification), Switching over to hydroelectric power, Energy efficiency projects, Fuel switching from coal to gas, Improving energy efficiency at the user end, Improved Agriculture practices and to increase carbon sink potential(IPCC,2007). This financial instrument of selling GHG emission is called carbon trade under Clean Development Mechanism. Kyoto protocol does not necessarily reduce industrial GHG emissions in the world taken as a whole, although it aids to afforestation and forest conservation. (Dash 2010).

Carbon trading is moving across all the countries in a very rapid way and was expected to involve 1000 billion dollars trading by 2012. Renewable and methane captures are at the top of the list. Size of the project is determined based on the total emissions saleable over accrediting period. Carbon trading was in full swing in many developing countries like Brazil, Mexico, China and India despite the fact that USA did not ratify the Kyoto Protocol. Developed nations, especially USA, Japan and Australia wanted that large economies like China, India, Brazil, and Mexico should take some steps to control carbon emission although they are listed under Annex-2 countries. This was the scenario before 2007 (Vyas 2009, Stefan 2009)

In a series of conferences organized by UNO (Bali

2007, Poznan 2008, Bonn 2009, Copenhagen 2009, Mexico 2010), the outcome was voluntary emission cuts by BASIC countries and retention of Kyoto Protocol. Consultations could yield a political accord not a legally binding treaty. No specific emission targets set for the developed countries. Consensus was to keep temperature rise to below two degrees Celsius by 2050, but no strong commitment was made. Emphasis was on mobilization of financial resources to support reforestation efforts of developing countries.

INDIA'S VOLUNTARY POLICY SHIFT

Considering an annual growth rate of 7-8% in GDP in 2002-2012, the GHG emission from all sources in 2000 in India was estimated at about 1485 million Mg; per capita emissions about 1.1 Mg. This was about 3% of total global emissions. An assessment of the current and projected trends indicate that green house gas emissions grew @ 4% annum during 1990 and 2000 and projected to grow further due to developmental needs. The absolute level will not be less than 5% of global emissions in 2020. (Sharma et al 2006, Shukla 2006, FSI 2009). In India, the estimate was 2115 million Mg of GHG emission in 2010 and >2800-3000 million Mg of GHG emission by 2020. At present the power sector contributes 21.3%, Industry sector 16.8%, Transport sector 14.0%, Agriculture sector 12.5%, Fossil fuel retrieval, processing and distribution 11.3%, Residential, commercial and other sources 10.3%, Land use and biomass burning 10.0% and water disposal and treatment 3.4% towards annual GHG emissions in the world (Patro 2012, based on www.worldwatch.org).

The forest conservation policy of the Government of India stipulates to conserve 33% of the total land area of the country under forests to increase the GHG sink. Indian Prime Minister's council on climate change has approved eight missions under India's National Action Plan on Climate Change :(i) achieving energy efficiency; 'Perform, Achieve and Trade' (PAT) mechanism, (ii) promoting Renewable energy; (iii) promoting sustainable development especially through clean technology development and transfer, (iv) promoting afforestation, and enhanced forestation to increase sink factor (v) promoting sustainable agriculture. The PM's Office has announced that by 2015, India will save about 5% of annual energy consumption and nearly 100 million Mg of CO_2 emissions per year. The National Solar Mission has approved enhancement of solar energy generation. These actions indicate India's concern and positive voluntary actions.

Tables 4 and 5 show the forest and tree cover in India and its different regions reflecting the terrestrial potential sink for the GHG CO_2 in India.

Table 4. Forest and tree cover of the country in 2009 (FSI 2009, 2011)

Class	Area (M ha)	% of Total Area
Forest Cover		
VDF (very dense forest)	8.3471	2.54
MDF (medium dense forest)	32.0736	9.76
Open Forest (OF)	28.782	8.75
Total Forest Cover	69.2027	21.05
Tree Cover	09.28	02.82
(Tree patches <1ha with canopy density >10%)		
Total Forest and Tree Cover	78.48	23.87
Scrub	04.2176	01.28
Non-forest	255.306	77.67
Total Geographical Area	328.7263	100

Notes: 55.51 M ha lies at <1000 m, 11.67 M.ha >1000 to 3000 m, and 1.91 M.ha >3000 m altitude. Conversion of OF to MDF and MDF to VDF will increase the canopy cover and CO_2 sink.

Table 5. Region wise distribution of forest cover in India

Region*	Geographic Area (km^2)	Total Forest Cover	% of GA	Scrub
South (5)	6, 36,263	1,18,284	18.59	14,891
North (9)	7, 72,644	83,126	10.76	4,561
West (4)	8, 49,676	80,205	09.44	10,272
N-East (8)	2, 62, 179	1,73,182	66.05	919
South East (3)	3, 24,153	82,060	25.32	5,544
Central (2)	4, 43,436	1,31,878	29.74	2,263
Islands (4)	8,884	6,883	77.48	03
Total	3,287,263	6,77,033	20.60	38,475
Current (2009-2011) (21. 05FC+2.82TC=23.87%FCandTC				

Note: Industrial and transport emissions are heavy in south, west, south-east, central regions but the forest cover (sink factor) are very less. This requires special effort for protection of natural forests, afforestation etc.

GHG Estimate as per FSI Report (Based on satellite data)

It has been estimated that the CO_2 removal by India's forests and tree cover was enough to neutralize 9.31%-9.50% of India's total emissions (CO_2 equivalent) at 2000 level of emissions. In 2000 India's level of emissions was estimated at about 1454-1485, million tonnes (Sharma et al. 2006, Shukla 2006)). Thus 9.31% of 1485 amounts to 138.25 million Mg. It appears 78.48 million ha of forests of all categories absorb 138.25 million Mg of GHG per year amounting on the average of 1 ha of forest and tree cover neutralizing 1.76 Mg CO_2 per year (FSI 2009, Kishwan et al. 2009, Melkenia 2009). They also estimated that the C-load in the atmosphere would increase further because of accelerated developmental process and the removal by forests in 2010 and 2020 would be respectively 6.53% and 4.87% of our projected annual emissions. This is a gross estimate and the site specific estimates would be different. Although the national mandate is to have 33% of the total land area on forests, but none of the regions except North-East and Islands meet that mandate. South-East and Central regions are close to the mandate of 33%. It is very clear that the GHG absorption potential of forests is not adequate and it will require considerable effort by the country to fulfill the mandate in a reasonable time. However, the average GHG absorption value appears to be an underestimate as it does not differentiate the rate of primary productivity on an altitudinal gradient, type of forests, the succession stage of the forest and the ground vegetation.

There are other field methods such as Net Primary Productivity Estimation methods used by ecologists and estimation of CO_2 absorption by 1 ha of forest- plants by NPP methods, which give much higher value (5.12 Mg to 12 Mg per ha per year) than the estimate made in FSI report (Dash 2010, Behera and Mishra 2012). But these studies show the importance of forests and tree cover and the urgent need to increase forest and tree cover in India. The grasslands, scrub lands, crops also neutralize GHG and this has not been estimated separately. The other GHG sinks are soil, water bodies and planktons in the water bodies including Bays and Oceans.

Kishwan et al (2009) have also estimated component-wise carbon in India's forest biomass and in soil in 1995 and 2005. The total estimate for 2005 was 3755.811 million tonnes of carbon in soil amounting to 55.4723 Mg per ha. The total estimate amount of carbon in forest above ground biomass was 2865.739 million Mg amounting to 0.3310 Mg C per Mg biomass and 42.32 Mg of carbon per ha of biomass. Over the last two decades, the national forestry legislation and policies have transformed India's forests into a significant net sink of GHG (FSI 2009) (Table 6, Figure 6). The carbon stocks stored in country's forests and tree cover and soil have been estimated as 6,621.55 million Mg in 2005 with an annual increase of 38 million Mg.

Table 6. Soil Organic Carbon (million tonnes in 2005) pool Estimates (0-30cm) in India's Forests (Based on Kishwan et al. 2009)

Forest Type (Group)	Total SOC (million Mg) 1995	2005
Himalayan dry temperate forest	1122.144	1158.343
Himalayan moist temperate forest	159616.937	175149.168
Littoral and swamp forest	27216.904	34181.021
Montane wet temperate forest	298233.293	299387.893
Sub alpine and alpine forest	149698.375	153105.661
Sub tropical broad leaved hill forest	22518.833	26243.102
Sub tropical dry evergreen forest	79836.780	81468.766
Sub tropical pine forest	229031.601	238432.151
Tropical dry deciduous forest	623475.447	655037.332
Tropical dry evergreen forest	7021.363	8645.709
Tropical moist deciduous forest	1270222.177	1335848.398
Tropical semi evergreen forest	140549.907	160925.000
Tropical thorn forest	32681.741	37225.399
Tropical wet evergreen forest	511078.124	549003.366
Total	3552303.628	3755811.310

Soil faunal biodiversity on the average account for 2 to 4 Mg of biomass per ha (Dash and Dash 2008, Dash et al 2009)) amounting to about 1.2 to 2.4 Mg Carbon per ha.(mean = 2 Mg C per ha) (Table 7).

The carbon dynamics (Figure 7) is linked to the activity of soil biodiversity functioning, which is very important in many Indian land uses. There is need of popularizing the concept that forests and soil bio-diversity are important C-sinks and they are to be protected, regenerated, and afforestation is to be practiced.

It appears 78.48 million ha of forest with 12% tropical evergreen category, 34% tropical moist deciduous, 30%tropical dry deciduous, 5% tropical thorn, 6% sub-tropical pine, and 11% Himalayan temperate category and tree cover could neutralize 138.25

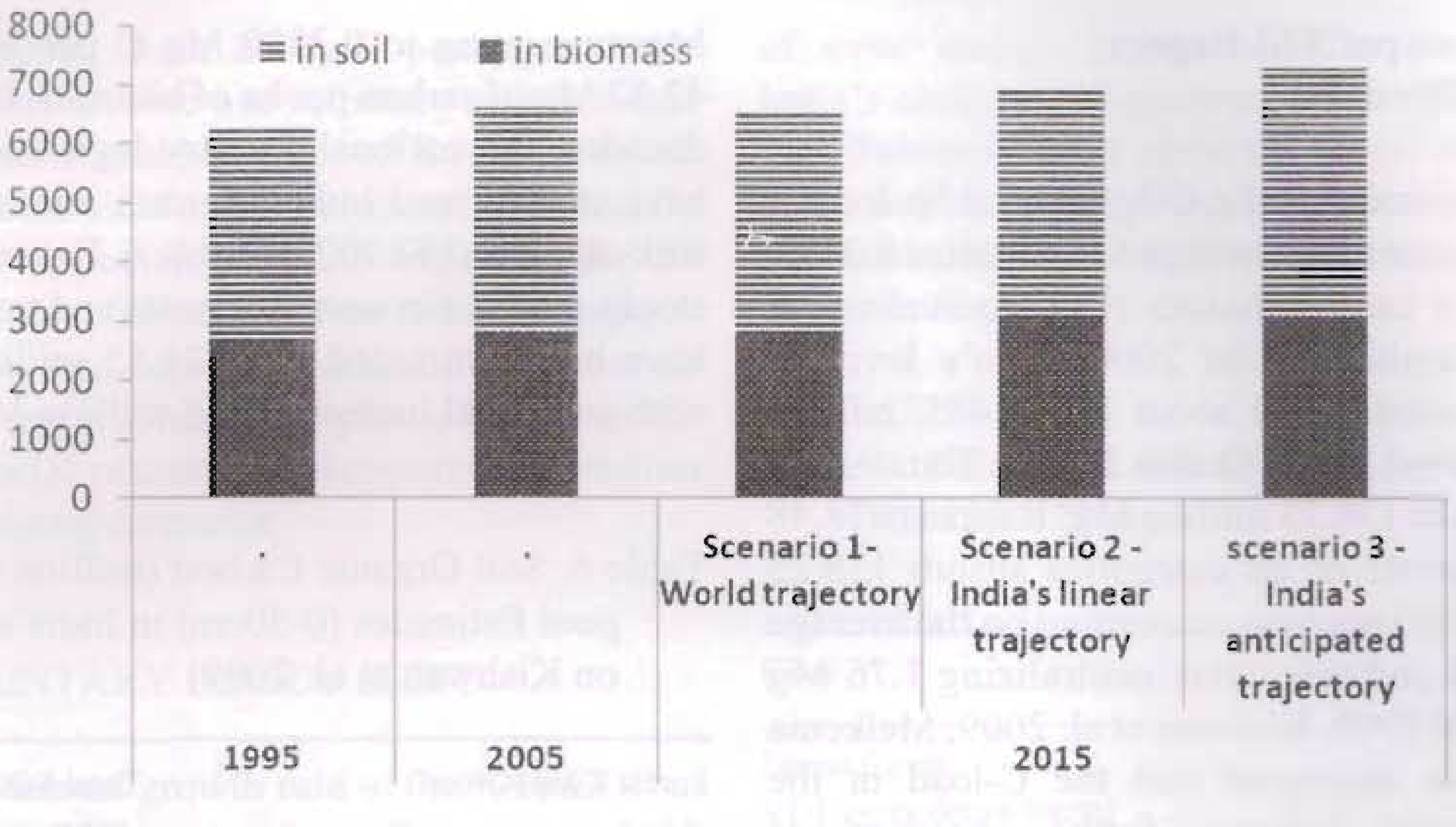

Figure 6. Soil Carbon in Indian Forests (Kishwan et al 2009)

Table 7 Estimate of Soil Biodiversity Carbon in India (mean= 2 Mg C per ha)

Forest Type	Total Soil Biodiversity C Mg ha^{-1}, 2005	Area ha
Himalayan dry temperate forest	32	64,000
Himalayan moist temperate forest	2447	48,94,000
Montane wet temperate forest	2593	51,86,000
Sub alpine and alpine forest	2067	41,34,000
Littoral and swamp forest	481	9,62,000
Sub tropical broad leaved hill forest	303	6,06,000
Sub tropical dry evergreen forest	1248	24,96,000
Sub tropical pine forest	4743	94,86,000
Tropical dry deciduous forest	19156	3,83.12,000
Tropical dry evergreen forest	165	3,30,000
Tropical moist deciduous forest	24284	4,85, 68,000
Tropical semi evergreen forest	2946	58,92,000
Tropical thorn forest	1827	36,54,000
Tropical wet evergreen forest	5414	1,08,28,000
Total	67,706	13,54,12,000 (135.412 million Mg)

million Mg of GHG per year amounting on the average to 1 ha of forest and tree cover neutralizing 1.786 Mg of GHG per year (FSI Report 2009 2011 Kishwan et al. 2009, Melkania 2009) . Dash (2010 a) has compared the green house gas emission from main industrial sources and the forest cover and assimilatory potential of GHG for Orissa forests by using data of Shukla 2006 and Sharma et al 2006 and by primary productivity methods. Dash (2010) found wide difference in GHG assimilation in two methods. Behera and Mishra (2012) estimated C-sequestration in a 5-year old and 10-year old reclaimed vegetation (plantations) from growth data and found that the annual increment in biomass C per ha amounted to 2.79 Mg which amounts to C-sequestration of 10.23 Mg CO_2 per ha.

However, in recent times the loss of forest area is attributed to fragmentation (Behera and Mishra 2010) due to anthropogenic activities such as road construction, electric transmission lines, mining, river valley projects, conversion of forest land to other purposes etc. Fragmentation brings host of other problems like canopy loss, increase in peripheral areas etc. A study was made by the School of Life Sciences, Sambalpur University, on the effect of fragmentation (Figure 8) in a very dense forest area of Hemgiri, Sundergarh district of Odisha (Figures 9a and b). The forest in Hemgiri-Sundergarh is the resource base and life supporting zone of the tribal people who live there. Due to coal mining, and heavy transportation the forest tract in recent time has been disturbed. This interference has led to fragmentation of large corridor of natural forest into smaller patches. The small patches are usually more accessible due to increase in its edge. There is also other biotic pressure.

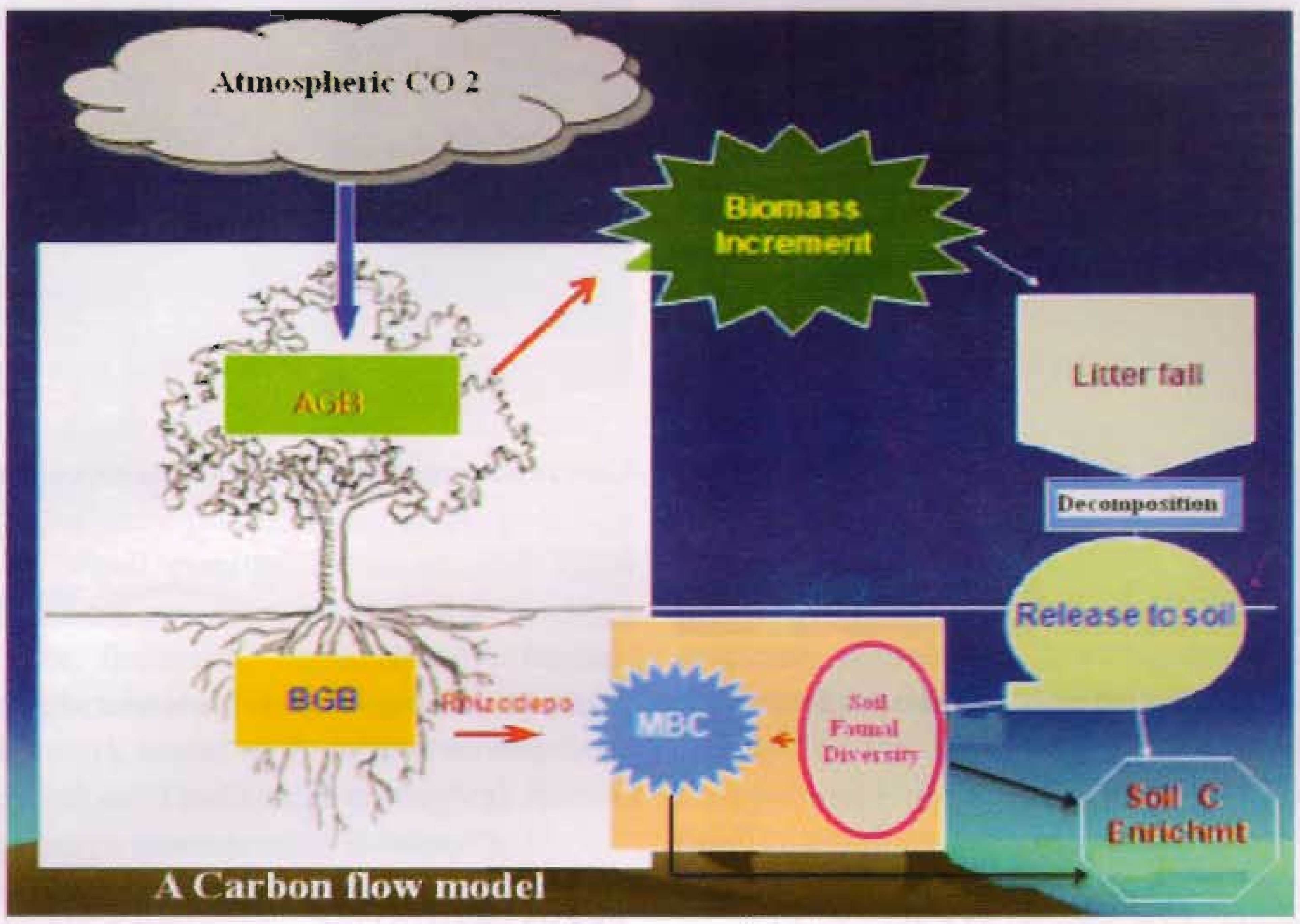

Figure 7. Carbon flow model in the soil system

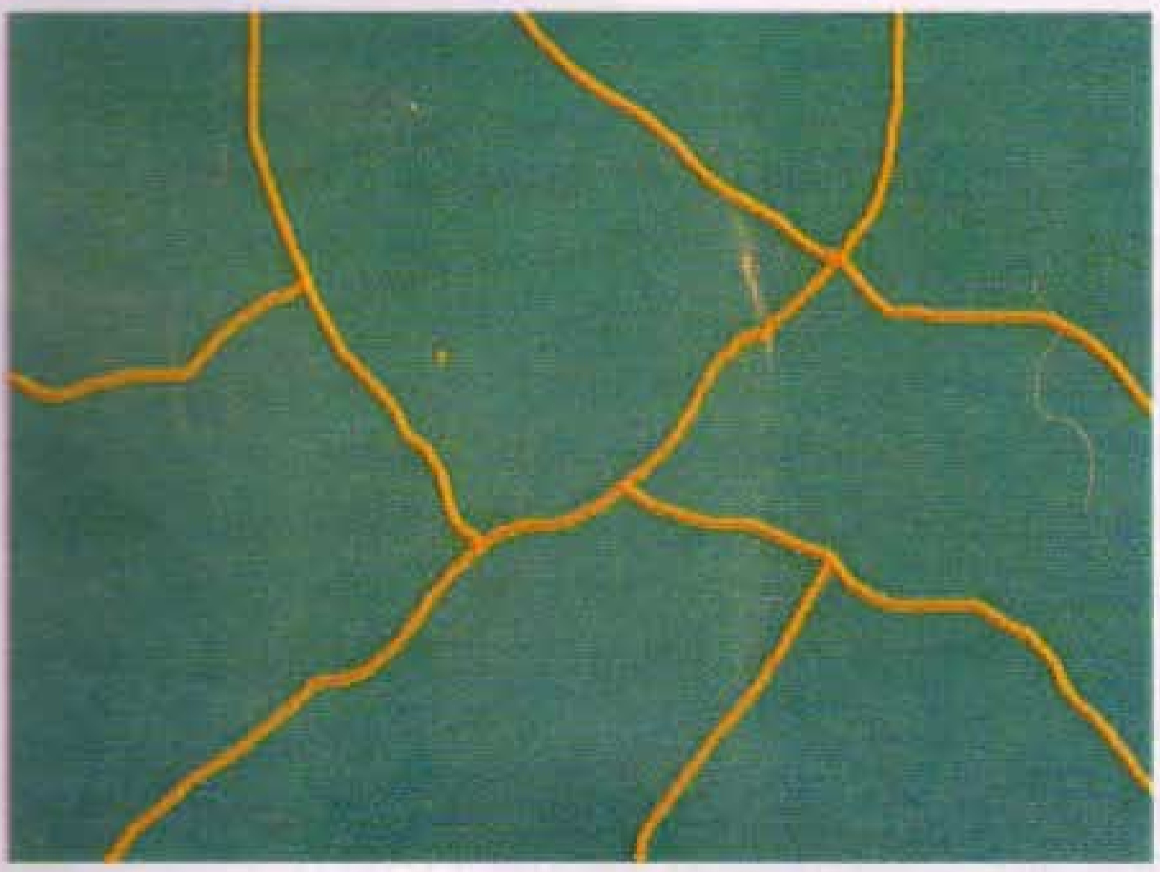

Figure 8 Forest Fragmentation

Table 8. Ecological characteristics of the core, periphery and edge of the forest

Characteristics	Forest Core	Periphery	Forest Edge
Mean Tree Density (No. ha^{-1})	2500	1700	1000
Shannon-Wiener Index	2.65	2.5	2.3
Total Basal Area (Trees) (m^2 ha^{-1})	32	10	06

Such disturbance has exerted adverse impact on the distribution, composition and association of constituent species. Figure 10 shows changes in tree association in core, periphery and edge of these patches. This change has affected the canopy cover and thereby the GHG sink potential. There is also a change in ecological characteristics (Table 8) with regard to total basal area of trees, species diversity and other parameters (Behera and Mishra 2010). The canopy cover of *Diospyros-Buchanania-Butea* association is not as dense as that of *Shorea-Pterocarpus-Terminalia* association.

CORE

Shorea-Pterocarpus-Terminalia

▼

PERIPHERY

Shorea-Terminalia-Diospyros

▼

EDGE

Diospyros-Buchanania-Butea

Figure 10. Plant associations have changed in core, periphery and edge of the forest

Figure 9a. Dense forest with closed canopy of Hemgiri, Sundergarh district

Figure 9b. A disturbed forest (peripheral site) of Hemgiri, Sundergarh district.

Regulatory Aspects

In India, thermal power from coal based plants is the most important energy source. However coal based thermal power plants are GHG emitting and pollution generating plants. Many mega thermal power plants operate in India and many are in the pipeline. It is the right time to debate whether the EIA document should give importance to the carbon foot-print and GHG emissions of industries that plan to set up thermal power plants and mineral based plants in particular and all industries in general. Besides environmental discipline in the society is call of the time. In view of this everybody should try to reduce the carbon foot print while moving, at work and at home. In recent time the development issues and environmental protection issues have created conflicts. Since natural resource (mineral) maps are usually not considered while taking decisions on wildlife conservation, this has created serious conflicts for their conservation and for creating wildlife corridors and for mining activities. Mineral resources are essential for industrialization and development. Biodiversity, especially forests and wildlife are also very important for many reasons and for livelihood options of a large section of the people. In view of this very judicious decision considering cost-benefit analysis, ecosystem services analysis and long term benefits should be taken. Political and other considerations should be kept aside. Ecotourism should not be allowed in core areas of PAs.

FOOD SECURITY

In 2011 the global population reached 7 billion. India's population reached 1.21 billion with annual growth of 1.41 per cent. The global population has been estimated to reach 9 billion by 2050 and India's population will reach 1.6 billion. It is obvious that there will be huge demand on resources, especially on food. The 'Green Revolution' of 1960s helped India to overcome chronic shortage of food and reduced hunger. Based on FAO report (FAO 2008b,d), a recent report of Government of India and Association of Biotechnologist led Enterprises (Dash 2012) has revealed that the number of people who do not have food security increased from 800 million in 1998 to 1 billion in 2009 in the world because of rise of food prices from 2006 to 2008. In India about 25% people are classified as Below Poverty Line (Census 2011). It means about 360 million people do not have food security.

Dash (2012), quoting FAO report (2008d), mentions that in recent times the dietary preferences change in developing countries and because of population rise and changed lifestyle, there will be 50% rise in cereals and 85% rise in demand of meat products between 2000 and 2030 and the food demand will double by 2050 putting enormous pressure on land, water and energy require-ents. Indian census (2011) finds that about 69% of India's population (about 800 million) lives in villages. About 40-50% of them depend upon biodiversity such as agriculture, forest products, animal husbandry, fishing and biodiversity based cottage industry for their sustained livelihood. Hence, biodiversity conservation and management to get value-added products are important for poverty eradication (Dash 2010). The livelihood options and rural economy are largely bio-resource-based, especially on agriculture and horti-culture (crops and fruits) as farmers, marginal farmers, labourers etc, home garden raising vegetables, fruits, flower and selling in the local market; keeping local breed cows and buffaloes for milk, dung, ploughing; catching fish, prawn, turtle, from local river, rivulets, common property ponds, own ponds; goat for meat, milk, skin; small poultry for meat and egg; keeping pigs for meat, and skin; using local forests/ Gramya Jungle for firewood, fruits, honey, herbal medicine, plucking kendu leaf for making bidi (a type of cigarette); artisan work based on bamboo, cane, wood and other bio-resources. Traditional ecological knowledge and bio- resource management is important.

Food grain production in India increased from 95 million Mg in 1967 and 108 million Mg in 1970s to 234 million Mg in 2008 and to about 250 million Mg in 2011 (Prasad 2009, TOI 2012). Total crop production and yield has increased considerably and has met food requirement of the people but considering the fact India's population is growing @1.41 %, crop production has to be doubled for future requirement. Another green technology based green revolution is needed. However the yield varied from 1 Mg ha^{-1} in 1967 to 2.13 Mg ha^{-1} in 2011 for rice, 1.1 Mg ha^{-1} in 1967 to 2.9 Mg ha^{-1} in 2011 for wheat, 1.1 Mg ha^{-1} in 1967 to 1.9 Mg ha^{-1} in 2011 for maize, 0.5 to 0.6 Mg ha^{-1} for pulses (Prasad 2009, en.wikipedia.org/wiki. Agriculture_in_India). The arable land area has increased from about 120-122 million ha to about 159.7 million ha and the irrigated crop area is about 82.6 million ha. At present agriculture account for 16% of GDP and 10% of export earnings (Ayyappan 2012, Orissa University of Agriculture and Technology Convocation Address)

Agriculture continues to be the largest sector in terms of employment, largely to the unskilled people as labourers. However the contribution of agriculture sector to India's GDP has fallen from 30% in 1990-1991 to 14.5% in 2011-2012 (Dash 2012) indicating that the economy is changing from agrarian to other sectors. Agriculture remains for sustenance and livelihood largely for the rural people. The income from these occupations is subsistence level and does not meet the family requirements fully. To meet the challenge, agricultural productivity has to be increased and food should be available at affordable prices in India. The option of converting more forest area for agriculture is not available as there is serious constraint of forest land area (Figure 11, Dash 2012). Further conversion of forest area to agricultural land will create ecological backlash. Only solution is to increase the crop production through technology application and switch over to those Genetically Modified (GM) foods, which have stood the rigorous scientific testing and protocol and declared as safe for human consumption.

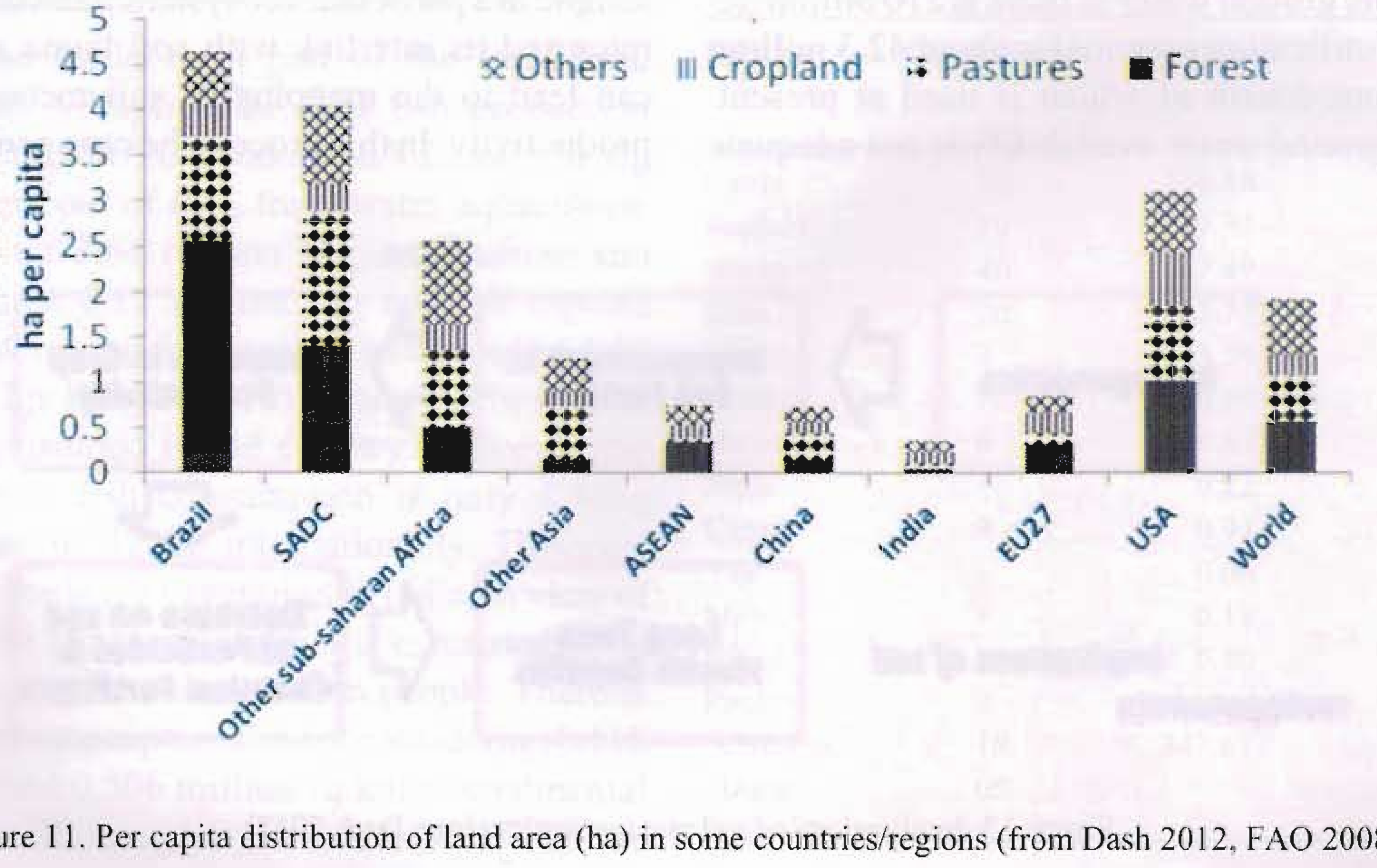

Figure 11. Per capita distribution of land area (ha) in some countries/regions (from Dash 2012, FAO 2008)

Considering India's forest cover and land area, it will not be sustainable to convert forest land to crop land. Only option is left to apply green technology and adopt population control measures. Biotechnology enabled the global increase in corn and soybean production by 130 million and 83 million Mg, respectively (Dash 2012). Dash (2012) points out that biotech can improve agricultural production by promoting the use of disease resistant crops, enhancing the flavour and nutritional value of food products and subsequently impact global health and economies, especially among developing countries.

Water Availability for Agriculture

Of the total water used in India, agriculture is the most dominant users of water resource. About 50 to 60% of water resource is used for irrigation (Patnaik 2006). Both surface and ground water is used for agriculture. India receives annually about 1050 to 1170 mm of precipitation. This is a huge water resource but almost 90% of this precipitation falls between mid-June and mid-October. Fourteen major river systems account for 85%of surface flow and share 83% of the drainage basin. They serve 80% of the total population. There are about 100 medium and minor rivers. The storage capacity is only 3.65 million m^3. Of the total annual precipitation, India utilizes only 10-15%, which may increase to about 26% by 2025. We need to apply improved technology to increase water harvesting and storage capacity and ground water utilization.

The Central Ground Water Board has estimated that the available ground water in India is 210 billion m3 and the annual utilization potential is about 42.3 million hectare, only one-fourth of which is used at present. However, the ground water availability is not adequate in provinces like Tamil Nadu and Andhra Pradesh and excessive ground water use (unsustainable use) for agriculture in Punjab, Haryana, Delhi and Rajasthan has depleted ground water resource. More than 26 cubic miles of ground water vanished from aquifers in these states due to excessive agriculture use and may bring collapse in agriculture production unless remedial measures taken on priority basis (NASA satellite data-Yahoo internet news dated 14 August 2009).

Adequate ground water recharge and shifting to non water intensive crops are important to address the problem. Due to large scale deforestation and monsoon failure, there is a regular occurrence of drought in Kalahandi district and some other districts of Orissa, in Jharkhand, Bihar, Karnataka, Rajasthan, and Maharashtra. The supply of drinking water in Indian villages is not adequate, especially in summer. There is no organized water supply in most of the villages and even in some small towns.

Although there is good precipitation in India, sufficient care is to be taken to manage this water efficiently. The climate change has brought irregularity in incidence of monsoon rains and amount of rain fall has also become erratic. In view of this water storage facility should be created to harvest more water. Diversification crops are also required. Crops requiring less water for production should be chosen.

Soil Metagenomics

Soil Metagenomics (Figure 12) involves the analysis of a mixture of microbial genomes isolated from a soil sample in a particular ecosystem/habitat. Soil Metagenomics and its interlink with soil fauna and soil fertility can lead to the mapping of soil metagenome to crop productivity. In this process the crop productivity can be

Figure 12. Implications of soil metagenomics (from Dash 2012)

increased by scientifically manipulating the soil metagenome without extensive utilization of pesticides and chemical fertilizers. Metagenomics studies can also improve the nutritional benefits of food crops; which will have a positive impact on public health (Dash 2012).

Soil faunal biodiversity has important role in many land uses and for crop productivity (Dash et al 2009).Studies on Soil biodiversity carried out in a project funded by UNEP-TSBF, Nairobi in multiple centres in India coordinated by Jawaharlal Nehru University from 2002-2010 have provided insight to the role of soil biodiversity, especially earthworms and soil fauna in variety of land uses (Dash and Saxena 2012). ICAR National Fund for Basic, Strategic and Frontier Application Research in Agriculture had initiated a study of the dynamics of soil Metagenomics with participation of IARI, GB Pant University of Agriculture and Technology, and Tamilnadu Agricultural University (Dash 2012). M S Swaminathan Research Foundation has developed a biodiversity conservation model called the '4C Model' that takes care of conservation, cultivation, consumption and commerce requirements for crop plants. This model involves Gene-Seed-Grain Banks that help scientific selection and preservation of good seeds from land races (Dash 2012).

Soil Metagenomics and soil faunal studies in situ and ex situ should thrust areas of research so that the findings can be applied for increasing crop productivity to meet the challenges of the future.

Animal Protein

Fish, prawn, and turtle form part of the livelihood support in Indian villages. The total fish production (capture and culture) in India was about 8.29 million Mg in 2010-2011, and out of this, fresh water aquaculture amounted to about 3.84 million Mg, mariculture and coastal aquaculture 0.15 million Mg and the capture fishery (both marine and fresh water) amounted to 4.30 million Mg (Dilip Kumar 2012). About 90% of fish production is consumed in the country. However the average per capita fish consumption is only 5.48kg compared to that of 12 kg internationally. However about 30-40 % people are vegetarian in India. In view of this the per capita fish consumption is estimated to be around 9kg among the non-vegetarian people. There is good scope to increase capture fishery considering 8,118 km of coastline and 0.506 million sq.km of continental shelf and 2.03 million sq.km of Exclusive Economic Zone (upto 22m depth). The area under ponds, tanks, beels and fresh water lakes etc amounts to about 3.42 million hectare. The current average aquaculture production is 600 kg ha^{-1} yr^{-1} and this yield can be increased considerably with innovative technology and management input. There is need of renovating village ponds for water harvesting and fish culture on priority. Rice-fish integration systems, cage culture etc are innovative systems, which should be widely practiced. The length of rivers and canals is 1,71,334 km. The cleaning of rivers and canals for fish culture will boost the village economy. Serious efforts are to be made using modern technology to increase the production to maintain at least 10-12kg of per capita consumption even if the population grows to 1.6 billion by 2050.

The animals (Table 9) are important for providing protein rich meat, milk and organic manure for agriculture, dung-fuel for rural homes, and by-products like bone meal etc as manures etc. However with reduction in grazing land and monetary constrains for stall feeding by the small and marginal land owners, government subsidy helps the farmers and the rural economy. But this is not the permanent solution. India has >483 million livestock; about 187 million cattle, 97 million buffaloes, 62 million sheep, 120 million goats, 14 million pigs, 1 million horses and mule, 1 million camels, and 1 million other livestock (Table 9). These

Table 9. Animal Resource of India (GOI 2005, Khillare et al. 2012)

Species	No of Breeds	Population1997 (million)	Population2003 (million)
Cattle	30	198.88	187.38
Buffalo	10	89.92	96.62
Sheep	40	57.49	61.79
Goat	20	122.72	120.10
Pig	3	13.29	14.14
Donkey	-	0.88	0.67
Horse	6	0.83	0.79
Mule	-	0.22	0.31
Camel	9	0.91	0.64
Yak	-	0.06	0.07
Mithun	-	0.18	0.28
Rabbit	-	0.40	
Poultry:			
Chicken	18	347.61	440.70
Duck	05		

animals provide meat, milk and produce a huge quantity of dung, which is utilized for biogas production. Besides 440 million poultry chicken are also available.

Indian leather industry includes 125 medium and large scale units, 1200 small scale units and thousands of tiny tanneries in rural areas. Hides and skins are terminal markets. The states of Tamilnadu, Uttar Pradesh and West Bengal account for more than 80% of country's leather output.

Animal resource forms an important part in food security, especially for protein security and livelihood options for weaker section of the society. Fish and livestock yield can improve over all food security in India and income for rural people. Women are largely form the work force in animal farms and hence this sector helps in women empowerment through financial security. Marginal and small land owners are the owners of 71% of cattle, 83% of buffaloes, 88% of small ruminants, 70% of pigs and 74% of poultry (government of India-publication 2005). In view of this the village livelihood sustainability is dependent on animal resources. The live-stock contributes about 25% of the agro-sector of the country in terms of money. This is the important sector for scientific research to increase the milk, egg and meat production. There is good scope to enhance this production and other welfare measures are required. Genetic selection of animal breeds, feed and nutrition aspects, health and disease aspects and opening of veterinary dispensaries and hospitals in villages are the priority areas.

A CASE STUDY

In a case study involving ten districts of Odisha, the livelihood options, (Table 10) environmental sustainability and pollution aspects (Table 11) were reviewed (World Bank Sponsored Project) and the data are presented below.

Environmental Impact Assessment (EIA)

Since 1994 EIA study has become mandatory for all new projects or expansion or modernization of existing projects which have substantial stake on environment. As per 14 September 2006 notification of Ministry of Environment and Forests of Government of India, and subsequent amendments, the generic structure of environmental impact assessment document and check list of environmental impacts have been stipulated. The purpose is to assess the expected impacts and to address them through an environmental management plan if the developmental project is allowed to operate. The check list includes land environment, water environment, vegetation, fauna, air environment, aesthetics, and socio-economic aspects, building materials, energy conservation and environmental management plan. The check list is a reflection of livelihood options prevailing in rural India. However there is a big gap between the EIA stipulations and implementation. The sustainability concerns of Indian rural systems have not been adequately addressed. The interest of multinational companies and industrial houses of the country have received more attention than the natural resource management or furtherance of traditional livelihood options conserving the 'traditional ecological knowledge' available in village systems. Ramakrishna (2009) points out emphatically that 'very traditional societies living close to nature and natural resources around them may have to have traditional ecological knowledge being brought in to a much larger degree so as to avoid social disruptions setting in, compared to the more modern societies who may need traditional ecological knowledge only to be brought in so as to create buffering mechanisms within the socio-ecological system and thus cope up with the ill-effects arising from excessive use of energy-intensive technologies.'

My understanding is that sustainable development in Indian rural systems depends on creating facilities to enhance the existing livelihood options, adopting effective community participatory approaches, and sustainable management of bio-resources. However, this does not prevent opening of new avenues which will have minimum environmental impacts and can be addressed by application of green technology and will create livelihood options for youth. This is the time to strengthen the EIA protocol and its judicious implementation to address environmental uncertainties and to conserve bio-resources based traditional ecological knowledge and rural livelihood options of about 360 million people in the country.

Environmental Aspects

Most of these livelihood options cited above have some environmental liability for people and these are never addressed in Indian situations.

Table 10. Livelihood support in Odisha villages (Dash 2007, 2008)

Social Category	Bioresources Used	Issues
Landless and Wage earner: predominately SC and STs, financially weaker section (Other Backward Classes etc)	Forest, and forest products, Domesticated goat, poultry, Rivers, Nallas for fish and depend on upper-class/government/ Private project work for wages	Food security, lack of provision for health issues, largely depend upon community common- property bioresources
Marginal and small farmers (Financially weaker section) (usually with <1 acre land)	Cannot survive on land alone, non-monsoon time-depend on common-property bioresources, domesticated goat, cow and poultry	Unable to harness benefits because of small holdings, and lack of adequate water resource/irrigation and above cited issues
Ecosystem Dependent people (Forest dependent communities, Fishing communities) (Tribals, Fisherfolk)	Fully bioresources based livelihood, Home garden, Animal rearing etc.	Seasonal unemployment, Exposure to risks, Income variable, Accident/health risk- can not afford insurance
Displaced people due to industrialization	Bioresource,Employment, Entrepreneurship etc	Loss of land and livelihood, unable to adjust to new livelihood options and new homes etc.
Widows, Destitute, Persons with disability, Disaster affected	Bioresources(Community common-property based),Domestic help,	Unable to cope with problems, Food security, Health security, Identity crisis
Artisans	Bioresources (bamboo, cane, wood etc)	Finance, Marketing etc
Miscellaneous (small %)	Employment, Small Business,	Health issues and other problems

Table 11. Environmental Liability of Livelihood options in villages

Environmental Stress	Criteria	Remark	Pollution
Low	Bio-resource based livelihood, Non-biodegradable substances are small in quantity and reusable.	Materials are biodegradable, (small tea stalls, tailoring, etc), cooking by biomass based fuels	Foul smell, Air pollution from biomass-cooking
Medium	Bio-degradable substances with high organic and salt loading are produced, Non-biodegradable and non-hazardous substances are produced in small quantity and recycling is possible to a large extent, fossil fuels in small quantity are used.	Fish drying activity, Bakery and Pitha(cake) making, BOD of the effluent not exceeding 100mg/litre, Workers involved in Agricultural activities using tractors, diesel irrigation pumps seasonally, stone crushers etc	Foul smell, Air pollution by exhaust gases and Suspended particulate matter, Health risks
High	Non-biodegradable, hazardous and toxic substances that create severe and adverse environmental impacts; Natural resources are used in significant quantities which are not sustainable, Fossil fuel is routinely used	Chemical fertilizer and pesticides used in agricultural field, Large brick kilns, Bio-resource based furniture making, Furnace and boilers using coal	Workers exposed to severe pollution, Depletion of resource due to unsustainable practices

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