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DEFORESTATION AND ENVIRONMENTAL SUSTAINABILITY: A STUDY OF INTERDEPENDENCE

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ABSTRACT

This paper tries to analyse the implications of forest management vis-a-vis sustainable development. The entire paper is divided into five segments. The first part presents the introduction which discusses the importance of forest and its bearing on mankind, the meaning of sustainable development and sustainable forest management. The second portion is devoted to the effects of deforestation. In the third segment an economic theoretical base for the forest management has been provided. To understand the theoretical model for forest depletion, the logic of inter-temporal choice has been applied which treats one unit of a commodity consumed in current period (t0) and one unit of the same consumed at a later period (t1) as entirely two different commodities. So, it is a matter of constrained choice of the same commodity over a time period. However, at a later stage, the social cost involved in the use of natural resource like forest has also been taken into account for price determination. The fourth section proceeds on the data analysis which tries to demonstrate the inter-relationship between forest cover and the variables like Human Development Index (HDI), Human Poverty Index (HPI), GDP (Per Capita), Poverty, No. of threatened species, GEF benefit index for biodiversity and environmental sustainability. For this cross-section data has been taken and correlation matrix calculated. Finally, the fifth and the last section is given to the concluding observations.

KEYWORDS

Deforestation, Forest management and Environmental Sustainability.

INTRODUCTION

Humankind and evolution of civilisation have been profoundly influenced by the presence or absence of forest or their relative abundance or scarcity. Forests are a renewable resource and they play a vital role in enhancing the quality of environment by influencing the life support system.

During the process of development, our civilisation has faced three different stages of forests:

1) Civilisation dominated by forests,
2) Civilisation overcoming forests and
3) Civilisation dominating forests.

The decades after Second World War could be placed under the third stage. These periods are characterised by growth and progress all over the world. Material progress has been achieved at the cost of exploitation of natural resources. Though, we are still in the third stage, but the pace of deforestation has a bit slowed down since 1990s with the Millennium Development Goals (MDGs) declaring goal-7 as to 'Ensure Environmental Sustainability' and the target to achieve this is to integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources. The first two indicators to monitor the progress are- Proportion of land area covered by forest and the ratio of area protected to maintain biological diversity to surface area. Different figures for world (India) with regard to % of total forest area covered by land in 2005, the total forest in 2005, total change in forest area over a period 1990 to 2005 and average annual rate of change in forest area over 1990-2005 are 30.3 (22.8) %, 39520000 (677000) sq. km., -1253000 (37600) sq. km. and -0.2 (0.4) % respectively (Human Development Report 2007-08).

There have been four major reasons for deforestation, often in combination with each other- excessive cutting down of trees for timber, over grazing, fuel wood consumption and clearance of land for living & cultivation. Today vast stretches of forest are lost as a price for development. Narmada Valley Project and all other such projects have submerged thousands of hectares of virgin tropic ever green forests. Whatever be the cause, this deforestation has serious consequence on the quality of life. The influence of forest on environment may be localised or far reaching. The climate, rainfall, relative humidity, wind, soil, etc. are all influenced by forests. Hence indiscriminate deforestation disturbs ecological balance and deteriorates quality of life.

Thus the current global distresses with the forest cover and hence the environment rests on the belief that deforestation and environmental alteration has crossed the limit to a point where the well being of not only the future generation but of current generation is also being threatened. Here one draws closer to the issue of environmental sustainability which is the process of making sure current processes of interaction with the environment and are pursued with the idea of keeping the environment as pristine as naturally possible based on ideal-seeking behaviour. An "unsustainable situation" occurs when natural capital (the sum total of nature's resources) is used up faster than it can be replenished. Sustainability requires that human activity only uses nature's resources at a rate at which they can be replenished naturally. Inherently the concept of sustainable development is intertwined with the concept of carrying capacity. Theoretically, the long-term result of environmental degradation is the inability to sustain human life. Such degradation on a global scale could imply extinction for humanity. This can be understood with the help of following table-1:

TABLE - 1: LEVEL OF CONSUMPTION AND ENVIRONMENTAL SUSTAINABILITY

Consumption of Renewable Resources	State of Environment	Sustainability
More than nature's ability to replenish	Environmental Degradation	Not sustainable
Equal to nature's ability to replenish	Environmental Equilibrium	Steady state economy
Less than nature's ability to replenish	Environment Renewal	Environmentally sustainable

It is in this backdrop that the present paper tries to analyse the implications of forest management vis-a-vis sustainable development. The entire paper is divided into five segments. The first part presents the introduction which discusses the importance of forest and its bearing on mankind, the meaning of sustainable development and sustainable forest management. The second portion is devoted to the effects of deforestation. In the third segment an economic theoretical base for the forest management has been provided. To understand the theoretical model for forest depletion, the logic of inter-temporal choice has been applied which treats one unit of a commodity consumed in current period (t_0) and one unit of the same consumed at a later period (t_1) as entirely two different commodities. So, it is a matter of constrained choice of the same commodity over a time period. However, at a later stage, the social cost involved in the use of natural resource like forest has also been taken into account for price determination. The fourth section proceeds on the data analysis which tries to demonstrate the inter-relationship between forest cover and the variables like Human Development Index (HDI), Human Poverty Index (HPI), GDP (Per Capita), Poverty, No. of threatened species, GEF benefit index for biodiversity and environmental sustainability. For this cross-section data has been taken and correlation matrix calculated. Finally, the fifth and the last section is given to the concluding observations.

EFFECTS OF DEFORESTATION

Forest cover is helpful in maintaining the temperature level and preventing them from rising. A portion of the solar radiation is reflected back into the space by earth's atmosphere. The rest reaches the surface of the earth as not much is absorbed by the atmosphere. The forests present on the earth's surface will reflect

a portion of this sun's rays again back into outer space and absorb the rest. This is called the 'albedo effect'- a phenomenon that refers to the proportion of sunlight that the earth surface reflects back into space.

In the absence of forests, the entire heat that is not absorbed by the atmosphere but strikes the earth's surface are reflected by the earth's surface, leading to a rise in atmospheric temperature. But if the forest coverage is thick and wide, these forests would absorb the heat and prevent the rise in temperature. Secondly, the ultra violet rays from the sun are absorbed by the ozone layer. But due to certain pollutants like fluoro carbons, the ozone layer is becoming thin or holes are formed in the ozone layer. Under such conditions the forests would serve as a natural filter of the ultra violet radiation that threatens the health of the people.

Thirdly, the destruction of forests, particularly tropical forests could change the global climate and destabilise polar ice caps. The tropical rain forests are reservoirs of carbon, which is stored in living vegetation. Releasing this carbon by cutting trees and then burning them or leaving them to decay will add to the concentration of CO_2 in the atmosphere. The amount of CO_2 in the atmosphere has increased considerably in the past century. Forest clearance account for nearly fifty percent of the added CO_2 which traps heat that would otherwise pass through the atmosphere into outer space. This 'green house effect' means that the predicted doubling in the atmospheric concentrations of CO_2 will result in an average rise of about 5^0 F in the earth's atmosphere. The warming will not be uniform around the globe: the North and the South poles forest to have temperature increases to the extent of 18^0F; this may cause some melting of the polar ice packs, raising ocean levels and changing rainfall patterns around the world. When large areas of forests are destroyed less rain falls on the deforested region. Deforestation removes the sponge that holds rain water and sends half of it back to the atmosphere directly by transpiration.

One method, by which forests influence human activities, indirectly but strongly, is through the part they play in regulating the water cycle. The maintenance of dense and uniform woodland, particularly over hilly areas, is a major factor which can guarantee water supply during the dry season and also the best means of preventing floods in drainage basins at other times. Countries situated in Mediterranean climates and those in tropical countries, especially India, and the Far East, have long experienced disastrous floods, caused by unwise deforestation of the slopes above river valleys.

Soil is also protected by the forests. When the trees are cut and root mat destroyed, soil erosion takes place due to full force of rains. Heavy rain removes nutrients by washing away the thin top layer of soil and air also squeezes out of soil due to compacted soil. Minerals and air are necessary for the growth of plants. The final result is a reduction in the productivity of agricultural crops.

Forests are also helpful in minimising the impact of air pollution, water pollution and noise pollution. By maintaining water flow of rivers, reducing sedimentation in the rivers and streams, by reducing surface runoff of rain water, reducing silting of reservoirs; forests to a great extent protect the habitat from serious water pollution problem.

Apart from these, the forests are home to a large variety of animals and birds. Deforestation has resulted in the extinction of some of the species of animals and birds. The list of number of threatened species in different countries is mentioned in table-2b. So, protection of forest is necessary from the point of view of maintaining ecological balance.

The ultimate objective of planned development is to ensure human well - being through sustained improvement in the quality of life of the people, particularly the poor and the vulnerable segments of the population. There is, however, a need to balance the harmful effects of human activity on global warming against the need for poverty reduction and economic growth in developing and least developed countries. The issue of global social justice cannot be delinked from the issue of global public goods like the atmosphere. The costs and benefits to the people living in different countries and their respective contributions must be dealt with in an integrated way. It is here that a determined effort is required for sustainable forest management (SFM) which is the management of forests according to the principles of sustainable development. Sustainable forest management uses very broad social, economic and environmental goals.

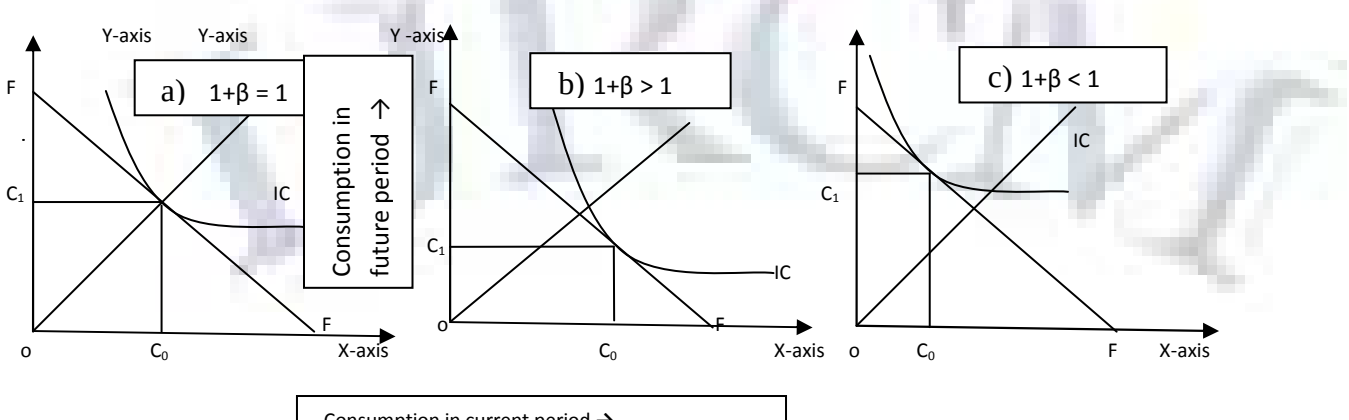
THEORETICAL BASE FOR FOREST MANAGEMENT

The growing concern about the increasing scarcity of fossil fuels and other raw materials has provided various theories and models of natural resource use. In majority of these works, an optimal depletion of exhaustible and renewable resources have been highlighted. The early classical and neo-classical theories emphasised only on relative scarcity of natural resources used as productive inputs in the economic process and held the optimistic view that market forces would dictate optimal rate of exploitation effectively and automatically. Theories based on this optimistic view that the economic system would automatically adopt itself in the long run to natural resource scarcity constraint, focussed on the optimal rate of depletion over time of those resources used as energy and material inputs in the economic process.

To facilitate an understanding of the theoretical model of forest depletion, an understanding of logic of inter-temporal choice is must. The analysis of inter-temporal choice treats one unit of a commodity consumed in the current period (t_0) as one unit of the same commodity consumed in future period (t_1) as two different commodities. The analysis therefore involves the choice of the same good over a time period and is therefore analogous to the constrained choice between alternative commodities in the traditional static consumer demand theory. Indifference curves can hence be used to express relative preferences between consumption in the two time periods.

The slope of such indifference curves- being the marginal rate of substitution of current for future consumption- will reflect the rate at which future consumption will be sacrificed for current consumption. Let the slope of the indifference curve be denoted by '1+β', where β is the marginal rate of time preference proper. Since individuals have a general preference for present consumption over future use, the value of future commodity flows should be discounted, to make it comparable with the current period quantities.

FIGURE-1a, b & c: INTER TEMPORAL ALLOCATION OF FOREST STOCK UNDER DIFFERENT LEVELS OF SOCIAL TIME PREFERENCE



In the above figures- 1-a, b and c; it has been shown that how a given amount of forest stock (OF) can be consumed either in current period (t_0) shown on the X-axis or may be left out for future consumption (t_1) shown on the y-axis. Equilibrium point is obtained with the interaction of indifference curve (IC) and forest constraint line (FF). Figure 1-a is a case of marginal rate of time preference such that 1+ β = 1 so that β = 0, and hence forest reserves are equally allocated between two time periods. OC_0 is consumed in present period and an equal amount OC_1 is left for future generation. In figure 1-b, the indifference curve reflects

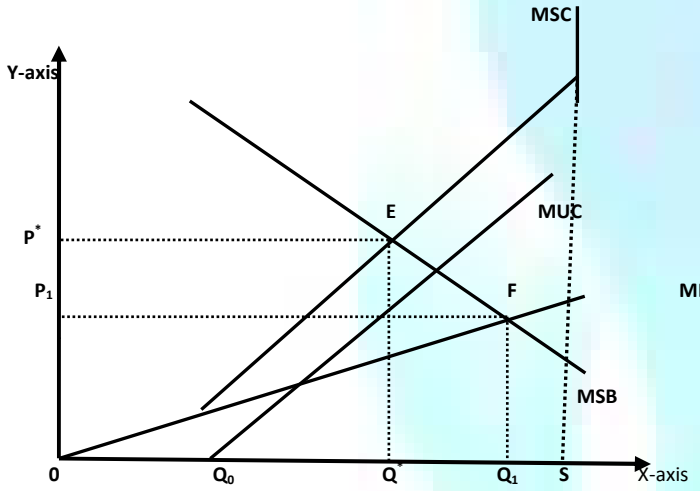
a positive time preference of 1+ β >1 i.e. β >0, leading to a high level of forest depletion in current period. Figure 1-c shows that maximum is left for future period and a small amount is being consumed in the current period. In this case 1+ β <1 i.e. β <0 and time preference is in favour of future period.

However, the above explanation doesn't take into account the costs involved into the use of forest resources and hence fails to explain the determination of prices consistent with optimal use of forest reserves. Pricing of forest use need demand and supply information on its use. The demand curve is a normal downward sloping curve which shows diminishing marginal social benefits with increased consumption. Regarding the supply curve, it is believed that forest reserves being a natural resource has perfectly inelastic supply at any given time period. But it is not so. For this calculation of Marginal Social Cost (MSC) is needed which has two components- Marginal Extraction (or harvesting) Cost (MEC) and Marginal User Cost (MUC).

Marginal Extraction Cost is the cost incurred to extract or harvest an additional unit of resource whereas Marginal User Cost is the resultant of fixed amount of forest stock at any given time. So the current consumption of forest stock at any time is at the expense of future benefits withdrawn i.e. it involves an opportunity cost. The entire analysis can be well understood with the help of figure-2 given below. On the X-axis is availability of forest reserves and on the Y-axis, the price or cost is depicted. Suppose the total availability of forest cover at any time is 'OS' which is in excess of the quantity that would be demanded by the society in future. So the current consumption will not rob the society of future benefits so long as the current consumption is less than or equal to the surplus amount (OQ_0). However, when resource extraction exceeds OQ_0 level, the current consumption or resource extraction will rob the society of their future benefits. This loss of future benefits due to current consumption can be termed as 'User Cost' or opportunity cost. User Cost of each successive unit (Marginal User Cost) of current consumption is the (discounted) value of the future consumption that is foregone. Since the demand curve for future resource use (MSB curve) is downward sloping, each successive unit of current consumption incurs a progressively greater loss of future benefits. Hence the Marginal User Cost (MUC) curve is upward sloping. The user cost can be seen as an externality i.e. a cost imposed on future generations by the production and consumption activities of the present generation. The real cost to the society of consuming a unit of resource in the current period is the sum of marginal extraction cost and marginal user cost. MSC is upward sloping.

The principle of optimality says that the society will gain maximum net benefit from the available forest stock at a point where marginal benefits and marginal costs of consumption are equal i.e. MSC= MSB. This point is E where Q^* level of depletion of forest reserve takes place and SQ^* is left for the future generation. The optimal resource price is P^*. If pricing decision is done on the basis of only MEC, the rate of forest depletion will increase to the level of Q_1. Thus, inclusion of MUC in the pricing decision of forest reserve use will reduce the rate of depletion and hence the burden on future generation can be lessened to a considerable extent. That's why; the present generation must be ready to pay progressively for the use of forest reserves to protect the interests of future generation. The developmental process can only then be sustainable.

FIGURE-2: OPTIMAL FOREST RESERVE UTILISATION AND PRICING



DATA ANALYSIS: INTERDEPENDENCE BETWEEN FOREST COVER AND OTHER VARIABLES

For the study the data has been taken for thirty one countries. The criteria being adopted for the selection of countries are HDI index, HPI index, GDP index, forest cover, rate of depletion in forest cover, extinction of plant & animal species and level of environmental sustainability. The entire data has been put in two tables-2a and 2b. The maximum and minimum values under each column have been highlighted by bold figures.

A simple look at the data reveals that the Japan has the maximum percentage of land area covered by forests. The country is very high on HDI and GDP index. The threatened plant species are very low (Only 12) and CO_2 emission is moderate with entire population having an access to safe drinking water which is a measure of environmental sustainability. The income inequality (shown by the Share of poorest quintile in National consumption or income) is also low. However, Iceland, a country having highest HDI index is having only 0.5% of land area as forest cover. In terms of total forest coverage area Brazil is highest but the rate of deforestation is also highest over there. Since 1970, over 600,000 square kilometers (232,000 square miles) of Amazon rainforest have been destroyed. In many tropical countries, the majority of deforestation results from the actions of poor subsistence cultivators. However, in Brazil only about one-third of recent deforestation can be linked to "shifted" cultivators. Historically a large portion of deforestation in Brazil can be attributed to land clearing for pastureland by commercial and speculative interests, misguided government policies, inappropriate World Bank projects, and commercial exploitation of forest resources. Favourable taxation policies, combined with government subsidized agriculture and colonization programmes, encourage the destruction of the Amazon. Brazilian deforestation is strongly correlated to the economic health of the country: the decline in deforestation from 1988-1991 nicely matched the economic slowdown during the same period, while the rocketing rate of deforestation from 1993-1998 paralleled Brazil's period of rapid economic growth. During lean times, ranchers and developers do not have the cash to rapidly expand their pasturelands and operations, while the government lacks funds to sponsor highways and colonization programmes and grant tax breaks and subsidies to forest exploiters. However, On July 5, 2007 current Brazilian president Luiz Inácio Lula da Silva, spoke at the International Conference on Biofuels in Brussels announcing that the government targets of leaning towards ethanol and biodiesel in fuel production and establishing more than 200,000 square kilometres of conservation units to protect the forest had allowed the rate of deforestation to fall by more than 50% in the three years since 2004. The country has medium HDI and GDP index. The number of threatened animal and plant species are also very large. The country has controlled the CO_2 emission and with high level of access to save drinking water, but income inequality is very high.

The average annual rate of deforestation is also high in Latin American and sub-Sahara African countries during the period 1990-2005, with a very high rate of -2.5% for Honduras. Between 1990 and 2005, 37.1 percent of the forests of Honduras disappeared. Worse, since the close of the 1990s, Honduras's rate of forest loss has increased by 9 percent. Honduras's high rate of deforestation stems from its poverty. Despite its natural wealth, both mineral and biological, Honduras is one of the poorest countries in Central America. Deforestation results from agricultural colonization by subsistence farmers, clearing for cattle pasture, collection of fuelwood (65 percent of the country's energy comes from fuelwood), mining activities, timber harvesting, and forest fires. While the government has increasingly taken a pro-environment stance by establishing protected areas and generally cracking down on some illegal forest activities—corruption notwithstanding—its biggest challenge is gaining support from people who rely on forests for subsistence activities. Where the government fails or lags, a

blossoming grassroots environmental movement has stepped in and is seen by many conservationists as a key to the future of the country's environment. In 2005, Father Andres Jose Tamayo, a Honduran priest who established the Movement of Olancho—a green group that has fought illegal loggers— won the prestigious Goldman prize for his environmental efforts in the country. The effects of deforestation are evident during tropical storms and hurricanes that periodically batter the country. In 1998, Hurricane Mitch killed thousands and caused widespread damage to infrastructure. Aerial surveys following the storm revealed that mudslides were worst in deforested areas. Hillsides forested with natural vegetation—which anchors soils—suffered less damage. For these countries the HPI, HDI, GDP and GEF index are quite low. In most of the countries where the forest area cover is low and rate of deforestation is high, poverty ratio is very high.

In Asia, the highest rate of deforestation is being found in Philippines which is -2.2% during the period 1990-2005. Widespread logging was responsible for much of the historical forest loss in the Philippines. Despite government bans on timber harvesting following severe flooding in the late 1980s and early 1990s, illegal logging continues today. Illicit wood cut from secondary and primary forests is routinely smuggled to other Asian countries. After temporarily lifting the log export ban in the late 1990s, the government has increasingly tried to crack down on timber smuggling and forest degradation, but with limited success. Indonesia also is experiencing one of the highest rates of tropical forest loss in the world. Indonesia was densely forested as recently as 1950. Forty percent of the forests existing in 1950 were cleared in the following 50 years. In round numbers, forest cover fell from 162 million ha to 98 million ha. The rate of forest loss is accelerating. On average, about 1 million ha per year were cleared in the 1980s, rising to about 1.7 million ha per year in the first part of the 1990s. Since 1996, deforestation appears to have increased to an average of 2 million ha per year. Deforestation in Indonesia is largely the result of a corrupt political and economic system that regarded natural resources, especially forests, as a source of revenue to be exploited for political ends and personal gain. Illegal logging has reached epidemic proportions as a result of Indonesia's chronic structural imbalance between legal wood supply and demand. More than 20 million hectares of forest have been cleared since 1985, but the majority of this land has not been put to productive alternative uses. The Indonesian Government is facing mounting pressure domestically and internationally to take action, but progress is slow and not all policy reforms in process are necessarily good news for forests.

India's coverage for forest is also not satisfactory. It is only 22.8% equivalent to 677000 sq. Kms. (about 67,701,000 hectares). Al least it should be one third of the entire coverage area. Out of these only 38 million ha of forests are well stocked (crown density above 40%). This resource has to meet the demand of a population of more than one billion people and around 450 million cattle. As such, country has to meet the needs of 16% of the world's population from 1.7 % of the world forest resources. The same forest has also to cater for the 19% of the world cattle population. Between 1990 and 2000, India gained an average of 361,500 hectares of forest per year. This amounts to an average annual reforestation rate of 0.57%. Between 2000 and 2005, the rate of forest change decreased by 92.3% to 0.04% per annum. In total, between 1990 and 2005, India gained 5.9% of its forest cover, or around 3,762,000 hectares. Measuring the total rate of habitat conversion (defined as change in forest area plus change in woodland area minus net plantation expansion) for the 1990-2005 intervals, India gained 1.0% of its forest and woodland habitat. With regard to people's involvement in forestry, the 1952 Policy laid down that it would be the duty of the forester to awaken the interest of the people in the development , extension and establishment of tree-lands wherever possible, and to make them tree minded[i]. However, the policy did not provide any strategic appraisal of how to bring about public participation in forest management. Rather, the government continued with British forest policies even after independence. Three reasons have been identified for deforestation and degradation of forests in India: defective forest policy, faulty policy implementation, and poverty[ii]. Recent developments have recognized afforestation and reforestation as activities, which could be undertaken under the Clean Development Mechanism (CDM) of the Kyoto Protocol. In a related development, forest management in India experienced a pivotal change in 1990 when a community based approach, named Joint Forest Management (JFM), was adopted as one of the main strategies for protection and management of state forest lands. JFM is a forest management strategy under which the forest department and the village community enter into an agreement to jointly protect and manage forest land adjoining villages and to share responsibilities and benefits. However, the success of JFM in India is yet to be ascertained.

Among African countries, Nigeria has one of the worst environmental records in the world. In recent years, the country has seen widespread social and environmental problems stemming from oil operations in the Niger River delta, and one of the world's highest deforestation rates. Deforestation is a serious problem in Nigeria, which currently has one of the highest rates of forest loss in the world. Since 1990, the country has lost some 6.1 million hectares or 35.7 percent of its forest covers. Worse, Nigeria's most bio-diverse ecosystems—its old-growth forests—are disappearing at an even faster rate. Between 1990 and 2005, the country lost a staggering 79 percent of these forests and since 2000 Nigeria has been losing an average of 11 percent of its primary forests per year—doubles the rate of the 1990s. These figures give Nigeria the dubious distinction of having one of the highest deforestation rates of natural forest on the planet. From 1971 to 1987, Uganda lost 50 percent of its forests, including virtually all of its primary forests. Between 1990 and 2005, Uganda lost 26.3 percent of its remaining forest cover, and deforestation continues today at a rate of 2.2 percent per year, mostly due to subsistence farming, cutting for fuelwood, and colonization by the burgeoning population.

An interrelationship between forest area coverage, rate of deforestation and many other variables can be well understood with the help of correlation matrix as given in table-3. The correlation matrix shows that there exists a Positive correlation between rate of deforestation and GDP index. This reflects that the growth process is responsible to a large extent for the rate of deforestation. A positive correlation between poverty and deforestation also reflects the linkages between these two. A positive correlation between HDI and deforestation may be due to the fact that one third of the weightage is given to GDP, a growth indicator in the calculation of HDI. A positive value of correlation exists with threatened animal species which is obvious that their habitat is decreasing while a similar relation with GEF index reflects a larger variation in biodiversity. The positive correlation between CO_2 and deforestation is a reflection that forest definitely cleans the air. A very high degree of positive correlation between CO_2 emission and GDP index is a reflection that growth process is definitely responsible for higher degree of CO_2 emissions due to urbanisation and industrialisation.

CONCLUSION

The global forested area in 2005 was about 4 billion hectares, covering 30% of total land area. But deforestation continues at about 13 million hectares a year. Reforestation reduced the net loss of forest area to 7.3 million hectares a year during 2000-05, an improvement from losses of 8.9 million hectares a year during 1990-2000. Sub- Saharan Africa and Latin America continued to have the largest forest loss after 1990. Agriculture and deforestation are responsible for one third of green house gas emissions. In many countries soil degradation, along with the loss of agricultural land through urbanisation and population growth, has led to substantial deforestation. The deforestation along with other types of pollution has led to climate change. Climate change has different effects on different regions (depending on geography) and different income groups (depending on livelihood and adaptive capacity). The effects also vary by the extent of adaptation, exposure to temperature change, and socio-economic conditions. Hence, the negative effects will not occur everywhere[iii]. These impacts depend on two main factors: exposure to the effects of climate change and capacity to adapt to them.

Exposure is partly determined by environmental factors. People, flora, and fauna in areas prone to flooding or facing water scarcity have far greater exposure. The level of exposure also depends on the population density or the infrastructure in environmentally sensitive areas. Adaptive capacity is the ability to deal with climate change, such as by building levies to combat flooding or irrigation systems to deal with drought. It is closely associated with society's wealth, educational strength, and access to technology[iv].

High exposure and low adaptive capacity occur mostly in developing countries, making them highly vulnerable to climate change. Poverty and political instability make the negative impacts of climate change more severe and weaken the ability to adapt.

The impacts of deforestation and consequently of climate change are costly- so is mitigating the causes of these or adapting to the unavoidable outcomes of change. There is substantial economic and social justification for mitigating deforestation. The costs of mitigation depend on the level at which deforestation stabilise. But the cost of inaction is significantly higher. The range of estimates could be wide, depending on underlying assumptions, on which consensus is lacking. For example, the Stern Review[v] estimates that without action the overall costs of climate change will be equivalent to losing at least 5% of global GDP each year, now and forever. They would be much higher under a wider range of risks and impacts.

Some steps to reduce deforestation are economically as well as socially desirable. This is important because forests protect biodiversity and provide livelihood for millions of poor people. Air pollution prematurely kills more than two million people a year. In China the health costs attributable to air pollution are estimated at $68 billion a year, nearly 4% of its economic output[vi]. And acid rain has contaminated one-third of the country, destroying some $4 billion worth of crops every year. Though the Chinese authorities have closed some polluting factories, but a sustained solution for that could be provided through reforestation.

So, countries need to adapt to the unavoidable effects of climate change that are already affecting the well-being of their people, particularly those who are poor. With poor adaptive capacity, inadequate social protection, and gaps in climate information, developing countries will find it difficult to respond as social insurance spending and total numbers of meteorological stations are lower in these countries. As climate change crosses national borders, a coordinated programme of funding and new technologies is required. But the funding needed for adaptation is enormous, and the amount available for climate adaptation in developing countries is still insufficient.

There is still a window of opportunity to act before the economic and human costs become insurmountable. But action requires measuring and monitoring the state of the environment and human well being and how they are changing. There are still information gaps, and many of the available data are not up to date. The impacts of carbon dioxide emissions are not well quantified, especially in developing countries. The impacts of extreme climate events are poorly tracked. Local impacts are not widely researched. Few projections on aquatic resources are available. Research on adaptation is still not comprehensive across a range of climate and socioeconomic futures. There is much to be learned about the multi-dimensional impact of deforestation and climate change on the life of human beings.

Numbers tell the story. But we still lack many of the numbers to tell the whole story.

TABLE-2 a: FOREST COVERAGE AREA AND OTHER INDICATORS OF DEVELOPMENT

Items→ /Country↓	**Forest Area[vii]**				Human Development Index (HDI)[viii] (2005)	Human Poverty Index % (HPI)[ix] (2005)	GDP[x] Index (2005)	GEF[xi] index (2005)
	%of total land Area (2005)	Total land area ('000 sq.km.) (2005)	Total change ('000 sq.km.) (1990-2005)	Average % annual change[xii] (1990-2005)				
Iceland	**0.5**	0.5	0.2	**5.6**	**0.968**	-	0.985	-
Norway	30.7	93.9	2.6	0.2	**0.968**	6.8	**1.000**	1.6
Australia	21.3	1636.8	-42.3	-0.2	0.962	12.1	0.962	95.8
Japan	**68.2**	248.7	-0.8	-	0.953	11.7	0.959	41.4
USA	33.1	3030.9	44.4	0.1	0.951	15.4	**1.000**	90.3
UK	11.8	28.5	2.3	0.6	0.946	14.8	0.969	2.1
Germany	31.7	110.8	3.4	0.2	0.935	10.3	0.949	**0.07**
Grecee	29.1	37.5	4.5	0.9	0.926	-	0.910	3.0
Brunei	52.8	2.8	-0.4	-0.7	0.894	-	0.941	0.5
Argentina	12.1	330.2	-22.24	-0.4	0.869	**4.1**	0.828	18.5
Mexico	33.7	642.4	-47.8	-0.5	0.829	6.8	0.781	75.8
Malaysia	63.6	208.9	-14.9	-0.4	0.811	8.3	0.783	14.8
Brazil	57.2	**4777.0**	**-423.3**	-0.5	0.800	9.7	0.740	**100.0**
Samao	60.4	1.7	0.4	2.1	0.785	-	0.688	-
Thailand	28.4	145.2	-14.5	-0.6	0.781	10.0	0.745	8.0
China	21.2	1972.9	401.5	1.7	0.777	11.7	0.703	64.8
Ecuador	39.2	108.5	-29.5	-1.4	0.772	8.7	0.629	30.0
Phillipines	24.0	71.6	-34.1	-2.2	0.771	15.3	0.657	33.7
SriLanka	29.9	19.3	-4.2	-1.2	0.743	17.8	0.639	6.6
El-salvadore	14.4	3.0	-0.8	-1.4	0.735	15.1	0.661	0.8
Algeria	1.0	22.8	4.9	1.8	0.733	21.5	0.711	3.0
Indonesia	48.8	885.0	-280.7	-1.6	0.728	18.2	0.609	90.0
Nicaragua	42.7	51.9	-13.5	-1.4	0.710	17.9	0.601	3.6
Honduras	41.5	46.5	-22.4	**-2.5**	0.700	16.5	0.590	7.9
India	***22.8***	***677.0***	***37.6***	***0.4***	***0.619***	***31.3***	***0.591***	***43.9***
Combodia	59.2	104.5	-25.0	-1.3	0.598	38.6	0.552	3.9
Nepal	25.4	36.4	-11.8	-1.6	0.534	38.1	0.458	2.2
Sudan	28.4	675.5	-88.4	-0.8	0.528	34.4	0.507	5.5
Zimbabwe	45.3	175.4	-46.9	-1.4	0.513	**40.3**	0.503	2.1
Uganda	18.4	36.3	-13.0	-1.8	0.505	34.7	0.447	3.3
Nigeria	12.2	110.9	-61.5	-2.4	**0.470**	37.3	**0.404**	6.6

TABLE-2 b: ANIMAL AND PLANT SPECIES AND ENVIRONMENTAL SUSTAINABILITY FACTOR

Items→ /Country↓	Animal Species[xiii]		Higher Plants[xiv]		Ensure Environmental Sustainability		Share of poorest quintile in National consumption or income (%) (1992-2005)
	Total known species (2004)	Threatened Species[xv] (2007)	Total known species (2004)	Threatened Species (2007)	CO_2 Emission Per Capita (Metric Tons) (2004)	Access to improved sanitation facility (% of population) (2004)	
Iceland	-	-	-	-	-	-	-
Norway	525	**32**	1715	**2**	19.1	**100**	9.6
Australia	1127	568	15638	55	16.2	**100**	8.6
Japan	763	190	5565	12	9.8	**100**	**10.6**
USA	1356	**937**	19473	242	**20.6**	**100**	5.4
UK	660	38	**1623**	13	9.8	**-**	6.1
Germany	613	59	2682	12	9.8	**100**	8.5
Grecee	530	95	4992	11	8.7	46	6.7
Brunei	713	48	2500	**2**	**0.0**	36	5.1
Argentina	1413	152	9372	42	3.7	91	3.1
Mexico	1570	579	26071	261	4.3	79	4.3
Malaysia	1083	225	15500	686	7.0	94	4.4
Brazil	**2290**	343	**56215**	382	1.8	75	2.9
Samao	-	-	-	-	-	-	-
Thailand	1271	157	11625	86	4.3	99	6.3
China	1801	351	32200	466	3.9	44	4.3
Ecuador	1856	340	19362	**1838**	2.3	89	3.3
Phillipines	812	253	8931	213	1.0	72	5.4
SriLanka	504	177	3314	280	0.6	91	7.0
El-salvadore	571	29	2911	26	0.9	62	**2.7**
Algeria	**472**	71	3164	3	6.0	92	7.0
Indonesia	2271	464	29375	386	1.7	55	7.1
Nicaragua	813	59	7590	39	0.7	47	5.6
Honduras	900	102	5680	110	1.1	69	3.4
India	1602	313	18664	247	1.2	33	8.1
Combodia	648	82	-	31	0.0	**17**	6.8
Nepal	477	72	6973	7	0.1	35	6.0
Sudan	1254	47	3137	17	0.3	34	-
Zimbabwe	883	35	4440	17	0.8	53	4.6
Uganda	1375	131	4900	38	0.1	43	5.7
Nigeria	1189	79	4715	171	0.8	44	5.0

Source: World Development Indicators 2008 and Human Development Report 2007-08.

TABLE-3: CORRELATION MATRIX BETWEEN VARIOUS VARIABLES LIKE FOREST DENSITY, AVERAGE RATE OF DEFORESTATION, ENVIRONMENTAL SUSTAINABILITY FACTORS, VARIOUS GROWTH INDICATORS AND POVERTY LEVEL

	ANS	ATS	CO2	DEFOR	FA	GDP	GEF	HDI	HPI	POVERTY	SANIT	THPS	TPS
ANS	1.00	0.55	-0.13	0.05	0.34	-0.04	0.72	0.03	-0.19	-0.31	-0.16	0.49	0.84
ATS		1.00	0.47	0.23	0.18	0.43	0.87	0.44	-0.29	-0.01	0.24	0.28	0.58
CO2			1.00	**0.49**	-0.01	0.86	0.30	0.75	-0.41	0.48	0.65	-0.10	-0.02
DEFOR				***1.00***	***-0.23***	***0.58***	***0.24***	***0.49***	***-0.34***	***0.32***	***0.32***	***-0.05***	***0.23***
FA					***1.00***	***0.07***	***0.26***	***0.13***	***-0.21***	***-0.19***	***0.08***	***0.36***	***0.46***
GDP						1.00	0.36	0.96	-0.76	0.32	0.81	-0.05	0.14
GEF							1.00	0.39	-0.31	-0.04	0.09	0.22	0.82
HDI								1.00	-0.88	0.22	0.81	0.08	0.21
HPI									1.00	0.10	-0.72	-0.28	-0.31
POVERTY										1.00	0.18	-0.34	-0.30
SANIT											1.00	0.13	-0.06
THPS												1.00	0.37
TPS													1.00

NOTES AND REFERENCES

[i] Government of India, 1952, 'National Forest Policy, *1952'.*

[ii] Singh, Katar, 1994, *Managing Common Pool Resources : Principles and Case Studies.* New Delhi: Oxford University Press .

[iii] IPCC (Intergovernmental panel on Climae Change), Climate Change (2007): The Physical Science Basis. Contribution of working group I to the fourth assessment report of IPCC. Cambridge UK. Cambridge University Press.

[iv] Burton, Ian, Elliot Diringer, and Joe Smith (2006), "Climate Change: International Policy Options", Pew Centre on Global Climate Change, Arlington, Va.

[v] Stern Nicholas (2006), "The Economics of Climate Change: The Stern Review", London. Cambridge University Press.

[vi] World Bank (2007), "Global Monitoring Report", Washinton D.C.

[vii] It is land under natural or planted stands of trees, whether productive or not.

[viii] A composite index measuring average achievement in three basic dimensions of human development—a long and healthy life, knowledge and a decent standard of living.

[ix] A composite index measuring deprivations in the three basic dimensions captured in the human development index—a long and healthy life, knowledge and a decent standard of living.

[x] One of the three indices on which the human development index is built. It is based on gross domestic product per capita (in purchasing power parity terms in US dollars)

[xi] This benefit index for biodiversity is a composite index of relative biodiversity potential based on the species represented in each country and their threat status and diversity of habitat types. The index has been normalized from 0 (no biodiversity potential) to 100 (maximum biodiversity potential).
[xii] It is the permanent conversion of natural forest area to other uses including agriculture, ranching, settlement and infrastructure.
[xiii] These include mammals (excluding whales and porpoises) and birds.
[xiv] These are native vascular plant species.
[xv] These are no. of species classified by the IUCN as endangered, vulnerable, rare, indeterminate, out of danger, or insufficiently known.

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