

Public Lecture Series



RECONCILING CLIMATE CHANGE AND ECONOMIC GROWTH: THE NEED FOR AN ALTERNATIVE PARADIGM OF DEVELOPMENT

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Synopsis of public lecture

Human welfare is inextricably linked to earth's climate. Similar to other life forms, the manner in which human beings respond to climate change is critical not only to survival, but also to well-being. It is a fact that current economic growth of the world is based on high carbon intensity. Unbridled economic activities, industrialization and urbanization have led to an unimaginable increase in global warming leading to extreme climate events. Under business as usual scenario, high consumption fossil fuel-based development path disturbs ecological balance, brings man made calamities and further can hasten the seismic / geological processes such as tsunami which may result in catastrophic destruction of earth's eco-systems threatening the future of mankind. Climate change is a powerful force in shaping the life chances of poor people and climate related risks are a major cause of human suffering, poverty, and reduced opportunity which will lead to large scale human development reversals in the world's poorest countries. Climate shocks pose many undesirable consequences such as threats to health and nutrition, loss of savings and assets, damage to property, and loss of crops. The short term and long term cost of extreme climate events can have devastating consequences for human development. In the race for rapid economic development among all countries, environmental concerns are often neglected. The paper discusses vividly not only the calamity that will be caused by green house gases and their consequent effects on earth, human development and the economy

but also offers climate change compatible development paradigm which will go along with climate adaptation and mitigation strategies for sustainable development. Thus, climate compatible development path has necessarily become an alternative paradigm of development embracing economic, social and environmental issues not only for meeting the needs of resource use of the present generation but also of the future generation as well.

Protect the climate system for the benefit of the present and future generations of humankind, on the basis of equality and in accordance with the common but differentiated responsibilities and respective capabilities-

Global Climate Convention, Rio de Janeiro, 1992

1.0 Introduction

The declaration of Global Climate Convention, 1992 clearly portrays the vital need to protect the climate system which has witnessed an irrational acceleration in climate change threatening the future of mankind in recent times. It is a fact that climate is influenced by sunshine, temperature, precipitation, humidity and wind velocities. Usually, changes in the climate system occur slowly and are responsible for the existing bio-diversity on the planet. However, the last few decades have seen rapid changes in this phenomenal world such that flora and fauna have not been able to adapt to changing climate. Human activities are largely responsible for this and human induced climate change has been widely recognized as one of the major problems threatening the earth today. Though natural events such as volcano eruption and solar radiation contribute to some extent in increasing the global temperature, the rise is caused mainly by greenhouse gases such as carbon dioxide, methane, water vapour and other gases as a result of human activities induced factors. The present global warming is a phenomenon where there is an increase in earth's surface

temperature leading to a change in global climate, melting of ice glaciers and consequent increase in the sea level. Ozone depletion in the troposphere which is the lowest part of the earth atmosphere also contributed to warming of earth surface. Preventing dangerous climate change is the agreed ultimate objective of climate policy formulated in the 1992 U.N. Framework Convention on Climate Change. (UNFCCC) Therefore, the objectives of the paper are not only to find out how climate change affects ecosystem leading to degradation of life but also suggest a new paradigm of development that will be compatible with adaptation and mitigation strategies to reduce greenhouse gas emissions in order to achieve economic and environmental sustainability. Descriptive analysis has been used to find out ways and means to reconcile climate change with economic growth for a climate resilient carbon neutral development path.

The paper is presented in six sections. In section one; overall subject matter has been presented. Section two deals with global climate instability and its impact on the economy, environment and human development along with an outline on climate change mitigation and adaptation strategies. Section three highlights theoretical framework containing various theories of economic development and highlights the relevant climate resilient development paradigm suitable for carbon neutral growth. Fourth section discusses climate change effects as well as perpetuation of human development and poverty traps among developing countries of Africa and Asia, focusing particularly on Nigeria and India. Section five highlights how to shape climate resilient development path through green energy sources. Section six concludes and provides suggestions for carbon neutral economic growth to achieve global climate stability.

2.0 Section: Two

2.1 Causes and Consequences of Climate Instability at Global Level

Global warming is caused mainly by three factors such as radiation from the sun, earth's natural temperature cycle as a result of changes in earth magnetic field and the accumulation of carbon dioxide (CO₂) in the atmosphere. Climate change refers to an increase in average temperature on account of a rise in emission of green house gases; while emission of carbon dioxide are weighed in tonnes and gigatonnes (Gt=10⁹ tonnes), green house gas concentration in the atmosphere is monitored in parts per million (ppm) molecules of dry air. In the baseline scenario i.e., business as usual scenario, CO₂ concentration would rise from 27 Gt in 2005 to 62 Gt in the year 2050, corresponding to an increase from 379 ppm to 550 ppm of CO₂ in the same period as against the natural range of 180 ppm to 330 ppm. (Aswathanarayana, 2010). Similarly atmospheric concentration of methane gas has increased from 775 parts per billion (ppb) molecules of dry air in 1990s to 1732 ppb in 2005 as against the normal range of methane between 320 ppb and 790 ppb. (IPCC, 2007) This phenomenon of global warming takes place in the atmosphere between earth surface and the ozone layer which is about 50 km up in the atmosphere. ((Nakicenovic, 2001) Further, it is pointed out that temperature tends to decline with distance from the surface of the earth.

The existing ozone layer around the earth protects the world population from the radiation of sun. However, continuous increase in human activity on earth has led to an increase in green house gases and consequent formation of holes in ozone layer. The Intergovernmental Panel on Climate Change (IPCC) consisting of renowned scientists had been formed by the United Nations to study global warming and to submit reports periodically. The committee in its reports, has concluded that most of the rise in temperature since the mid 20th century was likely caused by

increasing concentrations of green house gases as a result of human activities such as increased consumption of fossil fuel and deforestation.(UNDP,2008) Though the plants and trees separate carbon dioxide into carbon and oxygen during the process of photosynthesis reducing the level of green house gases in the atmosphere, the level of reduction is insufficient on account of unlimited activities of deforestation. The above findings have been confirmed by a number of national academies of science and independent scientific societies. The temperature level depends on a number of factors such as afforestation, oceans, moisture levels, topographic and wind movement factors. Besides the above extreme climate events, social factors have also contributed to the vulnerability of poor people. IPCC reports highlighted further that climate model projection pointed out likely increase in surface global temperature from 1.1 to 6.4 degree Celsius in 21st century. (National Academy of Sciences, 2008)

Moreover, warming is expected to increase after the year 2100 even if emissions are stopped due to the vast heat retention capacity of the oceans and the prolonged life span of carbon dioxide in the atmosphere. (IPCC, 2007) Increase in temperature would lead to a rise in sea level and change the amount and pattern of precipitation causing flood in some areas and expansion of sub-tropical deserts in some regions. (Oreskes, 2004)

As the global warming debate is raging on for a long time, it is essential to know how the earth has become warmer and the general consequences of global warming. It is observed that due to global warming, an increase in sea level has resulted correspondingly in a rise in carbon dioxide level also, because oceans release more CO₂ as water level increases. Moreover, when there is less ice in the Arctic region, sun's rays are not fully reflected back and the earth absorbs more of solar rays leading to further increase in global temperature. Above all, industrial

expansions all over the world also have contributed to a larger share of carbon dioxide and various changes in the climate have been reported below.

1. Global surface temperature: It is reported that the earth surface temperature has increased by one degree Fahrenheit since 1950.

2. Melting of glaciers: Arctic sea ice level has declined during the period 1978 to 2007 by nearly 30 per cent according to the National Snow and Ice Data Centre.

3. Increase in sea level: Scientists have pointed out further that melting of ice raises sea level. In addition to this, when water warms up due to increase in air temperature, sea water also expands leading to further rise in sea level by 1.7mm per year for the period 1870 to 1992. However after 1993, the rate of increase in water level has doubled to 3.26mm per year due to acceleration in the process of global warming. (Mann and Emanuel, 2006)

4. Carbon dioxide level (CO₂): The level of CO₂ concentration in the atmosphere has also increased to 392 ppm during the period 1950 to 2010. (Levitus et al, 2000)

Climate disasters as seen above have been increasing in frequency and intensity affecting lives of many millions, particularly people living in poor countries. The catastrophic development setbacks are avoidable and the ability to control climate change is linked with the theory of economic development pursued by the individual country for its development as explained below.

3.0 Section: Three

3.1 Responding to Climate Change: A Revisit to Economic Development Theories

Climate changes have complex relationships with economic variables such as consumption, production and distribution. The global climate change has paradigm shifting implications for development theories which remain aligned with various schools

of economic thought in the last fifty years. Even as early as 18th century, Malthus expressed concern over increasing pressure of population and its consequent threat to food security and other resources. Neo-Malthusians argument also hovers around population pressure and the accompanying increase in human activities which would lead to resource scarcity and competition over the scarce means to sustain livelihoods. Extreme climate related events such as drought, flood and rising sea level would force the people to migrate to other areas as environmental refugees leading to human development reversals and greater competition and conflicts for the available resources in destination areas. However, optimist economists have argued that improvements in technology and efficiency would outstrip the constraints imposed by increased population while at the same time environmental degradation affects human wellbeing negatively. IPCC as well as UNDP reports have confirmed that global warming is caused by increased human activities such as excess fossil fuel consumption and deforestation. Therefore, this section discusses cardinal features of three main development theories relating to climate change.

3.2 Neo-Liberal Development Theory

Orthodox neo-classical market driven development policy followed by countries all over the world since 1980's has been based on two distinct features namely, growth of national income and high energy consumption. However, consequent climate catastrophes which have been witnessed so far have taken place as a result of high fossil fuel consumption and have necessitated the dire need for evolving an alternative paradigm of climate compatible development path. Neo-liberal policy has treated environmental effects of economic growth as externalities and ignored them until reaching a threshold level of income. Instead of integrating and balancing the objectives of national income growth and bio-physical resilience, the neo classical model emphasized

mainly on income growth through market forces and policy tools such as liberalization, privatization and globalization which have resulted in foreign direct investment (FDI) led growth rather than broad based industrial growth using endogenous productive capacity. Neo-liberal economic policies have apparently favoured Trans National Corporations (TNCs) and foreign investors with more incentives such as tax holidays and non-insistence of environmental conditionality for the operation of TNCs, overriding the interests of domestic manufacturers. The undue emphasis placed on the principle of comparative advantage in foreign trade under this policy has led to specialization of production in mono culture primary products rather than diversified agricultural products, low wage in manufacturing and extractive industries and jobless economic growth which are not conducive for the development of poor countries. (Rudrappan, 2004) The Ramsey-Cass- Koopmans growth model formulated on the basis of neo-classical model of Solow-Swan, emphasized physical capital based economic growth but it is also less sensitive to climate change effects.

3.3 Economic Development and Environmental Degradation: An International Experience

A widely discussed concept under neo-classical theory is that of Environmental Kuznets Curve which shows that as per capita income increases, environmental quality initially worsens but with continued increase in income, environmental quality starts improving, giving rise to an inverted 'U' shaped curve. Another reason attributed is that as economic development progresses, there tends to be a parallel progression in environmental regulation as one goes from little or no regulation at low levels of development to strong environmental regulation at high levels of economic development highlighting the enhanced role of institutional development and property rights. (Yandle et al, 2004) Ignoring safe ecological limits under the neo classical theory of

development will increase the risk of undermining long run prospects of development in the world as attested below by the IPCC report. Climate disasters have been increasing in frequency affecting the lives of many millions of people. Between 2000 and 2004, nearly 326 climate disasters occurred affecting some 262 million people on an average per annum. While climate disasters affect 98 per cent of people living in poor countries, the economic impact and losses have been reported mainly in rich countries on the basis of estimated insured losses as well as higher property values.

In view of the above, it is observed that the neo-liberal policy has several deficiencies as a result of which climate stability could not be restored through climate change mitigation and adaptation strategies. Focussing only on growth of income, old development theory has neglected sustainable livelihood of human beings, overlooked environmental sustainability and ignored sustainability of resources and the phenomenon of jobless growth. (Chang, 2009) Furthermore, the neo-liberal paradigm has treated climate and the natural environment as exogenous to economic forces and this has resulted in several social, economic and environmental disorders leading to the formulation of the following inclusive and sustainable globalisation theory of economic development.

3.4 Inclusive and Sustainable Globalization Theory

Emphasizing on environmental standards and best practices in all the production, distribution and marketing activities of TNCs along with many other features of market economy, the World Bank President Robert Zoellick has favoured inclusive sustainable globalization model with a pro-active government promoting and integrating local producers in the process of global supply chain. (Zoellick, 2008) In addition to stressing the role of public-private partnerships (PPPs) in promoting sustainable development

objectives which have been formulated at the 2002 World Summit on Sustainable Development, Johannesburg, this model also favoured Washington Consensus strategy of achieving economic growth with a human face, targeting mainly the poorest among the poor in developing countries. (WBCSD, 2007)

However, in the context of shortcomings of this model such as “neutral” industrial policies, this model also has had limited results in developing broad-based sustainable growth at the local region which is essentially required for resolving the challenges posed by climate risk and vulnerability. Therefore, an alternative paradigm of development has been formulated subsequently to cope with climate uncertainty along with its associated risks and vulnerability.

3.5 Climate Compatible New Paradigm of Development

Contributions of Alice Amsden, (2003) Chang, (2009) Johnson, Lyuba Zarsky, Robert Wade and Sharukh Rafi Khan (2011) have advocated a new development agenda and they tried to create virtuous cycles of prosperity in the place of vicious cycles of poverty through the process of institutional development. Besides emphasizing on higher growth of national income with emphasis on social justice, the objective of the new paradigm is to encourage endogenous productive and technical capacity of socio-economic and institutional structure with a pro-active industrial policy pursued by the government for transformation and diversification of the economy so as to capture the benefits of global market economy both in domestic and foreign trade. (Rodrick, 2007) While focussing more on overcoming market failures which inhibit economic development, climate compatible model advocates government's strategic role in partnership with TNCs to promote quality foreign direct investment (FDI) in industrial development in low carbon and zero carbon green energy sources which will promote employment. The model not

only restricts investment in high resource-use, high energy-use and industries which results in high pollution but also encourages mobilization of domestic savings for channelling it into investment in local broad based productive capacity based on sustainable livelihood, sustainable resource use and environmental protection with cleaner production processes. It is pointed out further that this type of investment will pave the way for the promotion of social solidarity coupled with economic and environmental sustainability.

Among the three development models discussed, the above climate resilient development model has been found robust since it contains critical components namely economic growth, social equity and environmental sustainability and designed to go along with climate change mitigation and adaptation strategies because of its sound features of building an endogenous productive capacity with an inclusive growth and a strong role for the government which alone will enable carbon neutral development trajectory reducing climate risks and vulnerability. The truth is that in the race for rapid economic development among the world countries, environment is often neglected. As a result major environmental challenges faced so far were forest and agricultural land degradation, resource depletion such as water, mineral, forest, sand, rocks, environmental degradation, public health, loss of biodiversity, loss of resilience in ecosystems and the livelihood security of the poor.

It is observed that climate change is global but its effects will be local. Extreme climate events threaten developing countries more intensively because these countries lack sufficient financial and technical capabilities to manage climate risk. Addressing these needs will not be easier for developing countries as development will get harder with climate change. The forces generated by

climate change will be superimposed on the world marked by deep and pervasive human development deficits and disparities that divide the 'haves' and 'have not's'. IPCC projections show that the resilience of many ecosystems will be undermined by climate change. With the increase in temperature beyond 2^o C, the world will be facing unprecedented losses of biodiversity and the collapse of ecological systems which are intrinsically bad for both human and economic development during the 21st century. To avoid this, it is essential to adopt climate resilient development path through green energy sources described in subsequent chapters.

4.0 Section: Four

4.1 Climate Change and Perpetuation of Human Development Traps and Poverty Traps

Dangerous climate change has the capacity to deliver powerful systematic shocks to human development across poor countries though the industrialised nations are the major culprits of climate change. Reports pointed out that the entire continent of Africa contributes only about four per cent of carbon dioxide emission. However, climate change caused by the engulfed carbon dioxide around the globe not only affects growth but also impacts human development in diminished productive potentials, lost opportunities for health and education and in lost vital ecological system which are likely to prove irreversible. Deteriorating nutrition generates threats such as increased vulnerability to illness and fewer resources for medical treatment. Research studies pointed out that Lesotho and Swaziland in South Africa reported reduced health spending among 50 per cent of household during the 2002 food crisis. The state of reduced spending can have fatal consequences in the future life of poor people, particularly among children. Zimbabwe also demonstrated in its household survey analysis that climate shocks impact longevity of human

development. The incidence of illness increased by 16 per cent among children whenever drought occurred and whenever there was flood, illness increased by 40 per cent. (UNDP, 2008) The survey found that droughts between 1982 and 1984 had reduced average height of children by 2.3 cm and resulted in a loss of 0.4 years of schooling among children. Impact was severe among children in Zimbabwe because their households had few livestock to depend on which was considered as the main access to self insurance for poor people. Even this self insurance mechanism of poor people often failed when extreme events such as severe drought and flood destroy their livestock and other properties.

The above experience explains the transmission mechanism from climate shocks through nutrition to stunted growth and educational deprivation into long run human development losses. Changes in agricultural yield as a consequence of climate change will force many people to migrate to other parts of the world leading to spread of diseases, displacement of people as environmental refugees, social conflicts and consequent increase in poverty levels. Besides direct and indirect impact of droughts, floods and other climate shocks, they also interact with wider forces that hold back the development of human capabilities. Self reinforcing cycle of low productivity, low income, low savings, and low investments perpetuate poverty trap. Similarly, poor health and limited opportunities for education on account of climate shocks restrict opportunities for raising productivity levels and pulls down further to acute poverty. Poverty trap refers to threshold level for assets or income, below which people are unable to build productive assets, educate their children, improve their health and nutrition and increase in income. Capability of poor people is reduced along with their ability to participate in decision making process and to face problems such as unemployment, civil conflict and deceptions. Thus, climate disasters are the most potent forces sustaining low human development traps.

Besides the above, droughts and floods are often catalyst for a wide range of health problems such as diarrhoea, cholera and acute malnutrition. Water borne infectious diseases are also strongly influenced by climate and diseases spread rapidly in warm climate just like malaria which is known as a vector borne disease. Climate shocks pose main threats to the poor people in terms of their health and labour. Climate change interacts with human health in diverse ways. Those least equipped to respond to changing health threats- predominantly poor people in poor countries- will bear the brunt of health setbacks. Generally, ill-health is one of the most powerful forces holding back human development potential of poor households and the overall impact of climate change will be negative as attested by the reports of World Health Organisation.(WHO) Extreme climate events provide another set of worst threats. Floods, droughts and the storms bring in their wake increased health risks such as cholera and diarrhoea among children depriving their growth and education. There is already evidence in developing countries of the severe impact of rising temperature. During 2005, Bangladesh, India and Pakistan faced temperatures five to six degree Celsius above the regional average. As a result of excess heat, there were 400 death reports in India alone, though unreported deaths would multiply this figure many times over.

4.2 Coping with Risks and Vulnerability of Climate Shocks

As seen above, climate change creates risks such as droughts, floods, storms, which have the capacity to disrupt the lives of people through loss of income, assets and opportunities making them more vulnerable. However, vulnerability is different from risks. Whereas risk is about exposure to external hazards over which people have limited control, vulnerability is a measure of capacity to manage such hazards without suffering a long term, potentially irreversible loss of well being. High levels of economic dependence on agriculture, lower average incomes, fragile

ecological conditions and locations in tropical areas that face more extreme weather patterns are all vulnerable factors impeding human development.

Indian Noble Laureate Amartya Sen pointed out that human development refers to extension of freedom of choice. However, it is observed that climate change reduces people's freedom of choice halting human development further. Climate disaster affects livelihood by wiping out crops, destroying properties, reducing opportunities for employment and increasing prices of all commodities. Rich people can manage climate shocks by getting private insurance, by de-saving or by selling their properties. However, in developing countries poor people do have neither insurance cover nor tradable assets. It is observed that poor people also develop some sort of self-insurance mechanism against climate risks. One of these mechanisms is to build up assets such as livestock for sale in the event of crisis. Further, they use their meagre resources in disaster prevention by building walls and maintaining drainage channels. Another form of self-insurance is diversification of production and income. Research reports prove that Indian and African farmers seek to reduce their risk by producing drought resistant crops such as sorghum and cassava which provide more food security with a lower financial return and also by inter-cropping food staples with cash crops as well as by engaging in small trade. However, in the event of severe climate shocks, self-insurance mechanism often breaks down forcing the impoverished people to lead a vulnerable life in different parts of Africa and Asia as shown in the following map.

4.3 World Climate Change Vulnerability Index Map, 2010

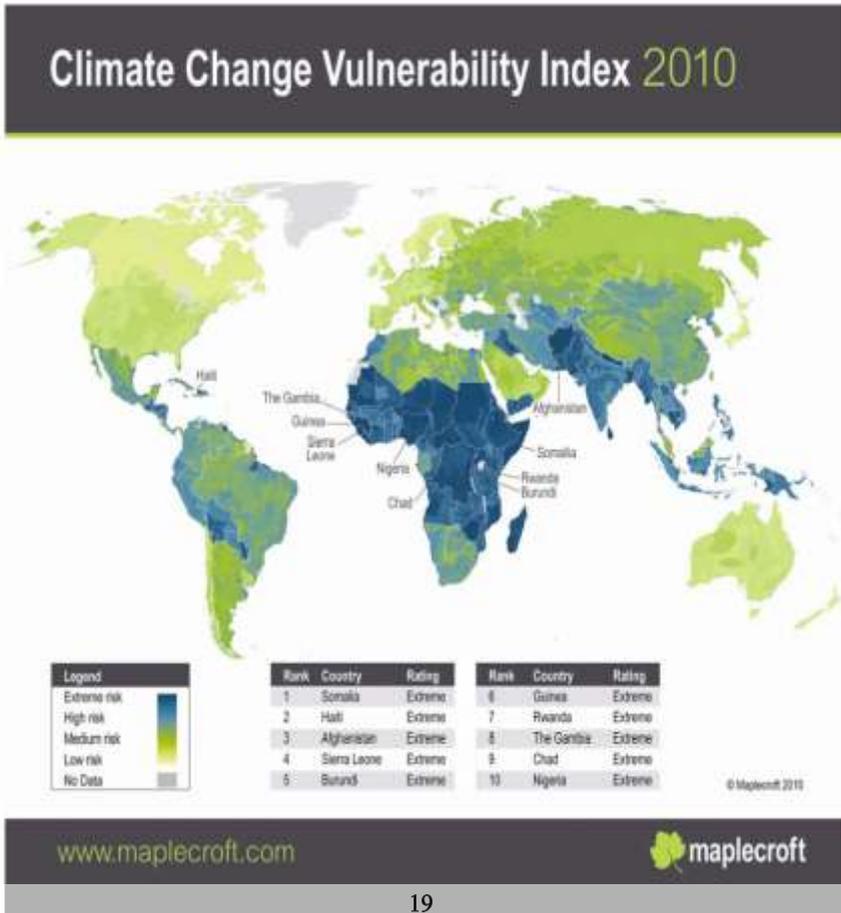
The Canadian Maplecroft group has published a Climate Change Vulnerability Index (CCVI) map, 2010 in the following Figure: 1 displaying vulnerable countries of the world based on bio-physical

natural hazards and the capacity of those regions to cope with risks and vulnerability unleashed by climate shocks. Climate Change Vulnerability Index ranks world countries on their capacity to mitigate risks to society and the business environment posed by changing patterns in natural hazards such as droughts, floods, storms and sea level rises and the resulting effects on ecosystems. The climate change vulnerability factors are taken into consideration under the following six groups: 1) economy; 2) natural resource security; 3) ecosystems; 4) poverty, development and health; 5) population, settlement and infrastructure; and 6) institutions, governance and social capital. The CCVI was calculated using a Geographical Information System (GIS) model. Each cell represents an area of approximately 25km². (Maplecroft, 2010) Vulnerability index maps would portray vulnerability of individual countries annually based on changing climate conditions in different regions; therefore vulnerability ranks assigned to countries would also vary under different years.

The following climate vulnerability map for the year 2010 reveals the most alarming fact that most of the ten countries which are facing extreme climate risk and vulnerability are located in Africa and Nigeria is one among them. The catastrophic human development setbacks described in the climate change vulnerability index map, 2010 are avoidable through the two requirements listed below for changing the 21st century scenario to a more favourable direction. The first is climate change mitigation. Without early mitigation measures and deep cuts in the emissions of CO₂, dangerous climate change will happen certainly and it will destroy human potential on a vast scale. The consequence will be reflected in surging inequalities within and across countries and rising poverty. Rich countries may escape the immediate effects, but will not escape the consequences of anger, resentment and transformation of human settlement patterns that will accompany dangerous climate change in poor countries. The second

requirement set out is adaptation. Adaptation is ultimately about building the resilience of the world's poor to the climate change problem largely created by the world's richest nations.

Figure 1



In 2006, Nicholas Stern, head of the United Kingdom's Government Economics Service presented his report on Economics of Climate Change to the British Government where he has advocated climate change mitigation as one of the cardinal objectives. (Stern, 2007) The stern report stated that if we don't act, the overall costs and risks of climate change would be equivalent to loosing at least five per cent of global GDP each year now and forever. If a wider range of risks and impact is taken into account, the estimates of damage could rise to 20 percent of GDP or more. In contrast, the costs of action reducing GHG emissions to avoid the worst impacts of climate change can limit to around one per cent of global GDP each year. Therefore, all out efforts have to be taken for climate change mitigation globally in view of its low cost. A sustainable emission pathway will be meaningful only if it is translated into practical national strategies and national carbon budgets among all countries. Many European Union countries have credible targets with a few countries like Canada and USA fall short of the target laid down under the Kyoto Protocol.

Climate change mitigation target should also be transformed into policies which are considered more challenging politically. The starting point of mitigation is putting a price on carbon emissions in the following two ways: 1) Tax on carbon dioxide emissions which could be used to support wider environmental tax reforms. 2) Cap-and-trade where the government seeks an overall emission cap and issues tradable allowance that grant business the right to emit a set amount. (Christopher & Robert, 2009) Those who can reduce emissions more cheaply are able to sell these allowances. Therefore, carbon markets are an essential condition for the transition to low level carbon economy. Moreover, the governments have a critical role in fixing regulations and in supporting research and development for a carbon neutral economic growth. The USA has used tax instrument to increase the development of renewable

wind power energy source. IPCC has advocated enhanced energy efficiency to reap double dividend not only by lowering carbon dioxide emissions but also reducing energy cost in sectors like automobile. The automobile sector which accounts for more than 30 per cent of green house emissions in rich countries, adoption of regulatory standard is a must to unlock double dividends.

In addition to this, international trade could also play a major role for the development of alternative fuel such as ethanol which is more efficient in cutting carbon emission as seen in Brazil. Another key for mitigation is carbon dioxide capture on storage (CCS) which helps coal fired power generation with mere zero emission. This breakthrough CCS technology should be developed and deployed more rapidly around the world. Adaptation of climate mitigation policies requires proper planning and implementation capacity. However, this is lacking in poor countries as a result of absence of social protection, insufficient infrastructure and inadequate climate related risk information.

4.5 Adaptation Strategy for Climate Change

Response to global warming requires immediate curtailment in the level of future climate change through adaptation. The aim of adaptation is to increase the climate resilience of communities by enhancing their capacity to cope with less predictable rainfall patterns, more frequent droughts, stronger heat wave, different diseases and weather hazards. It is the responsibility of all governments to develop strategies and projects that will enable people cope with changes occasioned by climate change. Several countries have been implementing adaptation projects by building resilience among the people through federal, state, local governments as well as with the help of non-governmental organizations and local community groups. The adaptive capacity of a country depends on five forms of livelihood capital-physical, natural social, human and financial capital as well as on access to

technology, access to information on climate variability, capacity of institutions, equitable distribution of resources, and international cooperation. However, in view of inadequacy of above factors among poor countries, many African and Asian countries are not able to build up adaptation capacity of communities sufficiently.

4.6 Climate Change Mitigation and Adaptation in India and Nigeria

Cooperation among world countries is essential for climate resilient development path. Strong economic, cultural and trade cooperation exist between India and Nigeria in addition to the existence of similarities between the two countries as listed below.

1. Both are developing countries having democratic form of governments and rule of law. While Nigeria is the economic power house of Africa, India is considered as the economic giant of Asia.
2. Nigeria is the mostly populated country in Africa with 150 million; while India is the second mostly populated country of the world with more than 1210 million.
3. Both countries possess similar climatic features because they are tropical countries depending to a large extent on climate sensitive sectors like agriculture, forestry and fishing for livelihood. Any adverse impact of climate change would threaten food security and livelihood of people. Furthermore, poor infrastructural facilities, weak institutional mechanisms, lack of financial resources and vast sectoral and regional climate variability adversely affect the adaptive capacity and vulnerability in both the countries.
4. Climate change have manifested itself in gradual changes in temperature, precipitation and a rise in the sea level resulting in changes in frequency, intensity and duration of climate shocks in both the countries.

5. Climate change has impacted different regions and sectors differently in Nigeria and India based on their levels of sensitivity, resource endowments and adaptive capacity and ultimately on their vulnerability.
6. Both Nigeria and India are signatories in all Climate Change Accords and therefore they have the responsibility to implement various proposals relating to climate change adaptation and mitigation strategies.
7. Poor people rely on solid fuels such as dung, wood, crop waste for the traditional methods of cooking, lighting and heating which are the sources of indoor pollution causing respiratory diseases including pneumonia and lung cancer which account for 20% of mortality particularly among women and children both in Nigeria and India. Consequently both countries suffer in human health deterioration particularly, spread of malaria as a result of increase in temperature. The fit analysis carried out in Nigeria indicated that there exists a strong correlation between incidence of malaria and temperature ($R^2=0.8$) for a given condition of humidity.
8. Under the global climate regime, Nigeria and India figure as Non-Annex I developing nations and thus they are not bound by qualitative emission reduction target. Even so, India acknowledges its substantial role in addressing the threats by formulating a National Action Plan for Climate Change comprising eight national missions and adaptation strategies.

4.7 Climate Change Action Plan in India

After climbing up steadily for at least two decades, India's green house gas emission began to decline rapidly after 1995 suggesting the start of decoupling process of environmental challenges and economic growth, as has occurred historically in rich countries at higher per capita income levels in terms of Kuznets inverted 'U'

curve. India's per capita emission ranks among the lowest averaging only 25% of the world and 5 % of USA's present emission. Furthermore, pressure from citizens activists and Government's policies driven by environmental challenges have reduced green house gas emission further.

In terms of UNFCC Accord, Kyoto Protocol, Marrakesh, Copenhagen and Cancun accords, several measures are being undertaken in India, which contribute to GHG mitigation. Some of them are:

1. Establishment of the Technology Information, Forecasting and Assessment Council under the Department of Science and Technology, which facilitates the transfer of environmentally sound technology.
2. Extensive efforts in conservation of forests and biodiversity.
3. Involvement of a number of governmental and independent agencies in climate change research in India
4. Using satellite data received from INSAT, cloud imageries will be projected. This will be used to derive cloud motion vectors, sea surface temperatures, and outgoing long wave radiation which in turn would be utilized for formulating mitigation measures.

To achieve the above mitigation strategy, following eight missions have been established focusing on promotion of understanding of climate change, adaptation, mitigation, energy efficiency and natural resource conservation.

1. National Solar Mission: In view of India's position in the equatorial Sun Belt getting abundance of solar power throughout the year, generation of more solar power has been given much importance.
2. National Mission for Enhanced Energy Efficiency: The

industrial sector of India which has been consuming 42% commercial energy emits 31% of total CO₂. Therefore, the mission aims at increased energy efficiency in this sector.

3. National Mission on Sustainable Habitat: The aim of the Mission is to make habitats more sustainable through improvements in energy efficiency of buildings to achieve 30% electricity savings in new buildings, management of Municipal Solid Waste (MSW) and urban public transport
4. National Water Mission: As water becomes a scarce resource, the National Water Mission aims at conserving water, minimising wastage and ensuring more equitable distribution through integrated water resource management and modern irrigation techniques.
5. National Mission for Sustaining the Himalayan Ecosystem: Land-use planning and water-shed management practices for sustainable development of mountain ecosystems have been formulated.
6. National Mission for a Green India: Aiming at enhancing ecosystem services such as carbon sinks, it provides for Green India campaign for afforestation of 6 million hectares and the national target of increasing land area under forest cover from 23% to 33%.
7. National Mission for Sustainable Agriculture: The objective is to make Indian agriculture more resilient to climate change by identifying new varieties of climate resilient crops, especially thermal resistant ones and alternative cropping patterns.
8. National Mission on Strategic Knowledge for Climate Change: Apart from usual budget grants, the mission aims at establishing a special Climate Research Fund also to promote research in climate change and related field in collaboration with global community.

Implementation: Each mission has to be implemented by the

respective ministries and the progress made by them would be submitted to the Prime Minister's Council on Climate Change annually for evaluation. Further, India is an active participant in the Clean Development Mechanism (CDM) established by the Protocol and has more than 500 registered CDM projects accounting for about a third of all global projects and most of them are bio-mass and renewable energy projects. Under a CDM project, all incandescent bulbs in residences will be replaced into compact fluorescent bulbs. The price differentials will be recovered by the role of carbon credits. It is estimated that this will reduce 24 million tons of CO₂ annually.

Under transportation, the government has directed all new four wheeled vehicles should comply with Euro IV standard emission norms and heavy vehicles should use Compressed Natural Gas (CNG) in big cities. For mass transit in urban areas, metro railways are being built up. The government also has introduced bio-fuel in the form of ethanol-blended gasoline and provides incentives for the production as well as commercialization of bio-fuels.

The “Perform Achieve and Trade”(PAT) scheme launched in April 2011 is an energy saving mechanism based on emission certificates targeting key industrial sectors with trading scheme. Despite no binding emission targets, Government of India acknowledged that it has a major role to play in global mitigation efforts in line with the principle of common but differentiated responsibility and respective capability. As such, India took on the voluntary target of reducing its carbon intensity by 25%. India's vision is to build a self-sustaining prosperous economy in terms of its capacity to unleash the creative energies of its people and the country is mindful of its responsibility to both present and future generations.

4.8 Climate Change and Policy in Nigeria

Nigeria also contributes a small quantity of green house gases to the depletion of ozone layer, emitting 100 million metric tonnes annually with a global rank of 43rd in the list of global emitters. The breakdown of emission in the country is as follows: gas flaring 30 per cent, transport 30 per cent, generators and lamps 20 per cent, industry 12 per cent and deforestation 8 per cent. The operation of generators totaling nearly 80 million in number not only emits green house gases but also adds indoor death caused by monoxide and intolerable noise pollution. (Sulaimon Salau, 2010) Nigeria's environment suffers from a number of environmental challenges such as acute deforestation, expansion of the Sahara desert in North forcing 100,000 families to migrate to south Nigeria as environmental refugees and environment pollution caused by gas flaring and production of crude oil in Niger delta. People living in Niger Delta region have become vulnerable as a result of erratic weather conditions and unpredictable rain fall. It is estimated that Sahara desert has been advancing into ten northern states at an average rate of 600 metres per year affecting nearly 60 million people on account of loss of 0.4 million ha of farm land due to desertification, deforestation, overgrazing, acid rain fall, respiratory diseases and higher temperature. Furthermore, research has shown that along the Nigerian coast, the sea level has increased at the rate of 46.2 cm between 1960 and 1970. Increasing sea level due to global warming has been threatening people living in low lying coastal areas of South West Nigeria, particularly in Lagos. Half of the population accounting nearly eight million faces the danger of sea erosion in coastal region of Lagos. The natural protective system in the form of mangroves in the coastal area and wetland ecosystem in many parts of Lagos have been reduced considerably mainly due to sea erosion and human settlement. As a result of these extreme climate events, eighty seven million farmers face the problem of food security and deepening rural poverty. (Rudrappan, 2010)

The Minister for Environment has stated that the government would be raising 40 million trees comprising mainly of economic species across the various eco-climate zones of the country to combat diversification as well as to provide jobs to Nigerian youth. Among the Nigerian states, only Cross River state has been pursuing the Reduced Emissions from Deforestation and Forest Degradation (REDD) programme successfully for the last few years. Green house gas emission of Nigeria, if reduced through the implementation of nearly some 750 projects identified by the World Bank under Clean Development Mechanism, (CDM) it would fetch the country 20 Euros per ton of green house gas which would lead to nearly one billion Euros as carbon credit which could be traded at the global carbon market for a 100 million tonnes of carbon emission reduction in Nigeria.

As a response to the growing disasters caused by the climate change, a bill for establishing a National Climate Change Commission has been passed by the National Assembly and sent for the assent of the President during December, 2010. The bill has not become a law till date and in all probability, it would be returned to National Assembly. In the absence of a commission, Nigeria is yet to formulate a suitable national climate change policy and strategy and the likely cost of this delay will be huge for the farmers, investors and the economy as a whole. However, in compliance with the requirement of Kyoto protocol, a Presidential Implementation Committee has been established under Federal Ministry of Environment for clean development Mechanism activities in Nigeria. The Committee while promoting CDM provides guidelines, procedures and keeps a register of approved CDM projects. For the formulation of a national strategy, various pilot projects are being undertaken across the three agro-ecological zones of Nigeria, mostly the coastal and rain forest zones in the south, the Nigeria Sahel and northern savannah. The projects will test local adaptation strategies that include finding alternatives to

deforestation, controlling erosion, conserving water and developing long term community adaptation plans. On the basis of these projects, it is expected that the proposed commission will coordinate national response to climate change amongst government agencies reducing the cost of governance and promote, regulate and develop a carbon market, besides developing a national climate change strategy for a carbon neutral economy in Nigeria. As Nigeria aspires to become one of the top-tier 20 economies of the world by 2020, as articulated in the Vision 20:2020, climate change necessitates putting the country onto an equitable climate resilient sustainable development path by formulating a suitable national strategy.

4.9 Climate Change Action Plan at *Covenant University*

As a university with world class standards and numerous awards as the best university of Nigeria, Covenant University has its own action plan for climate change. It has established a creative eco-social platform known as 'Hands in Green'. This unique initiative is designed to inspire support for climate change mitigation both within the university community and outside the campus to promote awareness about establishing a pollution free natural environment. 'Hands in Green' initiative is a University best practice that has the following measures as its operational framework.

1. Open sky: Once in a semester, the university organizes an awareness programme for a week. All participants have to wear green dress or a tie or a band around their hand and assemble in the vast garden of the campus for an highly interactive discussion to promote awareness on reducing global warming phenomenon.
2. Walk a thon program: All staff members will be encouraged to walk to their offices leaving behind their

- cars at home for reduction of CO₂.
3. Exhibition: An exhibition would also be organized to show case ideas and inventions relating to economic and the social preservation themes of climate change.
 4. Discovering Earth: The University organises a series of lectures during the awareness programme week on climate change, effects, mitigation and adaptation strategies in addition to celebrating all important world events such as world earth day, bio-diversity day and world water day.

Furthermore, the university has decided to convert waste into wealth by constructing a controlled dumpsite facility as well as a compost project on a two acre land for organic and other wastes for the production of organic manure in addition to promotion of clean environment at its sprawling campus. Thus, Covenant University has become a model in not only advocating climate resilient policy prescriptions but also translating them into reality.

5.0 Section: Five

5.1 Shaping Climate Resilient Development Path through Green Energy

A new political climate has grown in many countries around the world, thanks to the strong base in science and widening public awareness of climate change and its risks. The adoption of Renewable Energy Technologies (RETs) constituted a win-win situation, as renewable is not only green and job-generating, but also sustainable with a higher environmental benefit. Renewable fuels such as wind, solar, biomass, tides, and geothermal are

inexhaustible, indigenous and are often free as a resource. They just need to be captured efficiently and transformed into electricity, hydrogen or clean transportation fuels. The renewable energy sources have hardly any carbon footprint and environment friendly and do not require environmentally-damaging mining and transport. "Green energy" is a term used to describe the energy that is generated from the sources that are known to be non-polluting. For these reasons, "green" energy should be considered as the energy of the future. Most are related to sun in some way. Sunlight produces solar energy directly. It indirectly produces hydropower (through the movement of rain water), biomass (through photosynthesis) and tidal power (through tides caused by moon and sun). It is estimated that the share of total renewable sources in the world primary energy supply in the year 2005 was 12.7%, the share of coal 25.3%, oil 35.0% and natural gas 20.6% and hydro 2.6%.

Algae can also be used productively to produce not only several kinds of fuel end products, but also by-products which have wide ranging applications in chemical and pharmaceutical industries. They can be mass produced using land and water which are unsuitable for raising plant and food crops. They are energy-efficient and consume carbon dioxide; thereby reducing the level of global warming considerably.

"Bloom Box", recently unveiled by K.R. Sridhar, an Indian American has the potential to revolutionize electricity production. It is a fuel cell device consisting of a stack of ceramic disks coated with secret green and black "inks". It can convert any renewable and fossil fuel such as natural gas, biogas, coal and gas into electricity round the clock. Since no combustion is involved, there would be no noise, smell or emissions. (Fells, 1990)

Renewable technology favours decentralization and more importantly attempts to seek local solutions to local problems, independent of the national network. This process enhances the

flexibility of the system thereby spreading the economic benefits to the scattered population, who are often small in number. Several studies have pointed out that seventy-five percent of the world's energy supply is used by only 25 percent of the people living in wealthy and industrialised economies. (OECD, 1995) However, it is usually the under-developed or developing countries that face the maximum risk from climate-related threats. Therefore, the investment in green energy supply and progress should be encouraged by governments of all countries and other authorities for green energy replacement of fossil fuels which are far more environmentally benign for a sustainable future. One of the initiatives that gained political support from various countries at the Copenhagen Summit (2009) was the Reduced Emissions from Deforestation and Forest Degradation (REDD) programme. REDD programme involves supporting developing countries financially to conserve rather than clear tropical forests. Twenty-five years ago, methanol was vigorously promoted. Then came the phase of electric vehicles, the hybrid-electrics, the fuel cells, and the ethanol and finally to plug-in hybrids today.

There are ways of addressing poverty in the context of environment and climate change. Lack of economic opportunities forces people to exploit the natural resources around them unsustainably, leading to destruction of forests and other carbon sinks. Income poverty leads to inefficient use of energy in households, and the absence of electricity and clean fuels for the household use drastically reduces the productivity and socio-economic well being of the people. This can be overcome by combining poverty eradication and development projects with climate change mitigation programs. Investing in these green energy technologies which are sustainable in the long run will generate millions of jobs, revive the economy and bring overall socio-economic development. Thus, eradicating poverty through the alternative paradigm of development can also be made a part of climate mitigation action.

6.0 Section: Six

6.1 Conclusion

The foregoing discussion has led to the following important suggestions that have to be adopted in order to achieve the goal of zero net greenhouse gas emission that will be needed to achieve climate stability.

1. Innovative renewable new technologies that maximize the production and the use of carbon-free energy while minimizing cost and optimizing communions.
2. Slow growth of world population for reducing anthropogenic activities as well as adoption of climate resilient crops and farming systems to achieve global security.
3. Healing degraded or destroyed forest land so that soil and vegetation can serve as powerful net removers of the atmosphere's carbon and greenhouse gases.
4. Adoption of participatory approach to water management, forest management and rural development in general for carbon sink enhancement and promotion of sustainable development.
5. Active community participation is essential for effective implementation of adaptation and mitigation strategies. For this, members of communities should be given training for skill development to manage weather vulnerabilities as Climate Risk Managers of each local community.
6. An institutional mechanism such as Climate Innovation Centre should be established for developing / adopting technologies and products for climate mitigation and

adaptation purpose.

7. Three most efficient solutions for solving global warming such as monitoring on deforestation, universal carbon tax and international cooperation are essential.
8. Above all, good governance with strong institutions along with economic stability and political stability are required.

However, for the first half of the 21st century, there is no alternative to adaptation to climate change. Almost all countries have signed the Kyoto Protocol of the United Nations Framework Convention on Climate Change to stabilize the emission of greenhouse gases at a level which will ensure (a) adequate food production, (b) natural adaptation of ecosystem to climate change and (c) sustainable development. The Kyoto Protocol which came into force in 2005 ensures legally binding emission limitations for the developed countries and the same anyhow, will not apply to developing countries. However, the global economy needs international cooperation now than ever for achieving a climate resilient development path. Therefore, for the common good of all countries, both developed and developing should come forward to make concerted efforts to reduce green house gases as a response to buying insurance against future catastrophic changes. Climate mitigation and adaptation strategy should be reframed as an agenda of hope, growth, innovation, opportunity and an instrument for poverty reduction. Therefore, it is concluded that there is no time left to relax and all countries have to redouble their efforts to scale up climate change mitigation and adaptation initiatives that would enable them to embark upon a carbon neutral high growth for a socially equitable climate resilient sustainable development.

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