PERSPECTIVES ON GLOBAL CLIMATE CHANGE: FACING THE CHALLENGES BY THE APPLICATION OF SCIENCE AND TECHNOLOGY

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INTRODUCTION

Climate change must have started with the disruption by man in the Garden of Eden when the forbidden fruit was plucked and the perfect order of nature was disrupted and man started the search for survival with his competitors within the wide and limitless ecosphere. The flood experienced during Noah's era in the Bible, might have had climate change connection as issues of climate change have been seen both as secular and spiritual. A farmer in Burundi expressing frustration in the vagaries of climate recently said "it can't be that the sun and the rain are taking their turn to strike us, perhaps, it is that there are many sinners in our midst and God is trying to punish us" (Nshimirimana, 2008).

Climate change, environmental degradation and exposure to natural disasters appear to be the greatest challenges facing humanity today particularly when considering global agricultural and rural development challenges. Over the several millennia of human existence, climate change has become a dreaded phenomenon. Speaking to the African, Caribbean and Pacific (ACP) group of countries in 2008, the Director of the Technical Centre for Agricultural and Rural Cooperation (CTA), Dr Hansjorg Neun said, "Climate change strikes us at the core" (Spore, 2008). According to him CTA has been working with and will continue to work with its constituents to be able to cope with the challenges of climate change since more than 70% of those living in the ACP countries work in agricultural sector and climate change for them is not a theoretical discussion, it is the difference between life and death.

At our local levels, we hear and experience several climate and environment related problems such as floods, excessive destructive rainfall, cold and hot weathers, off season rains, prolonged drought, overflowing rivers, etc. The "Nation Newspaper" on Sunday, September 23, 2012 stated thus "Flood, flood everywhere. From Kogi to Benue and from Edo to Ebonyi and Bauchi to Kano the story is the same; floods, water, destruction, displacement, death and agony. Across all the regions of the country - North, South, East and West, the story is the same. The heavens have opened up as if a fury and the water have fallen ceaselessly, dams have been bursting, some have been opened up to forestall collapse and the fury of the waters have been wreaking havoc". ------"The heavy downpour has cast a dark and gloomy shadow over the expected joy of bumper harvests by farmers across the country. This is besides the threat to lives and properties as well as displacement leading to serious health hazards. This is coming on the heels of warnings by weather forecasters in 2011 and 2012 that heavy rains are expected".

A conference of this magnitude and focus must therefore go beyond the usual theoretical considerations to creating and building networks and linkages for practical actions to confront the impact of climate change on the most vulnerable groups-the poor, the sick and weak people, women and children, those who live by cultivating the land and rearing animals, harvesting from the wild, (water and forest resources), conserving biodiversity, local extractive industries, artisans, craft men, development giants, etc.

GLOBAL WARMING AND CLIMATE CHANGE

Disbelief

As the world is feeling the expressions of global warming and climate change, there are skeptics who belief the whole concept and phenomenon of climate is all a hoax unreal and sometimes confusing. The internet is awash with several comments and a few of such will suffice.

"I've had professors admit that the only reason they support global warming is so they can receive grant money for their studies. It's a hot topic so the government is willing to hand out the cash. These same professors also proved that we are in a cooling cycle using the same data they used to support global warming. It's all in the presentation. The amount of data used to project temperature change is so statistically insignificant it is irresponsible to call for dramatic social change. More study needs to be done to prove that man is causing climate change". (*Hank Risen, 2008)*

"The honest scientists are right, Global warming is a massive global con. Who is behind it, greedy governments, mad scientists, or the stirring media? At the moment we have global cooling. It has been proved beyond a doubt. If you tell a lie often enough, some people will believe it. NOT I. Or millions of other people worldwide. ------"(*Malcolm, 2009).*

"I have just been watching a program on tv titled "X-Ray Earth". It shows how satellites can see earth and map the CO_2 over the planet. A computer model shows an 8% increase in CO_2 and the animation showed how the earth is heating up in the last 10 yrs. But wait! ---------"We are being lied to by scientists that show us what they think might happen not what is happening. They only lie to us because they need the funds". *(Steve Francis, 2011)*

"If you people paid attention during elementary science class plants need carbon dioxide to survive, they use it to create food. The earth and everything else in nature including humans has a balance more CO_2 equals more food for plants equals more plant seeds equals more plants and the cycle continues. Is the earth warmer now than it was years ago? Yes it is, but it is also cooler than it was as well. It is a natural cycle to warm and cool". (*Jimmler, 2011)*

"I stumbled on this site while doing a research on global warming and I honestly am confused regarding this matter. Whether it's a myth or not, the adverse effects are being felt in most parts of the world at present and arguing whether it's real or not is not helping at all. Instead, people should be coming up with ways to mend the ozone layer which is deteriorating each single day otherwise; you will really feel the wrath of nature. Bear in mind, nature can be cruel and it does not forgive. (*Megan Edward, 2012)*

What is involved in Global Warming and Climate Change?

Climate change as a global phenomenon arises from changes in weather patterns and gradual increase in the temperature of the earth over time due to actions and inactions of humans. The resultant effects being witnessed globally include violent cyclones in the Caribbean region, floods in Africa, gradual sinking of islands in the Pacific region, heat waves in Europe, melting of glaciers in the Alps, ocean surge in Nigeria, etc.

Spore (2008) reports that alarm on climate change was first raised within the last three decades with the first report of International Panel on Climate Change (IPCC) dated 1990. It also states that the earth's temperature has risen by 0.74^0C with massive consequences. The regions of the Northern Hemisphere have seen the greatest temperature rises; they now have fewer very cold days in the winter and more very hot days in the summer. Also, since 1993, sea levels have risen by an annual average of 3.1mm. Furthermore, since the industrial age and the 1900s, it has definitely rained more in North and South America, Northern Europe and Central Asia, and

less in South-east, the Mediterranean basin and the Sahel. Intensive tropical cyclones have become more frequent in the North Atlantic.

What is happening has also been explained by Spore (2008) thus 'each day, the sun emits rays of light onto the Earth's surface. The Earth absorbs part of their heat, reflects another share into the atmosphere and sends out a third share in the form of infra-red rays. These rays are cushioned by the clouds and water vapour, which stabilizes the Earth's temperature. The problem being faced today is that the concentration of greenhouse gases (GHGs) produced by human activities has increased significantly. These GHGs trap a greater quantity of rays which are reflected on the Earth and cause it to heat up- this is the infamous greenhouse effect, a phenomenon first explained in 1824"

Greenhouse gases are those that can absorb and emit infrared radiation. The most abundant greenhouse gases are: - Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur hexafluoride (SF6)

Atmospheric concentrations of greenhouse gases are determined by the balance between sources (emissions of the gas from human activities and natural systems) and sinks (the removal of the gas from the atmosphere by conversion to a different chemical compound)
Man's activities which contribute to green house emissions are varied including exploitation of the natural resources for all kinds of development.
The main sources of greenhouse gases due to human activities are:

- Burning of fossil fuels and deforestation leading to higher carbon dioxide concentrations in the air.
- Land use change (mainly deforestation in the tropics) account for up to one third of total anthropogenic CO_2 emissions.
- Livestock enteric fermentation and manure management, paddy rice farming, land use and wetland changes, pipeline losses, and covered vented landfill emissions leading to higher methane concentrations in the atmosphere.
- Use of chlorofluorocarbons (CFCs) in refrigeration systems, and use of CFCs and halons in fire suppression systems and manufacturing processes.
- Agricultural activities, including the use of fertilizers, which lead to higher nitrous oxide (N_2O) concentrations.
- Waste dumps and waste waters.

Generally global greenhouse gas Emissions by Sector are show below.

Contributions by all the Sectors	Percentage of total
Energy Supply	26%
Transport	13%
Residential and Commercial Buildings	8%
Industry	19%
Waste and Waste water	3%
Forestry and Land use change	17%
Agriculture	14%

- Global Emissions in the Agricultural Sector

Emissions	Percentage
N_2O from soil management	38%
CH_4 from enteric fermentation	32%
Biomass burning	12%
Rice production	11%
Manure management	7%

- Source: IPCC, 2007; Smith et al. 2008; Ibia, 2012.

According to CTA (2008) the main GHGs is carbon dioxide (CO_2), which accounts for 70% of human-induced GHGs- 6 billion t are produced by burning fossil fuels, principally petroleum, for industry and transport. Added to this are the 1.6 billion t produced by deforestation. The more the planet heats up, the less the plants and seas are able to absorb CO_2 and the more land surface temperatures increase.

The Main Problem is therefore Too Much Carbon Dioxide in the Atmosphere

CO_2 naturally moves into and out of the atmosphere in many ways. For example, living plants take up and use CO_2 to produce energy, and animals breathe out CO_2 made from using energy. However, human invention and industrialization has greatly increased the amount of CO_2 in the atmosphere, with the result that greenhouse warming is increasing rapidly.

When *fossil fuels* burn, for instance in a power plant to make electricity, large amounts of CO_2 are released into the atmosphere. CO_2 also comes out of the ground together with *natural gas* during natural gas production. Industrial processes, such as refining oil, or producing iron, steel, cement and ammonia, also release large amounts of CO_2. Other major sources of CO_2 include emissions from cars, trucks, ships and aero planes, and emissions from domestic sources, such as heating your home. In addition, land clearing has reduced the ability of the earth to take up excess CO_2 (as there is less plant life to assist in natural regulation). All of these activities contribute to increasing the amount of CO_2 in the atmosphere.

One of the major characteristics of climate change is that it exhibits nonlinear relationships. Local emissions in one part of the globe have global consequences, while avoiding deforestation in one area will not help stabilize that area's weather. At the same time, the impact of the many different farming practices (both positive and negative) may not be visible immediately (LEISA, 2008).

EARTH SUMMITS, CONVENTIONS AND PROTOCOLS ON CLIMATE CHANGE

As part of global concern on issues of global warming and climate change and environmental sustainability several international earth summits, conventions and protocols have been entered into particularly by the developed nations. These earth summits are:

i) The 1972 Stockholm first Earth Summit (UN conference on the Human Environment) produced an action plan which laid out clearly the educational, informational, social and cultural aspects of environmental issues.

ii) In 1992, the second Earth Summit in Rio De-Janeiro (Brazil) adopted a Framework Convention on Climate Change, ratified by 50 countries which came into force in 1994. The 1992 Rio Earth Summit was attended by 152 world leaders + led to the signing of conventions on biological diversity +desertification, a framework convention on climate change, principles for sustainable forestry + Agenda 21 and resulted Kyoto Protocol. Agenda 21 encourages the development of national strategies, plans, policies and processes capable of encouraging sustainable social and environmental development.

iii) The third Earth Summit (aka "Rio+10"), held in 2002 in Johannesburg, South Africa, produced little action on the international level in part because George W. Bush boycotted the meeting. A delegation of U.S. members of Congress, mayors, and environmentalists helped spark change on the local and regional levels, however.

iv) In June, 2012 the fourth Earth Summit was held in Rio De-Janeiro, Brazil tagged Rio+20 Conference, world leaders, along with thousands of participants from governments, the private sector, NGOs and other groups, came together to shape how they (the world leaders) can reduce poverty, advance social equity and ensure environmental protection on an ever more crowded planet to get to the future needed by all.

Other international conventions and summits on environment and climate change include:

v) The Rio De-Janeiro Summit of 1967 where the first predictions on global warming were discussed and concerns raised.

vi) The Convention to Combat Desertification was held in 1977 to address land use practices and management of dry area ecosystems in an effort to desist degradation of arid, semi arid and sub-humid dry lands.

vii) The Montreal Protocol (1987) in Montreal, Canada which adopted protocol relating to substances which reduce the ozone layer.

viii) The creation of the Intergovernmental Panel on Climate Change (IPCC) in1988.

ix) 1997 witnessed the adoption of the Kyoto Protocol in Japan which commits industrialized countries to cutting greenhouse gas emissions by an average of 5.2% by 2012, compared with 1990 levels. The Kyoto Protocol is a protocol to the United Nations Framework Convention on Climate Change (UNFCCC or FCCC) that set binding obligations on the industrialized countries to reduce their emissions of greenhouse gases. The UNFCCC is an international environmental treaty with the goal of achieving the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

The Protocol was initially adopted on 11 December 1997 in Kyoto, Japan, and entered into force on 16 February 2005.

x) In 2007, the 13th United Nations Climate Change Conference in Bali (Indonesia) reached agreement on a "roadmap" aimed at producing a new treaty in 2009, in Copenhagen (Denmark). The treaty was to replace the Kyoto Protocol in 2012. The parties recognized that severe reductions in global emissions were needed, but disagreed to take up targets of cuts of 25 – 40% in GHG emissions for industrialized nations between then and 2020 which was proposed by the EU but rejected by the USA.

xi) The 2009 United Nations Climate Change Conference, (Copenhagen Summit), was held in Bali Centre Copenhagen, Denmark. The conference included the 15th Conference of the Parties (COP 15) to the United Nations Framework Convention on Climate Change and the 5th Meeting of the Parties (MOP 5) to the Kyoto Protocol. According to the Bali Road Map, a framework for climate change mitigation beyond 2012 was to be agreed there. On Friday 18 December, the final day of the conference, international media reported that the climate talks were "in disarray". Media also reported that in lieu of a summit collapse, solely a "weak political statement" was anticipated at the conclusion of the conference. The Copenhagen Accord was drafted by the United States, China, India, Brazil and South Africa on December 18, and judged a "meaningful agreement" by the United States government. It was "taken note of", but not "adopted", in a debate of all the participating countries the next day, and it was not passed unanimously. The document recognized that climate change is one of the greatest challenges of the present day and that actions should be taken to keep any temperature increases to below 2 °C. The document is not legally binding and does not contain any legally binding commitments for reducing CO_2 emissions. Many countries and non-governmental organizations were opposed to this agreement, but, throughout 2010, 138 countries had either formally signed on to agreement or signaled they would.

xii) The 2010 United Nations Climate Change Conference was held in Cancun, Mexico, from 29 November to 10 December 2010. The conference is officially referred to as the 16th session of the Conference of the Parties (COP 16) to the United Nations Framework Convention on Climate Change(UNFCCC) and the 6th session of the Conference of the Parties serving as the meeting of the Parties (CMP 6) to the Kyoto Protocol. The outcome of the summit was an agreement adopted by the states' parties that called for a large "Green Climate Fund", and a "Climate Technology Centre" and network. It looked forward to a second commitment period for the Kyoto Protocol. The agreement calls on rich countries to reduce their greenhouse gas emissions as pledged in the Copenhagen Accord and for developing countries to plan to reduce their emissions.

xiii) The 2011 United Nations Climate Change Conference was held in Durban, South Africa, from 28 November to 11 December 2011 to establish a new treaty to limit carbon

emissions. The conference agreed to a legally binding deal comprising all countries, which will be prepared by 2015, and to take effect in 2020. There was also progress regarding the creation of a Green Climate Fund (GCF) for which a management framework was adopted. The fund is to distribute US$100 billion per year to help poor countries adapt to climate impacts.

A primary focus of the conference was to secure a global climate agreement as the Kyoto Protocol's first commitment period (2008–2012) was about to end.

VULNERABILITY, RESILLLIENCE AND ADAPTATION TO CLIMATE CHANGE

a) Vulnerability and impacts

Spore (2009) reported that wealthy nations, responsible for 64% of greenhouse gas emissions since 1950, will only bear 20% of the consequences of climate change while developing countries which cause just 2% of these emissions will pay 80% of the price according the World Bank Report for 2010. Communities around the world are feeling the effects of climate change, but African and Asian communities being the poorest are more vulnerable and the hardest hit. They are the least equipped to recover from the devastation that can result from weather extremes such as storms, floods, eroding coastlines, heat waves, and droughts. The subsequent loss of clean water for drinking and fishing, the loss of productive conditions for agriculture, hunting and grazing, and the spread of malaria and other heat-related diseases create threats to health and survival (Rockefeller Foundation, 2012).

Impacts on Food Security

Food security is better assessed by four key issues, namely food availability, food access, food affordability and food stability. All these indices may be impacted by climate change. The overall availability of food is affected by changes in agricultural yields as well as by changes in arable land. Changes in food production, together with other factors, are likely to impact food prices and will affect the ability of poor households to access food.

Changes in temperature and precipitation associated with continued emissions of greenhouse gases will bring changes in land suitability and crop yields. Changes in climate and increases in some extreme weather events, such as floods and droughts, could disrupt stability in the supply of food and people's livelihoods making it more difficult for them to earn a stable income to purchase food.

Heavy rainfall leading to flooding can destroy entire crops over wide areas and devastate food stores, assets (such as farming equipment) and agricultural land (due to sedimentation). Areas that are highly dependent on seasonal rainfall, and those that are highly dependent on rain-fed agriculture for food security, are particularly vulnerable.

Heat waves and changes in temperature extremes even for short periods can be critical, especially if they coincide with key stages of crop development. Drought results in agricultural losses, reductions in water quality and availability, and is a major driver of global food insecurity. Droughts are especially devastating in arid and semi-arid areas, reducing the quality and productivity of crop yields and livestock

Impacts on Human Health

Climate change affects the ability of individuals to use food effectively by altering the conditions for food safety and changing the disease pressure from vector, water, and food-borne diseases. The main concern about climate change and food security is that changing climatic conditions can initiate a vicious circle where infectious disease causes or compounds hunger, which, in turn, makes the affected populations more susceptible to infectious disease. The result can be a substantial decline in labor productivity and an increase in poverty and even mortality.

Climate change has the potential to affect different diseases, including respiratory illness and diarrhea. Disease results in a reduced ability to absorb nutrients from food and increases the nutritional requirements of people who are ill. Poor health in a community also leads to a loss of labour productivity. Decreased water availability and quality in some areas are likely to result in increased health and sanitation problems, such as diarrheal disease. This, together with changes in the patterns of vector-borne disease, has the potential to increase malnutrition by negatively affecting food production and utilization.

Impacts on Infrastructure

Long term climate change and extreme weather remain serious threats to critical infrastructure globally. Essential infrastructure which guarantees the energy and water supplies and enables safe and reliable use of roads, sea, rail and air transportation is vulnerable to climate change (Lord Henley, 2012). Insights into what climate change and extreme weather mean for our infrastructure is already known-floods submerging roads and washing away portions of roads and bridges, torrential rain, harmattan haze and dust disruption air transport, rain storm and flood damaging energy and water infrastructure and thus affecting supplies, etc.

b) Resilience and Adaptation

Resilience is the capacity to cope with these environmental changes essential to survival. Adaptation is not only managing the risks associated with damages, it is about taking the opportunities global warming and climate change presents to develop new, innovative systems and services (health, agriculture, infrastructure, etc).

Adaptation would require conscious technological efforts which involve large scale, medium scale and small scale levels depending on the development issues targeted. Issues like building river bank barriers to protect farmlands, communities, utility infrastructure, etc as well as providing irrigation facilities for agricultural production which make production less dependent on natural rain are scientific and technological. Adaption would also mean introducing new methods of doing things (farming practices, design of homes, introduction of new breeds of crops and livestock, etc. Management skills are also subject to changes to cope with the new technologies which moderate and improve on traditional practices.

All processes need to be built on local coping mechanisms, local innovations, and local practices, in ways which enhance local capacities (LEISA, 2008). This calls for integrated, multi-dimensional and multi-sectorial approaches to these challenges as it offers opportunities for Green economy and Green development.

MITIGATION: APPLICATION OF SCIENCE AND TECHNOLOGY

Meeting the challenges of mitigating climate change has brought about the development and application of scientific and technological models, concepts and practices in global activities. These include sustainable development, climate-smart agriculture, carbon sequestration, green development, low impact development, green economy, carbon credits, carbon capture and storage, etc.

i. Sustainable Development Strategies

Sustainable development (SD) is a pattern of economic growth in which resource use aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but also for generations to come. The concept stresses the balance between the interests of economic growth and environmental protection; emphasizing the importance of inter-generational transfers, the preservation of non-renewable resources, and a variety of loosely defined principles regarding the responsibilities and accountability of policy makers.

Sustainable development ties together concern for the carrying capacity of natural systems with the social challenges faced by humanity. The concept of sustainable development is often

broken out into three constituent parts: environmental sustainability, economic sustainability and sociopolitical sustainability. Scientific and technological approaches which guarantee sustainable development environment, economic productions and social stability are critical to tackle and mitigate climate change

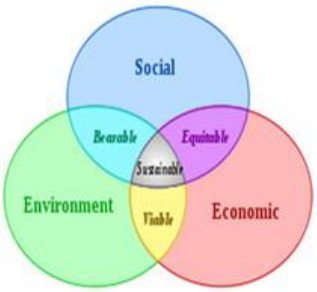

Figure 1: The Three Pillers of Sustainability (Wikipedia 2012)

ii. **Climate-Smart Agriculture**

Considering the contributions of agriculture to greenhouse gases emissions, any meaningful approach to mitigating or reducing emissions must include agriculture and "Climate-Smart agriculture" has been advocated as critical part of the solutions (AFF, 2011; Amalu, 2012). Climate-Smart agriculture draws attention to landscape approaches to sustainable agricultural production, such that issues concerning integrated planning of land use, agriculture, forestry, fisheries and water to ensure synergies are adequately captured. Practical approaches in these regards include, mulching, intercropping, conservation agriculture, crop rotation, integrated crop-livestock management and improved water management, etc (AFF, 2011).

Climate-Smart agriculture seeks to increase productivity in an environmentally and socially sustainable way, strengthen farmers' resilience to climate change and agriculture's contribution to climate change by reducing greenhouse gases emissions and increasing carbon storage in farmlands, particularly in the soils.

iii. Carbon Sequestration

Increasing the amount of carbon stored in the soil (sequestration) is of major practical interest in the mitigation chain. Therefore, land management practices that increase the amount of carbon (organic matter) stored in the soil will reduce the amount of carbon dioxide (CO_2) released into the atmosphere.

Scherr and Sthapit (2012) reported that Land makes up a quarter of Earth's surface, and its soil and plants hold three times as much carbon as the atmosphere. More than 30 percent of all greenhouse gas emissions arise from the land use sector. Thus, no strategy for mitigating global climate change can be complete or successful without reducing emissions from agriculture, forestry, and other land uses. Moreover, only land-based or "terrestrial" carbon sequestration offers the possibility today of large-scale removal of greenhouse gases from the atmosphere, through plant photosynthesis.

What can be done to reduce Carbon Dioxide and Other GHG Emissions?

Reducing greenhouse gas emissions to avoid dangerous climate change requires that humans make many changes in the way we generate electricity, heat our homes and move from place to place. These changes include developing more renewable energy sources, switching to less carbon-intensive fuels and generally being more energy efficient. However, as fossil fuels are expected to be widely used in the coming decades, something must be done to reduce the emissions made from their use.

According to Scherr and Sthapit (2012) five major strategies for reducing and sequestering terrestrial greenhouse gas emissions are:

• **Enriching Soil Carbon**. Soil is the third largest carbon pool on Earth's surface. Agricultural soils can be managed to reduce emissions by minimizing tillage, reducing use of nitrogen fertilizers, and preventing erosion. Soils can store the carbon captured by plants from the atmosphere by building up soil organic matter, which also has benefits for crop production. Adding biochar (biomass burned in a low-oxygen environment) can further enhance carbon storage in soil.

• **Farming with Perennials**. Perennial crops, grasses, palms, and trees constantly maintain and develop their root and woody biomass and associated carbon, while providing vegetative cover for soils. There is large potential to substitute annual tilled crops with perennials, particularly for animal feed and vegetable oils, as well as to incorporate woody perennials into annual cropping systems in agroforestry systems.

• **Climate-friendly Livestock Production**. Rapid growth in demand for livestock products has triggered a huge rise in the number of animals, the concentration of wastes in feedlots and dairies, and the clearing of natural grasslands and forests for grazing. Livestock- related emissions of carbon and methane now account for 14.5 percent of total greenhouse gas emissions—more than the transport sector. A reduction in livestock numbers may be needed but production innovations can help, including rotational grazing systems, manure management, methane capture for biogas production, and improved feeds and feed additives.

• **Protecting Natural Habitat**. The planet's 4 billion hectares of forests and 5 billion hectares of natural grasslands are a massive reservoir of carbon—both in vegetation above ground and in root systems below ground. As forests and grasslands grow, they remove carbon from the atmosphere. Deforestation, land clearing, and forest and grassland fires are major sources of greenhouse gas emissions. Incentives are needed to encourage farmers and land users to maintain natural vegetation through product certification, payments for climate services, securing tenure rights, and community fire control. The conservation of natural habitat will benefit biodiversity in the face of climate change.

• **Restoring degraded Watersheds and Rangelands**. Extensive areas of the world have been denuded of vegetation through land clearing for crops or grazing and from overuse and poor management. Degradation has not only generated a huge amount of greenhouse gas emissions, but local people have lost a valuable livelihood asset as well as essential watershed functions. Restoring vegetative cover on degraded lands can be a win-win-win strategy for addressing climate change, rural poverty, and water scarcity.

Agricultural communities can play a central role in fighting climate change. Even at a relatively low price for mitigating carbon emissions, improved land management could offset a quarter of global emissions from fossil fuel use in a year. In contrast, solutions for reducing emissions by carbon capture in the energy sector are unlikely to be widely utilized for decades and do not remove the greenhouse gases already in the atmosphere. To tackle the climate challenge, we need to pursue land use solutions in addition to efforts to improve energy efficiency and speed the transition to renewable energy.

Yet so far, the international science and policy communities have been slow to embrace terrestrial climate action. Some fear that investments in land use will not produce "real" climate benefits, or that land use action would distract attention from investment in energy alternatives. There is also a concern that land management changes cannot be implemented quickly enough and at a scale that would make a difference to the climate

iv. Carbon Capture and Storage

Carbon Capture and Storage (CCS) can make an essential contribution to the overall greenhouse gas reduction effort by reducing the emission of CO_2 from industries and power stations that use fossil fuels. Most of the technologies needed for CCS are already being used extensively in a variety of industries, but are yet to be widely applied to power generation and industry at commercial scale.

v. Green Development

Green development is a land use planning concept that includes consideration of community-wide or regional environmental implications of development, as well as site-specific green building concepts. This includes city planning, environmental planning, architecture, landscape architecture and community building.

vi. Low-impact Development

Low-impact development (LID) is a term used in Canada and the United States to describe a land planning and engineering design approach to managing stormwater runoff. LID emphasizes conservation and use of on-site natural features to protect water quality. This approach implements engineered small-scale hydrologic controls to replicate the pre-development hydrologic regime of watersheds through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source.

vii. Green Economy

The Green economy is one that results in improved human well-being and **social equity**, while significantly reducing environmental risks and ecological scarcities (UNEP, 2011). A green economy is part of the broader concept of sustainable development, but does not replace it. It simply offers us a bridge towards development that is sustainable. It generally refers to encouraging economic development that prioritizes sustainability-that is working with nature and not against it in the quest to meet people's needs and rights, instead of disregarding environmental concerns in the process of growing the economy.

Karl Burkart (2012) defines a green economy as based on six main sectors:

- Renewable energy (solar, wind, geothermal, marine including wave, biogas, and fuel cell)
- Green buildings (green retrofits for energy and water efficiency, residential and commercial assessment; green products and materials, and LEED construction)
- Clean transportation (alternative fuels, public transit, hybrid and electric vehicles, car sharing and carpooling programs)
- Water management (Water reclamation, grey water and rainwater systems, low-water landscaping, water purification, storm water management)
- Waste management (recycling, municipal solid waste salvage, brownfield land remediation, Superfund cleanup, sustainable packaging)
- Land management (organic agriculture, habitat conservation and restoration; urban forestry and parks, reforestation and afforestation and soil stabilization)

Green economy includes green energy generation based on renewable energy to substitute for fossil fuels and energy conservation for efficient energy use.

viii. Carbon Credits

A carbon credit is a generic term for any tradable certificate or permit representing the right to emit one tonne of carbon dioxide or the mass of another greenhouse gas with a carbon dioxide equivalent (tCO_2e) equivalent to one tonne of carbon dioxide.

Carbon credits and carbon markets are a component of national and international attempts to mitigate the growth in concentrations of greenhouse gases (GHGs). One carbon credit is equal to one metric tonne of carbon dioxide, or in some markets, carbon dioxide equivalent gases. Carbon trading is an application of an emissions trading approach. Greenhouse gas emissions are capped and then markets are used to allocate the emissions among the group of regulated sources.

The goal is to allow market mechanisms to drive industrial and commercial processes in the direction of low emissions or less carbon intensive approaches than those used when there is no cost to emitting carbon dioxide and other GHGs into the atmosphere. Since GHG mitigation projects generate credits, this approach can be used to finance carbon reduction schemes between trading partners and around the world.

ix. Research and Development

Research is the key to development and therefore need not be ever-emphasized. All aspects of research that drive development have to be accorded priority. As proposed by ASA (2012) such research should be well-integrated interdisciplinary research efforts in hazards-related science and engineering in order to improve the understanding of natural hazards and technological hazards linked to natural phenomena, mitigate their effects, and to better prepare for, respond to, and recover from disasters. Research and development should make investments in strongly interdisciplinary research that will reduce the impact of such hazards, enhance the safety of society, and contribute to sustainability.

CONCLUSION

Global warming and climate change and the resulting devastation the human population across all regions is facing, remain core issues in the front burner of the global community. The International Panel on Climate Change (IPCC) reports in recent years indicates a 0.76^0C increase in the world's average temperature in the last century, expecting temperatures to rise by 2^0C by 2050. These warming temperatures are changing climate indices leading to rising sea levels, the disappearance of glaciers, and the drastic changes in rainfall patterns, etc. Scientific and technological approaches remain options to cope with and mitigate the devastating effects of global warming and climate change already taking toll on human health, food security, integrity of infrastructure, and degradation of natural resources, etc.

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