E-ISSN: 2708-4469
P-ISSN: 2708-4450
IJAMCJ 2025; 6(1): 20-23

www.masscomjournal.com
Received: 21-10-2024
Accepted: 27-11-2024

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Bridging the gap: Integrating climate mitigation and adaptation strategies for sustainable future

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DOI: https://doi.org/10.22271/27084450.2025.v6.i1a.93

Abstract
Nowadays, at the forefront of policies and plans of national, international, and European levels stand the sustainable development and adaptation to climate change. Under a worst-case scenario, response to climate change may result in retrogression, which goes against the ideas of sustainable development because it increases the amount of greenhouse gases emitted while making certain populations more vulnerable. This would mean that including goals of sustainable climate change adaptation into a framework of sustainable development could open a window toward planning scenarios where sustainability and resilience are combined.

Human-caused climate change is increasing the risk to the continued survival of life on Earth. The increasingly ominous shift in Earth's climate is the result of increasing atmospheric carbon dioxide and other greenhouse gases, largely from human activities like burning fossil fuels. It is expected that climate change will worsen over the coming two to three decades with heatwaves, wildfires, droughts, storms, and floods. These will increasingly be hazardous to human health and international stability because of these events for which adaptation and mitigation strategies should be taken. Besides perpetuating the current problems, pollution and environmental degradation elevate the risk of nature and humanity before the altering climate. In this assessment, we look at the condition of global climate change from several angles as it is now.

Keywords: Sustainable development, environmental sustainability, adaptation to climate change, effect of Climate change in Food and Agriculture, protection of human life and biodiversity, maladaptation

Introduction
Environmental degradation and climate change, with regard to the future of the planet, have related risks. These have emerged, amongst other reasons, from the obsession of the rising global population with the current race of development which often neglects the sudden changes in natural systems and the resultant fallout. Indeed, natural resources extraction and fossil fuels combustion have been major drivers of global economic systems since the Industrial Revolution; likewise, land-use changes including urbanization and intensification of agriculture have supplanted forestation, leading to pervasive environmental change.

Using fossil fuels for power, heating, and transportation has significantly raised greenhouse gas (GHG) emissions and changed patterns of precipitation and temperature around the world.4 In 2022, the average worldwide temperature was approximately 0.86 °C higher than the average of 13.9 °C during the 20th century.5. Since 1977, there has been a 46-year streak in which global temperatures have surpassed the average for the 20th century. Moreover, there has been a global shift in the precipitation pattern. The effects of climate change are becoming increasingly apparent globally, as evidenced by the severe weather events and related disasters that occur everywhere. These include forest fires in Australia and the United States, accelerated melting of high-latitude ice sheets, rising sea levels, changes to river flow patterns, intense rainfall in China, droughts in South Africa.

Experts are increasingly in consensus that for an effective response to the challenges created by global warming, mitigation and adaptation techniques of climate change are imperative. The reason being, the climate would still vary even if all human emissions were brought to a close overnight. Since it will take decades for climate change mitigation actions to make a difference in rising temperatures, global systems need to be altered for the changes that are happening and will continue over the coming decades. This may involve developing and implementing adaptation and climate resilience strengthening plans in all global development systems.

Others include the development of drought-resistant crops to fight water shortage and constructing coastal sea walls to protect the growing sea levels from reaching the coastal towns. This shall include the use of artificial intelligence, high-resolution monitoring and simulation, and satellite-based remote sensing in order to develop data-and record-informed Earth system and climate models of the past and present that show the frequency and strength of extreme weather events for the purpose of future preparedness. These models will then be used to predict future occurrences, locations, and severeness of extreme events with appropriate warnings to protect people and the environment at places of high risk. It involves reducing people's general risk and vulnerability, enhancing their capacity to respond, and making people more aware of how to cope with the impacts of climate change. There is also the need for collaboration among residents, researchers, and policy makers on specific climate change adaptation strategies that must be done at various levels.

Another eternal requirement of the hour is strict, timely action to curb anthropogenic GHG emissions, or else global warming and climatic shifting will further deteriorate. Under the Paris Agreement, ratified by virtually all nations, global warming must be limited to 1.5 °C by the end of this century. This means it is imperative that greenhouse gases peak no later than 2025 and should be reduced by 43% by 2030, with carbon neutrality at least by 2050. This will be an unprecedented urgent transition towards low-carbon energy from the fossil fuel-based energy now in use. If anything, the rapid expansion of cleaner and renewable sources of energy is not translating to the meeting of global climate goals as set forth under the Paris Agreement. Even though it has long been promised that there will be a significant reduction in GHG emissions.

Drivers of Climate Change

Some of the principal means by which human activity has modified the Earth's surface albedo include land use changes such as urbanization and deforestation. When there are trees and other vegetation around, the Earth then absorbs more heat since they reflect less energy from the sun, compared to bare earth or surfaces. More specifically, human activities involving high energy in most cases from the burning of fossil fuels result in high CO2 emissions. Meanwhile, a tremendous amount of GHGs is liberated to the atmosphere due to human activities. Examples of such gases are methane, nitrous oxide, ozone, hydro chlorofluoro carbons (HCFC) and chlorofluoro carbons (CFC). The Earth gets warmer due to the way these gases can capture the longwave radiation that is supposed to be emitted to space.

Agriculture is not only a basic human activity, threatened by climate change itself, but it also is one of the major factors contributing to environmental degradation and climate change. It represents the most significant human impact on water and land resources. Indeed, 1.4 billion hectares of arable land account for ten percent of all the ice-free land, while 2.5 billion are used for pasture and grain agriculture. About 5 per cent of the world's wooded area or four billion hectares are used for plantation forestry. Agriculture is one of the major contributors to GHG emissions, as well as land degradation, which such an expansive operation causes. It accounts for over a third of the atmospheric concentration of CO2 every year from human activities through emission of between 13 and 15 billion tonnes yearly. Taking all together, 25% of the anthropogenic carbon dioxide [mostly due to deforestation], 50% of the methane [mostly from rice and enteric fermentation], and more than 75% of the nitrogen dioxide [mostly from fertilizer application] emitted each year is contributed by agriculture.

Due to the presence of higher thermal inertia surfaces, such as concrete and asphalt, in addition to different convection efficiency and surface albedo, there is greater anthropogenic activity. All these reasons make the modified landscape no longer benefit from evaporative cooling and act like a heat accumulator. This has been referred to as the UHI effect, which influences other climate parameters such as rainfall, pollution, and so on. Simultaneously, urbanization and metropolis-specific energy needs are inducing enormous quantities of greenhouse gases and related emissions, adding to climate change. Moreover, metropolitan areas, being densely populated with high infrastructure, are most vulnerable to various manifestations of climate change in the form of heatwaves, extreme weather events, and flooding.

Consequences of Climate Change Globally

As such, the consequences of climate change and variability on forest ecosystems are evident in many parts of the world already, while further impacts over the coming decades are all but unavoidable. Possible impacts include increased and decreased plant growth, increased frequency and severity of fire and disease, and increased intensity of extreme weather events such as wind, rainstorms, and droughts. These impacts will vary across different regions. Such change in climate is damaging to the potential to provide various essential wood and non-wood products and environmental services of the forests, protection of watersheds included, to the lives of those living near the forests, communities dependent on them, and other people are getting benefit from the forests.

Climate Change as a Threat to Sustainable Development

Development pathways resilient to climate change integrate three significant concepts: (1) sustainable development as the overarching framework for societies, regions, countries, and world community; (2) impacts of climate change as challenges to-and potentially opportunities for-sustainable development; and (3) mitigation strategies to reduce any impacts that may make gains so far fragile or even reversible. In the context of this study, resilience is the degree by which a social, ecological, or socio-ecological system or component exerts ability to anticipate, reduce, accommodate, or recover from the impact of a hazardous event or trend in a timely and efficient manner.

Climate resilience refers to the outcomes of evolutionary processes for managing change in a manner that minimizes disruptions and maximizes opportunities. It is not possible to isolate degrees of climate change from considerations of alternative climate-resilient pathways. In the words of most climate change scientists, decision makers, and stakeholders, the pre-requisite for achieving climate resilience for most systems can be realized with negligible effort and far-reaching transformational adaptation.

However, on the other hand, the threshold amount of climate change is high enough that can keep climate resilience out of cope from serious impacts on most systems.

New climate change and sustainable development risks include loss of ecosystem services, land and water management issues, health effects, exposure to extreme risk for slash and burn in specific vulnerable areas, more frequent Cadmundi food commodity price spikes, consequences for international migration patterns at a specific time and place, increasing flood-related hazards, risk of food insecurity, systemic risk to infrastructure from enhanced extreme events, loss of biodiversity, and vulnerability of rural livelihoods. These risks vary with the size of the climate change and the population's vulnerability by region and class. Already at the present temperature, a variety of rare and endangered systems are at risk, and with each additional small increment in global mean temperature, the hazards multiply. As temperatures rise, so do the risks.

Adaptation and Mitigation Strategies

Whatever mitigation option is pursued, some degree of climate change and related adverse impacts are unavoidable due to inertia in the socio-economic and climate systems driving greenhouse gas emissions. On the other hand, the lower the probability of the impacts, the sooner mitigation actions need to start. Even under the moderate climate change scenario, however, adaptation would be necessary in order to protect food security and livelihoods in many of the developing countries that are likely to be most vulnerable.

This means that the most critical challenge faced in climate policy is how to create a proper balance between the methodologies of adaptation and mitigation to reduce the general impacts of climate change. Put differently, this recognizes that many of the measures for mitigating and adapting to climate change share a number of positive synergies-so positive, in fact, that "climate response" resources could be used considerably more efficiently than they are today. Importantly, many of these synergies apply to rural life in developing countries and occur in the sectors of forestry and agriculture.

Adaptation and Mitigation of the Climate Change

Carbon sequestration through utilization and conservation of natural resources acting as carbon sinks highly contributes to mitigating the impacts of climate change. 3. The forests, marshes, and oceans ecosystems are a natural sink by nature through absorption of carbon dioxide from the atmosphere and store it in their repositories. Such carbon sinks may be preserved by curbing anthropogenic land-use changes, drainage, and deforestation prevent large quantities of carbon dioxide leaking into the atmosphere. Additionally, work to enhance and protect natural carbon sinks can sequester more carbon, thereby lessening the impact of climate change. For instance, reforestation efforts can help restore forests that were lost due to such activities as deforestation or land-use change, whereas wetland restoration can enhance carbon storage in coastal ecosystems.

Adaptation and mitigation; these are two key strategies in response to climate change. Whereas adaptation and mitigation deal with the effects of climate change, the former focuses on the causes. In the context of the forest industry, adaptation involves practices that would reduce the exposure of humans to climate change and changes in management, which reduce the vulnerability of forests to climate change. Within the sector of forestry, mitigation practices broadly fall into four categories including: product substitution, enhanced forest carbon sinks, reduced emissions from deforestation, as well as reduced emissions from the deterioration of the forest. The use of wood as a fuel substitute for fossil fuels and substitution of wood fiber for production of cement, steel, and aluminum will substantially help to reduce the effect of GHG.

Organic farming methods may permit a reduction in agricultural GHG emissions on a global scale by building up soil organic carbon. It was noticed that shallow inversion tillage, inter-row loosening, and inter-row cutting-that is, reduced intensity of tillage-shown higher soil C stocks, minor reductions in yield (~5.5%), and non-significant increases in weed incidence, since any type of tillage may be subject to the redistribution of carbon gains to deeper depths and the mineralization of labile carbon fractions. ICL systems have higher proportions of grass-clover leys in crop rotations compared to brief non-grazed ley periods, and these may be pivotal to realize a net carbon benefit. Many unique characteristics exist that affect the decomposition of carbon; thus, the capacity for organic systems to act as carbon sinks remains a subject of debate.

It is of essence that in trying to meet the energy needs of the future and striving for a clean, safe energy system for our planet, renewable, sustainable, and environmentally friendly alternative fuels be researched. Biomass, geothermal resources, sun, water, and wind energy are examples of natural resources that can be converted into these different forms of clean energy. 2027 is a tipping point, when renewables are predicted to start overwhelming the supply of electricity globally-an important changing balance of power. Over 90% of the grid-scale capacity comes from hydropower; however, its potential is constrained by capital costs running into billions of dollars and finding suitable places. In 2022, approximately 90% of all new renewable energy installations were wind and solar photovoltaic. Solar PV is about to overtake coal in terms of installed power capacity.

The definition of carbon capture, utilization and storage represents a process involving the capture of CO_2 emissions either from industrial operations or power generation, the utilization of the captured CO_2, or otherwise, for uses, and the geological storage of residual CO_2 or its storage for long-term periods. CCUS is an indispensable technology because of the need to reduce greenhouse gas emissions as part of tackling climate change. It basically covers CO_2 separation from the atmosphere directly or major emission sources like power plants, transportation to geological locations where it could be securely stored over long periods or converted to other forms. CCUS plays a vital role in mitigating global warming by reducing CO_2 emissions from fossil fuels or directly recovering CO_2 from the atmosphere.

Also, restructuring of the crop production system should be done to give prominence to crops that have low environmental and carbon footprint. It is also important to consider geographical re-distribution of crops in areas that are suitable for intensive management-that is, where the water supplies are adequate and the productivity is high. These will be combined with new technologies to enhance crop productivity, such as genome editing, marker-assisted selection, and genotyping, while releasing more land for bioenergy production to reduce greenhouse gas emission or afforestation to enhance carbon sequestration. Another aspect is the intelligent improvement of synthetic fertilizers' use efficiency by chemically tunable structures, with biodegradable coatings engineered to be responsive to signaling molecules in the rhizosphere of plants, could precisely deliver nutrients to crops and, therefore, minimize losses of ammonium NH4.

Conclusion

Global systems have been rapidly changing in the last 150 years, catering to the needs of a growing and rich global population. However, two of the most major side effects of such rapid development include over-exploiting natural resources and disrupting biogeochemical cycles. In particular, energy production through the use of fossil fuels has hastened climate change, thereby resulting in complex Earth system feedbacks that will be much more difficult to predict than could be garnered through merely increasing average world temperatures. Therefore, and with a view to the mitigation and adaptation of climate change, efforts should be directed towards restructuring local and global food, as well as socio-ecological systems.

It is a continuous but very relevant task of the industry to achieve more economic growth and quality of life with less environmental damage due to energy use.

To date, the emissions cut in the energy and transport sectors can be achieved to close the gap between promise and action on climate change, since the vast potentials of alternative sources of energy around the world may meet the world's energy demand. National contributions really should do more to raise the percentage of clean and renewable energy sources into the world's energy mix. Reaching carbon-neutral agriculture requires mitigation of emissions both from livestock systems and fertilizers. Efficient recycling of agricultural waste in agro ecosystems, proper management of soil and crop-livestock production systems, and improvement in the quality of bio/organic fertilizers are needed. It is important that dietary choices, changes in waste water treatment, and transportation modes have much priority towards reduction in the impact of climate change. We will be needing unwavering effort by all sectors of the international community to meet these challenges brought about by climate change and environmental degradation. We have to pull together, and quick, if we are to beat back the complex problems facing the planet that threaten our very way of life. It is in this way alone that we can make sure of a secure future for present and future generations.

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