

Review

Adapting to climate change in developing countries: a review of strategies, constraints and development in Nigeria

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This paper has attempted to incorporate the concept of variability and vulnerability into the debate over the paths to sustainability. It highlights the spatiality of sustainability, using mitigation and adaptability in developing countries and most especially Nigeria as a case study. It argued that environmental improvement in some Nigeria cities has led to environmental degradation due to poverty, lack of information, politics and ownership right and land tenure system and the likes. This review is supported by the close spatial relationship between equity, technology, infrastructure, information and skills. Most Nigeria cities suffer from environmental poverty, defined as the lack of the healthy environment needed for society's survival and development as a direct result of environmental degradation caused by human activities. It highlights the importance of political power and ownership right as determinants of adaptive measures which in fact affect different cities in Nigeria. The tickles effects may cause severe pre-emptive and adaptive environmental and economic disparities. Level of adaptation is positively related to income at the early stage of development, but negatively related at later stages, leading to severe skewed adaptive disparity. The study perspective helps reveal the varied possible paths and outcomes in Nigeria as some places get poorer and more vulnerable while other places get wealthier and less vulnerable. The powerful and wealthy may achieve rapid economic growth and environmental recovery at the expense of the powerless and poor. To avoid these risks of adaptive disparities, regions should seek alternatives that would be more likely to enable them to achieve coordinated development that evades environmental vulnerability and extreme variability, while achieving economic growth through proper adaptive strategies. The paper supports the idea that social determinants of equity, such as poverty reduction, access to economic resources, improvement in technology as well as proper information and trained of skill manpower will help in no small measure at reducing the constraints experienced with Climate Change. Further research will need to expand the scope of inquiry to test for cities which are still in the early stages of development; the assumptions may be used as a tool for generating future scenarios.

Keywords: Adaptation, Mitigation, Risks, Sustainability, Variability, Vulnerability.

INTRODUCTION

The world today has witnessed significant changes in climate conditions and this has heightened concerns from major stakeholders around the world in putting forward

projects, programs and potential means of adaptation in the changing climate. Although anthropogenic emissions of greenhouse gases associated with the use of fossil fuels mainly are from the rich industrialized—and post industrial—countries, the impacts of climate change will be more severe in poor developing countries. Reasons being that many developing countries, in terms of

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national income and employment, rely heavily on agriculture that is directly affected by climatic change, also the high number of poor people in these countries is generally more vulnerable and likely to feel the negative effects of climate change (Yohe and Tol 2002), and the economic and technological capacity to adapt to climatic change is often very limited in developing countries. Climate change in the reality represents one of the greatest environmental, social, and economic threats facing the planet today. In developing countries, climate change will have a significant impact on the livelihoods and living conditions of the poor. It is a particular threat to the attainment of the Millennium Development Goals (MDGs) and progress in sustainable development in Sub-Saharan Africa. Increasing temperatures and shifting rain patterns across Africa reduce access to food and create effects that impact regions, farming systems, households, and individuals in varying ways (Davidson *et al.*, 2003). Additional global changes, including changed trade patterns and energy policies, have the potential to exacerbate the negative effects of climate change on some of these systems and groups. Thus, analyses of the biophysical and socioeconomic factors that determine exposure, adaptation, and the capacity to adapt to climate change are urgently needed so that policymakers can make more informed decisions.

However, adaptation to climate change did not receive much attention in the first years of the international climate change studies, where there was more focus on mitigation and impacts (Kates, 2000), but adaptation has recently been covered more extensively and has an important place in the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) (2007). There is an emerging process of seeing climate change as a mainstreaming issue that implies that vulnerabilities and adaptation strategies are linked to the development of poverty reduction strategies (Halsnæs and Trærup 2009).

Furthermore, climate impacts are been described with increasing confidence by IPCC (2007). These impacts might be direct (e.g., changes in agricultural potential caused by rainfall change or inundation of cities and infrastructure due to sea level rise and higher disease burden) or they might be indirect (e.g., through effects of climatic change on world market prices of agricultural and fisheries products). Therefore, the need for adaptation is inevitable no matter how efficiently we manage to reduce the growth in emissions (Yohe, 2000), because the inertia in the climate system will lead to climate change and resulting impacts on natural and managed systems. Measures cover a correspondingly broad range, from direct interventions such as dike-building to prevent flooding, large-scale relocation of farmers, new crop selection and building of dams to expand irrigation, to capacity development in public administration, civil society, and research (Ole *et al.*, 2009).

Extent of climate change in developing countries

Many developing countries have already experienced weather events in terms of floods, droughts, heat waves, and tropical cyclones that are more frequent or intense than previous experiences (Dai *et al.*, 2004; Trenberth *et al.*, 2007), and the resulting impacts point to the consequences on the environment, production systems, and livelihoods from future climate variability and change.

The earth surface temperatures have increased by about 0.74°C over the past 100 years (Trenberth *et al.*, 2007). However, the largest share of the increase (0.55°C) has occurred over the past 30 years. The largest temperature increases have occurred over land and in the arctic and subarctic regions. The observed temperature increases over the past 30 years in large parts of Africa, Asia, and Latin America are generally within the range of 0.5°C to 1.0°C, although there are regions with larger observed changes (e.g., in south-eastern Brazil and North Asia) (Cruz *et al.*, 2007; Magrin *et al.*, 2007; Trenberth *et al.*, 2007). Downward trends in precipitation have been observed in the tropics from 10°S to 30°N since the 1970s (Trenberth *et al.*, 2007). It has become wetter in eastern parts of South America and Northern and Central Asia but drier in the Sahel, Southern Africa, and parts of Southern Asia.

There are also emerging findings of climate effects on human systems, although these are often difficult to discern from other adaptation processes. In agricultural systems, both climate change and technological developments influence agricultural land use and management, but in many developing countries with traditional land management, the effects of climate change on agriculture might be more evident (Van Duivenbooden *et al.*, 2002). The majority of the data and studies are from developed countries—in particular, in temperate climates. There is thus a need to expand the observational series in developing countries and tropical and subtropical climates. Such studies might also increase the knowledge base on vulnerability and adaptive responses in subsistence agricultural systems and rural populations in developing countries.

Projected Future changes

Global warming generally increases the spatial variability of precipitation with reduced rainfall in the subtropics and increases at higher latitudes and parts of the tropics. There is a tendency for increased precipitation in monsoonal circulations due to enhanced moisture convergence, despite a tendency for a weakening of the monsoonal flows. However, there are still many uncertainties in tropical climate responses (Christensen *et al.*, 2007). The warming in Africa is projected to be above the global annual mean warming throughout the continent and in all seasons (Boko *et al.*,

2007). The dry subtropical regions will warm more than the moister tropics. The annual rainfall is projected to decrease in much of the Mediterranean Africa, northern Sahara, and southern to increase, whereas projections of changes in rainfall in the Sahel, the Guinean Coast, and the southern Sahara remain uncertain (Christensen *et al.*, 2007).

Vulnerability

There have been quite many attempts to define vulnerability, and in relation to climate change, vulnerability has been defined as the susceptibility of exposure to harmful stresses and the ability to respond to these stresses (Adger 2006; Adger *et al.*, 2007; Bohle *et al.*, 1994). It is important to recognize that vulnerability is highly contextual and must always be linked to specific hazards and the (likely) exposure to the impacts of these hazards (Brooks *et al.*, 2005; Kelly and Adger 2000). To this end, Luers (2005), suggested that vulnerability assessments should focus on the susceptibility of specific variables (such as food supply, income) that characterize the well-being of people to a specific damage (such as climate change).

Climate variability is concern to major poverty alleviation goals in developing countries, and this means that the linkages between climate vulnerabilities and development policies are increasingly being addressed in the literature as well as a policy without any possibility of implementation.

The vulnerabilities and adaptive capacities that vary greatly between nations and regions of developing is not experience only because of differences in the projected change of climate parameters. Taking a cue from sub-Saharan Africa which is highly vulnerable to climate change and other stressors (Boko *et al.*, 2007), and in an assessment of vulnerability to climate-related mortality, this region was represented with 33 of the 59 countries found to be highly or moderately-highly vulnerable (Brooks *et al.*, 2005). Sub-Saharan countries also come out in the lowest quintile of a ranking on adaptive capacity of nations to climate change (Haddad, 2005).

Water stress will be an even larger problem than currently in northern and southern Africa, and in the same regions, agricultural production—and thereby food security—is likely to be negatively affected (Boko *et al.*, 2007). In general, climate problems, such as recurrent drought, exacerbate the many existing problems in the region (Kates, 2000).

Adaptation in a Context

Smit and Pilifosova (2001), presented a broad definition of adaptation as the adjustment in ecological, social, or economic systems in response to actual or expected

climatic stimuli and their effects or impacts. This term refers to changes in processes, practices, or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate (Ole *et al.*, 2009). This definition is retained in the IPCC Fourth Assessment Report, where it is reiterated that adaptation comprises actions to reduce vulnerability or enhance resilience (Adger *et al.*, 2007). It involves adjustments to reduce the vulnerability of communities, regions, or activities to climatic change and variability. Adaptation is important in the climate change issue in two ways—one relating to the assessment of impacts and vulnerabilities, the other to the development and evaluation of response options.

Adaptation also is considered an important response option or strategy, along with mitigation (Fankhauser, 1996; Smith, 1996; Pielke, 1998). Even with reductions in greenhouse gas (GHG) emissions, global temperatures are expected to increase, other changes in climate including extremes are likely, and sea level will continue to rise (Raper *et al.*, 1996; White and Etkin, 1997; Wigley, 1999). Hence, development of planned adaptation strategies to deal with these risks is regarded as a necessary complement to mitigation actions (Burton, 1996; Smith *et al.*, 1996; Parry *et al.*, 1998; Smith *et al.*, 1999). Article 4.1 of the United Nations Framework Convention on Climate Change (UNFCCC) commits parties to formulating, cooperating on, and implementing “measures to facilitate adequate adaptation to climate change.” The Kyoto Protocol (Article 10) also commits parties to promote and facilitate adaptation and deploy adaptation technologies to address climate change.

However, Planning of adaptation invariably is complicated by multiple policy criteria and interests that may be in conflict (Hareau *et al.*, 1999). For example, the economically most efficient path to implement an adaptation option might not be the most effective or equitable one. Moreover, decisions have to be made in the face of uncertainty (Lempert *et al.*, 2000). Uncertainties that are pertinent to adaptation are associated with climate change itself, its associated extremes, their effects, the vulnerability of systems and regions, conditions that influence vulnerability, and many attributes of adaptations, including their costs, implement ability, consequences, and effectiveness (Campos *et al.*, 1996)

Determinants of Adaptive Capacity

Adaptive capacity refers to the potential, capability, or ability of a system to adapt to climate change stimuli or their effects or impacts. Adaptive capacity greatly influences the vulnerability of communities and regions to climate change effects and hazards (Bohle *et al.*, 1994; Downing *et al.*, 1999; Mileti, 1999; Kates, 2000).

Human activities and groups are considered sensitive to

climate to the degree that they can be affected by it and vulnerable to the degree that they can be harmed (Rayner and Malone, 1998). Because vulnerability and its causes play essential roles in determining impacts, understanding the dynamics of vulnerability is as important as understanding climate itself (Liverman, 1990, Handmer *et al.*, 1999).

With regard to climate change, the vulnerability of a given system or society is a function of its physical exposure to climate change effects and its ability to adapt to these conditions.

Chambers (1989) distinguishes between these two aspects of differential vulnerability: physical exposure to the hazardous agent and the ability to cope with its impacts. Thus, vulnerability recognizes the role of socioeconomic systems in amplifying or moderating the impacts of climate change and “emphasizes the degree to which the risks of climate catastrophe can be cushioned or ameliorated by adaptive actions that or can be brought with the reach of populations at risk” (Downing, 1991).

Although scholarship on adaptive capacity is extremely limited in the climate change field, there is considerable understanding of the conditions that influence the adaptability of societies to climate stimuli in the fields of hazards, resource management, and sustainable development. Some of these determinants are discussed below:

Economic Resources

Whether it is expressed as the economic assets, capital resources, financial means, wealth, or poverty, the economic condition of nations and groups clearly is a determinant of adaptive capacity (Burton *et al.*, 1998; Kates, 2000). It is widely accepted that wealthy nations are better prepared to bear the costs of adaptation to climate change impacts and risks than poorer nations (Goklany, 1995; Burton, 1996). It is also recognized that poverty is directly related to vulnerability (Fankhauser and Tol, 1997; Rayner and Malone, 1998). Although poverty should not be considered synonymous with vulnerability, it is “a rough indicator of the ability to cope” (Dow, 1992). Bohle *et al.*, (1994) state that, by definition, it usually is the poor who are among the most vulnerable to famine, malnutrition, and hunger.

Technology

Lack of technology has the potential to seriously impede a nation’s ability to implement adaptation options by limiting the range of possible responses (Scheraga and Grambsch, 1998). Adaptive capacity is likely to vary, depending on availability and access to technology at various levels (i.e., from local to national) and in all

sectors (Burton, 1996). Many of the adaptive strategies identified as possible in the management of climate change directly or indirectly involve technology (e.g., warning systems, protective structures, crop breeding and irrigation, settlement and relocation or redesign, flood control measures).

Hence, a community’s current level of technology and its ability to develop technologies are important determinants of adaptive capacity. Moreover, openness to the development and utilization of new technologies for sustainable extraction, use, and development of natural resources is the key to strengthening adaptive capacity (Goklany, 1995). For example, in the context of Asian agriculture and the impact of future climate change, Iglesias *et al.* (1996) note that the development of heat-resistant rice cultivars will be especially crucial.

Information and Skills

“Successful adaptation requires the recognition of the necessity to adapt, knowledge about available options, the capacity to assess them, and the ability to implement the most suitable ones” (Fankhauser and Tol, 1997). In the context of climate variability and change, as information on weather hazards becomes more available and understood, it is possible to study, discuss, and implement adaptation measures (Downing, 1996).

Infrastructure

Adaptive capacity is likely to vary with social infrastructure (Toman and Bierbaum, 1996). Some researchers regard the adaptive capacity of a system as a function of availability of and access to resources by decision makers, as well as vulnerable subsectors of a population. For example, Nigeria uses fuel electric power to generate more than 80% of its electricity, which in turn supports local development and industry.

Equity

It is frequently argued that adaptive capacity will be greater if social institutions and arrangements governing the allocation of power and access to resources within a community, nation, or the globe assure that access to resources is equitably distributed (Ribot *et al.*, 1996; Mustafa, 1998; Handmer *et al.*, 1999; Rayner and Malone, 1999; Toth, 1999). The extent to which nations or communities are “entitled” to draw on resources greatly influences their adaptive capacity and their ability to cope (Adger and Kelly, 2000). Some people regard the adaptive capacity of a system as a function not only of the *availability* of resources but of *access* to those resources

by decision makers and vulnerable subsectors of a population (Kelly and Adger, 2000).

However these determinants of adaptive capacity are not independent of each other, nor are they mutually exclusive. Adaptive capacity is the outcome of a combination of determinants and varies widely between countries and groups, as well as over time. "Vulnerability varies spatially because national environments, housing and social structure vary spatially. It varies temporally because people move through different life stages with varying mixes of resources and liabilities" (Uitto, 1998) (cited in Vincent, 2007)

Constraints of adaptation

However, there has been a significant level of acceptability of forms of climate change techniques, but in the reality, level of adaptation in developing countries of which Nigeria is a part has been subjected to slow form of development as a result of the following reasons.

Poverty

Poverty is identified as the largest barrier to developing the capacity to cope and adapt (Adger *et al.*, 2001). The poor usually have a very low adaptive capacity due to their limited access to information, technology and other capital assets which make them highly vulnerable to climate change.

Today, although Nigeria should be one of the richest countries in the world with vast oil reserves and a plentiful workforce, yet over 65% of the country's populations live under the poverty line and half of those live in abject poverty. That's 80 million people. Part of this is because of rampant corruption in urban areas and the ongoing failure of repeated programs to address the poverty issue. Many of these programs have been dismissed as mere slogans, with former President Ibrahim Babangida stating the "Nigerian economy has defied all economic theories." Few funds allocated to poverty campaigns have trickled down to the masses due to inefficiency, lack of knowledge and corruption, leaving the 90% of the rural community to rely on subsistence farming with almost half struggling to make a living on smallholdings barely one hectare in size.

This lack of productivity in the agricultural sector is the root cause of rural poverty in Nigeria. as the oil revenues largely bypass those living and working outside that industry. The failure of agriculture in Nigeria is often blamed on the federal system; with the central government planning ignored or by passed by regional governments. What is clear, however, that as the agriculture industry has declined decade after decade, the ability to provide food for the family and sell on the excess has diminished year by year, fuelling poverty in

Nigeria and of course, malnutrition. The progression of percentages of those living in absolute poverty for the year 2005 is 54.7% and year 2010 as 60.9% and this no level of abatement.

Adaptive capacity in countries where there is a high incidence of poverty will likely remain limited. In addition, the poverty level in most third world countries is quite alarming as compared to elsewhere in developed economies.

Lack of Information

This forms a major problem faced by the low economy population who in most cases live in the most remote places geographically and in most cases lack the services of extension programs and this programs causes leading problem of literacy level that stand as 50.4% at of year 2011 with the male composition of 72.1% and female 50.4%.

Though according to the National Bureau of Statistic, over 95 per cent of Nigerians lack access to the Internet. It also stated that the same percentage of the population had no personal computers, an indication of why Nigeria's development rate had been slow. Experts said Information and Communications Technology played a crucial role in the socio-economic growth of poor countries. The survey covered all the 36 states of the federation and the Federal Capital Territory. It also considered access to mobile phone, radio and television among Nigerians. The NBS said access to PC appeared to be low with a national average of 4.5 per cent, whereas only 0.9 per cent of those who had access to computers actually owned them.

The draft National Information Communications Technology Policy released by the Ministry of Communications Technology showed that the country's PC penetration was 4.7 per 100 people as at 2010. Similarly, the International Communications Union's statistics showed that the number of PCs in the country was still as low as seven per 1,000 inhabitants (Dayo Oketola, 2013). The survey noted that urban dwellers had more access and ownership of Internet services at 11.6 per cent compared to the rural dwellers, which was put at 1.5 per cent (Dayo Oketola, 2013). Going by the equation embedded in the NBS data, it means that over 158 million Nigerians do not have access to the Internet.

Land tenure system

This is commonly noted in Africa, where so many people claim ownership to land and this has often led to disputes among communities and individuals as to who stands at the receiving end the proceeds from an adaptation strategy, e.g. REDD project.

The Land Use Act of 1978 was meant to usher in a

new land reform in Nigeria, as it stands, represents an abrogation of the right of ownership of land hitherto enjoyed by Nigerians, at least in the southern half of the country, and its nationalization by government is inconsistent with democratic practices and the operations of a free market economic system (Mabogunje, 2002). Many State Governments failed to establish the Land Use and Allocation Committee in their states for many years. This has hampered the steady and continuous delivery of land for building purposes as well for climate mitigation projects. Many Governors do not give the urgent attention needed to their responsibility of granting consent for land assignments or mortgaging, thereby impeding the development of an efficient land for adaptive measures.

The inconveniences and delays in securing Statutory Certificates of Occupancy have induced many land transactions among Nigerians to move to the informal market or be falsely dated as having been concluded before March 28, 1978, the operative date for the Land Use Decree. The exclusion by the Decree of the rights of families or individuals to develop private lay-outs has led to the emergence of a disjointed, uncoordinated and incoherent system of physical planning in Nigerian cities and a declining rate of housing provision and mitigative and adaptive strategies in the country. The power of Governors and the Local Governments to revoke any right of occupancy over land “for overriding public interest” has been used arbitrarily in the past and helps to underscore the fragility of the rights conferred by the Certificate.

These various weaknesses of the Land-Use Decree of 1978 have become the major grounds on which many groups interested in the development of efficient and effective system adaptive measures in Nigeria will to have to agitate to have the Decree first, removed as hindrance to change (Mabogunje, 2002)

Politics and ownership rights

The terrain of Nigeria political arena is often been the problem of transparency in the government when it comes to the intervention schemes from NGO's and international organization. The concern had always been the equitable distribution of such good and services to the vulnerabilities. This has brought up the issue of the ownership, ethnicity, religion and community rights of directly impacted citizens

Adaptation Strategies

In many cases people will adapt to climate change simply by changing their behaviour and this could be by moving to a different location or by changing their occupation. But often they will employ different forms of technology,

whether “hard” forms, such as new irrigation systems or drought-resistant seeds, or “soft” technologies, such as insurance schemes or crop rotation patterns. Or they could use a combination of hard and soft, as with early warning systems that combine hard measuring devices with soft knowledge and skills that can raise awareness and stimulate appropriate action.

Many of these technologies are already available and widely used. The global climate system has always confronted human societies with extreme weather events and in many respects future climate change will simply exacerbate these events, altering their scale, duration or intensity. Thus it should be possible to adapt to some extent by modifying or extending existing technologies. Farmers have taken advantage of technological advances to cope better with arid environments, introducing new crop hybrids and making better use of scarce water, as with systems of drip irrigation. Nowadays human societies can also take advantage of “high” technologies such as earth observation systems that can provide more accurate weather forecasts, or crops that are based on genetically modified organisms. Finally too, people can look towards a horizon of future technologies yet to be invented or developed – which might include crops that need little or no water, or a malaria vaccine. Whatever the level of technology, its application is likely to be an iterative process rather than a one-off activity (UNFCCC, 2006).

However how innovative any form of adaptation technique may be, it must be such that will be inexpensive and readily available to the various categories of people, most especially the vulnerable people of the developing world who seem to be the worst affected by climate change.

However adaptation varies across the various environment and facets of human survival strategies. Some of these are highlighted and discussed below:

Coastal zones

A substantial proportion of the world's population lives at the interface of land, sea and air in the world's coastal zones e.g. Lagos, Port Harcourt and so on.. Here people can exploit many opportunities for investment and production but also find themselves exposed to a range of natural hazards, from storms and cyclones to widespread flooding and coastal erosion. The effects will not, however, be uniform. Certain coastal environments will be at greater risk, such as tidal deltas and low-lying coastal plains, for example, sandy beaches and barrier islands, coastal wetlands, estuaries and lagoons, and coral reefs and atolls. On this basis, increased coastal flooding is expected to be most severe in South and South-East Asia, Africa, the southern Mediterranean coasts, the Caribbean and in most islands in the Indian and Pacific Oceans. Under this type of condition the

action for adaptation can involve many organizations or institutions, but in practice the responsibility tends to fall on the public sector. In coastal zones climate change is likely to affect food and water security, biodiversity, and human health and safety – collective goods and systems for which governments have prime responsibility.

Nevertheless, at all stages governments should ensure continuous public consultation.

This is mainly because people have a right to participate in the decisions that affect their lives, indeed they will demand it – communities all over the world are becoming increasingly resistant to top-down planning. But local acceptance and cooperation is also vital because most measures will depend on local expertise for implementation and maintenance (UNFCCC, 2006).

Water resources

All life – human, animal and plant – relies on sufficient and dependable supplies of water. But this vital resource is under pressure. Large urban populations, extensive irrigated agriculture and rapid industrial development are in many places using water faster than it can be replaced. In response, policymakers are now taking a broader and more inclusive approach to water, referred to as integrated water resource management (IWRM). This is based on an understanding that the world's complex hydrological cycles depend critically upon healthy ecosystems and that the fresh water they deliver is a replicable but finite resource. IWRM also recognizes that water has both human and economic value – but that human requirements should take precedence. Essential water supplies should be accessible to all, and their distribution should be managed in a participatory fashion with a particular concern for the interests of the poor.

Examples of the technology that has been integrated into these scenarios include strategies that are concerned with boosting supplies – by building more reservoirs, for example, or harvesting rainwater for agricultural use. Others involve reducing demand by cutting leakage from pipes, say, or switching from flush toilets to dry forms of sanitation. They can also be classified as hard technologies that involve new constructions or different types of equipment, or soft technologies that are more concerned with management of behaviour; thus, agricultural policy makers will consider both the hard option of encouraging more efficient types of irrigation as well as the soft option of introducing or modifying forms of water pricing.

Another useful addition to the IWRM framework is the concept of “soft paths”. This focuses on water not as an end product but rather as a service, and underlines the importance of sustainability. Thus, rather than trying to transfer water from distant sources it aims to exploit local

resources by harvesting rain or storm water, for example, and it makes more efforts to treat wastewater using “green infrastructure” such as sand filters and wetlands. This will also involve focusing more on what is termed “green water”. As opposed to “blue water”, which is the visible volume above and below the ground, green water is the precipitation that is absorbed by soil and plants and subsequently returned to the atmosphere through plant transpiration. Green water is an under-valued resource even though it represents more than two-thirds of precipitation. Despite the growing urgency of the problem only a few developing countries have started drawing up national adaptation programmes of action. Mauritania, for instance, has carried out a needs assessment which indicates the potential for drip irrigation systems, but also highlights the importance of building better hydrological monitoring systems and involving communities in the management of water resources.

Guyana, too, has made an assessment that includes the need to manage demand through water tariffs while reducing contamination of supplies with better septic tank systems and improving storm water drainage.

Clearly many more countries now need to consider the climate change implications for water supplies and to examine the most promising technologies for adaptation. (UNFCCC 2006)

Agriculture

Minor climatic variations can have a major impact on agricultural output even in a single growing season, so long-term agricultural productivity and food security will certainly be affected by ongoing climate change – a matter of increasing concern since over the next 30 years global food production will need to double to feed the planet's growing population.

In its *Third Assessment Report the Intergovernmental Panel on Climate Change* presented a number of scenarios and looked at the implications for global regions. For Africa it concluded that many countries would experience a fall in grain yields and would be vulnerable to droughts, floods and other extreme events that would put greater stress on water resources, food security and human health.

However, Most of the adaptation for crop production is likely to rely on human intervention. Fortunately, farming communities have considerable experience of coping with adverse climatic events, such as droughts and, floods, and with salinity. They have, for example, introduced new forms of irrigation, or diversified to varieties that are higher yielding or have greater tolerance for drought or salty conditions. They have also changed land topographies by using “grass waterways” – areas where grass is left to grow permanently to drain run-off water (UNFCCC, 2006).

Infrastructure

All human settlements are critically dependant on many types of infrastructure, from power and water supplies to transportation to systems of waste disposal. In many parts of the world, particularly in developing countries, this infrastructure is already under severe strain, as a result of population growth, rural–urban migration, high levels of poverty and the demand for more roads and vehicles. All these strains are likely to interact with, and be exacerbated by, different aspects of climate change. Some of these effects will be direct. Changes in temperature or rainfall along with sea level rise or extreme weather events will have an immediate impact, as storms or hurricanes bring down power lines, wash away roads or bridges or overwhelm systems of drainage. There can also be less obvious, longer-term changes; if higher temperatures lead to drier soils, for example, this could lead to subsidence.

Adaptation strategies will thus largely be based on existing experience – ensuring that current requirements are enacted and, where necessary, strengthened to meet the future challenges of climate change – and required good information. For simple hazard mapping, authorities largely use accumulated experience. In future, however, they will have to make more use of vulnerability-based assessments, which will require accurate and comprehensive data on land use, for example, and the location of infrastructure which can then be fed into computer simulations through GIS. But rather than trying to predict extreme climatic events precisely, such assessments can also incorporate more probabilistic and uncertain information to help planners consider the broader context of the problem and suggest a range of responses.

Adaptation for infrastructure will thus demand many types of change, in both the public and private sectors. In general the most successful strategies are likely to be those where the proposals for adaptation meet a number of human needs beyond environmental benefits (UNFCCC, 2006).

Forestry

In recent times forestry has received quite a number of attentions as a collective vital tool in ameliorating the upsurge of climate change. Forests have been noted as quite imperative in the process of adaption. This in a way has led to the development of various strategies to help save and protect the remaining forests of the world while ensuring the benefits to the people whose livelihoods depend on it.

CONCLUSION

The main essence of the processes of adaptation need a

critical observation as the context seem not complimentary enough for most countries of the world, most especially the developing and the low economic countries.

However, Adaptation is an important part of *societ al* response to global climate change. Planned, anticipatory adaptation has the potential to reduce vulnerability and realize opportunities associated with climate change effects and hazards. There are numerous examples of successful adaptations that would apply to climate change risks and opportunities. Substantial reductions in climate change damages can be achieved, especially in the most vulnerable regions, through timely deployment of adaptation measures.

Therefore there is a great need for an enhanced form of adaptation which will be complementary enough and suitable for the different societies and geographical regions of the world. Also the prompt intervention from international organizations and the developed countries around the world as regards the discharge of their commitments and policies to the less developed world that are under the critical impact of climate change-climate justice.

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