

THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Unsustainable Development, Climate Change and Floods: Interactions and Impacts

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Abstract:

The impacts of global climate change on communities and economies the world over has been a topical issue in recent years. One of the notable and most devastating impacts of climate change over the years has been flooding. Every year, reports from all over the world give an indication of the devastation caused by floods through loss of lives and property in both rural and urban areas. The problem in the urban centres is usually exacerbated by unsustainable development practices evident through the sprawling of slums, deforestation and building in waterways which are all mainly due to poor land use planning. The study examined the combined impact of climate change and unsustainable development on the frequency and severity of flood events in Ghana in the face of rapid population growth. The study reviewed related studies in other flood-prone areas of the world looking at attempts that have been made and how successful and otherwise these attempts have been and recommendations made accordingly.

Keywords: *Unsustainable development, climate change, floods*

1. Introduction

The contribution of climate changes to flooding have been studied in many areas of the world (e.g. Bhowmik, 1998; Khalequzzaman, 2000; and Maza *et al.*, 2004). Also studied have been the added contribution of unsustainable development to flooding in these areas (e.g. Smith, 2004; Rain *et al.*, 2012). The possible interaction of these two variables to exacerbate the problem of flooding has however not received the needed attention.

With close to 25 million inhabitants, Ghana is a mid-sized and rapidly growing West African country considered a middle-income country (lower-middle income) by the World Bank. Ghana as a developing country is endowed with lots of natural resources such as gold, diamond, timber, cocoa, bauxite, and recently oil, which are exploited to aid development. With a population growth rate of about 2.1 % and a declining agriculture sector (Ghana Statistical Service, 2014) due to climate change *inter alia*, the rural urban exodus is rampant leading to sprawling and unplanned settlements in the cities in the wake of increasing urbanization. With poor land-use planning where settlements have sprang up in river flood plains coupled with inadequate legislation and enforcement, development in the urban centres have taken a rather unsustainable path. Merging with climate change, these may combine to exacerbate the frequency and damage from flood events in these areas. The question now on the mind of the reader may be this: how does unsustainable development and climate change exacerbate the incidence of flooding in Ghana?

With the issue of rapid population growth and urbanization in mind, this paper seeks to look at the impact of the interplay of climate change and unsustainable development on the severity of flood events in the Ghanaian environment.

2. Study Area

The study is limited to the Greater Accra Region (Accra) due to the rapid rate of urbanization in the city and the annual flood events that plagues it. The findings however would be generalized to all other cities since these cities ultimately seek the path of development and urbanization that Accra is currently treading.

Ghana is a western African nation with Accra, its capital, a coastal city facing the Atlantic Ocean (the Gulf of Guinea specifically). Accra occupies a total land area of 3,245 square kilometres, approximately 1.4 per cent of the total land mass of Ghana. Accra, though having the smallest land mass among the nation's ten administrative regions, houses about 15.4 percent of Ghana's population, only lower than the Ashanti region. It has a population of 3.9 million people as at the 2010 housing and population census with 9.1% of these living in slums (Ghana Statistical Service, 2012). These numbers are housed in a little over 1 million households.

The city is urbanizing at a rapid rate with an equally increasing population growth rate that is due mainly to migration. The rapid population growth is reflected by the significant modifications in land-use from 1985 to 2003 (Otoo *et al.*, 2006), suggesting a 35 percent conversion of non-urban to urban areas in the region (Jankowska *et al.*, 2011). Some researchers (e.g. Larbi, 1996; and Briggs and Yeboah, 2001) have offered that this intense urban expansion *inter alia*, a lack of infrastructural provisions has resulted in the incidence of various slum areas throughout Accra. Some of the popular slums in Accra according to the UN-HABITAT definition and criteria for slums include *Sodom and Gomorrah, New Fadama, Amui Djor, Ashaiman, Nima* and *Agbogbloshie*.

3. Literature Review

3.1 Sustainable Development versus Unsustainable Development

Sustainable development is an evolving concept that emerged in the 1980s in response to an emergent awareness of the necessity to balance economic and social progress with concern for the environment and the stewardship of natural resources (Edwards, 2009).

Sustainable development has been defined severally by various authors and corporate bodies (e.g. World Commission on Environment and Development, 1987). Notwithstanding the differences in definitions, all definitions of sustainable development require the earth to be regarded as a system that connects space and time. Regarding the world as a system over space, we will understand that pollution at one end of the globe may eventually affect people and livelihoods at the other end. Similarly, thinking of the world or the earth as a system over time, we realize that the decisions we make about the use of resources today will affect our children tomorrow (International Institute for Sustainable Development, n.d.).

The most often used definition for sustainable development comes from the World Commission on Environment and Development (popularly known as the Brundtland Commission, 1987):

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

The use of fossil fuels, minerals, and other natural resources by people living on earth is critical for their survival. Sustainability or sustainable development demands for considerations in the extraction, processing and efficient use of the especially non-renewable resources. Emphasis is placed as well on a paradigm shift to a greater reliance on renewable energy and the development of substitutes for toxic and dangerous materials, as well as finding efficient use for waste products.

The United Nations has described sustainable development in terms of three dimensions or domains, thus: economic, social (equity) and environment (ecology). The three dimensions (sometimes called pillars) of sustainability are a useful tool for defining the complete sustainability problem. It calls for the strengthening of all pillars concurrently; with a weakness in any one pillar rendering the whole system unsustainable.

However, www.thwink.org, a website dedicated to finding the root cause of the sustainability problem, has observed over the past years that most national and international problem solving efforts have been single pillar-focused at a time. They cite the United Nations Environmental Programme (UNEP), the environmental protection agencies (EPA) of many nations, and environmental NGOs as examples of bodies that are focused only on the environmental pillar in their activities. The economic growth pillar is championed by organizations such as the World Trade Organization (WTO) and the Organization for Economic Cooperation and Development (OECD). The United Nations, according to the website, is the only organization that attempts to strengthen all three domains (pillars) at a time, but then is crippled by the fact that most of its members are only interested in economic growth, hence its activities are more biased towards that.

Notwithstanding the bias towards the economic pillar, the concept of sustainable development has permeated into political circles and is now seen as a new requirement for development at the urban and metropolitan levels, with its principles and concepts being applied to land-use planning and urban planning in most developed nations and a few developing ones. But how far are developing nations willing to go to implement the concept and with its guiding principles?

Over the last few decades the international community has adopted an impressive number of environmentally-related international agreements geared towards sustainable development. Some of these conventions are the Bonn Agreement, the Kyoto Protocol, United Nations Convention on the High Seas, and the Convention on Biodiversity and Conservation. Nations, after ratifying these conventions, are resourced to fully implement them.

To achieve sustainable development in the West African sub-region and in Ghana for that matter, the concept of sustainable development with its pillars must be revisited and a concerted effort made to involve all disciplines so as to arrive at the desired goals as suggested by Mathieu (2006).

3.2. Climate Change

Two definitions that describe climate change in its totality have been offered by the Inter-governmental Panel for Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC defines climate change as: "a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use". The climate change experts believe that this definition is limiting since it excludes causes attributable to nature.

The IPCC defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods",

or in its paraphrased form, “a change in the climate that persists for decades or longer, arising from either natural causes or human activity.” This definition is the more popular one when it comes to disasters relating to climate change.

The effects of global climate change on world economies and livelihoods have been studied extensively within the last couple of years (e.g. Adams *et al.*, 1990; IPCC, 1996; Darwin *et al.*, 1995; Adams *et al.*, 1998). For example, Adams *et al.* (1998) claim that climate change is expected to influence mainly crop and livestock production as a result in hydrologic imbalances in the coming decades.

Climate change has been observed to result in changes in climatic factors such as temperature and precipitation and the frequency and severity of extreme weather events like droughts, floods, and wind storms. These events over the years have brought untold hardships on people and devastated livelihoods, as well as caused economic downturns in many nations of the world. These events are of course exacerbated by human activities that have modified and keep modifying the natural environment. Such activities include significant population increases, migration, and accelerated socio economic activities.

Most vulnerable to the impacts of climate changes are cities closer to coast.

Rain *et al.* (2012) explained that for coastal cities south of the Sahara such as Accra, significant sea level rise is a major impact from climate change which leads to the inundation of lagoons and seaside wetlands, increased storm surges and consequent flooding, changes in disease vectors, and drought. Many of these have implications that go far beyond the coast and sometimes threaten the fragile national economies.

The impact of climate change on Africans has been projected to be severest by the International Panel on Climate Change in coming decades (Boko *et al.*, 2007). This could be due to the possible ripple effect that a few of the effects of climate change may bring about. For example Rain *et al.* (2012) observed the threat to agricultural production as one of the impacts of climate change caused by the increased variability in rainfall leading to a drop in crop yield. With low crop yields, migration is induced from the farming areas to the urban centres to compound the already existing congestion. When the rains arrive, the floods come with its devastating effects.

Ghana is exposed to extremes of environmental impacts such as coastal erosion caused by the rising sea level in the south, and extreme temperatures leading to possible loss of livelihoods in the north. These effects are compounded by floods, drought, wildfires, land degradation, soil erosion, the threat of desertification, and the prevalence of diseases such as cholera and meningitis.

Major cash and staple crops, such cocoa and maize will be affected in growing measure by climatic shifts, including increased temperature, the contraction of cropping seasons and changes in the distribution of rainfall. In both urban and rural communities, socio-economic vulnerabilities are also extreme. Cities such as Accra which have sprawling slums form hazard-prone zones, exposing populations to unsafe water, restricted sanitation, and deadly flood risks.

3.3. Flooding

A flood occurs when a body of water rises to overflow land which is normally not submerged. Globally floods have taken its toll irrespective of location or people.

Smith (2004) has claimed flooding to be the most common environmental hazard worldwide lending to the widespread geographical distribution of river floodplains and low-lying coasts which have held a long standing attraction for human settlements. This event according to Smith, do claim about 20,000 lives each year rendering a further 20 million homeless.

The main climatic factors of floods, among others, include precipitation (volume of rainfall, its intensity and duration) or air temperature (especially important for the formation of winter floods), whereas the non-climatic factors include catchment topography, slopes, soil type, land use, density of the river network, etc.

Floods are not destructive in themselves but human activity that may be obstructive to the flow of the floodwater such as physical structures normally lead to the loss of lives and destruction of property.

In describing the flooding problem in Accra, Rain *et al.* (2012) sums it up thus:

“The Odaw River is the major stream draining central Accra, with its outlet into the Korle Lagoon, while smaller streams lead into lagoons to the east and west of central Accra. Much of the Odaw catchment area is built up and many of the streams are channelized. Rainfall in Accra occurs in the form of intensive storm events, which cause local flooding (BGR-GSD, 2006, Masiyandima *et al.*, 2003, Hayward and Oguntoyinbo, 1987).

Several factors contribute to the flooding problem. First, the massive growth of the city of Accra (Afeku, 2005) has increased the extent of impervious surfaces. Impervious surfaces are materials that prevent infiltration of water into the soils, and include roads, rooftops, sidewalks, bedrock outcrops and compacted soil (Arnold *et al.*, 1996). This leads to increased discharge that overloads drainage channels. Associated with this rapid urbanization are flaws in the drainage network such as undersized, unconnected or improperly channeled drains. In addition, poor development controls, limited garbage collection and disposal block channels and sewers, which slow drainage through the city (Afeku, 2005). In addition, field reconnaissance has indicated substantial uncontrolled development occurs in low-lying or unsafe areas – often immediately adjacent to and even directly over drainage channels”.

The issue of flooding in Ghana has become more and more prominent over the years. During the periods of heavy rainfall and subsequent flooding in Ghana (e.g. in 1995, 1999, 2001, 2005, and 2011), human lives have been lost with thousand others displaced. Floods in Northern Ghana have become an annual event, destroying properties, inundating farmlands, displacing people, with loss of lives. A more current issue of flooding in Ghana was the torrential rains on Wednesday, 3rd June 2015 which affected especially Accra leading to the loss of so many lives and destruction of property mainly due to obstructed drains, buildings on waterways, and poorly constructed drains.

3.4. Flooding and Climate Change

The subject of flooding has garnered interest from writers in the past two decades (e.g. Schreider *et al.*, 2000; Bronstert, 2003) especially in the face of the colossal damages caused by these events, and in the wake of the special attention and efforts being given to global climate change with its attendant effects; believed to have compounded the changing weather conditions in many places. The experts believe that the changing climates is responsible for the extended periods of either torrential rain or severe drought or extreme heat conditions in various parts of the world.

Flooding has been documented to be one of the most severe environmental issues distressing the city of Accra, likely to even get worse in the face of increasing climate change with the effect of rising sea levels (e.g. Rain *et al.*, 2012). Floods in Accra are caused by heavy rains that generally occur in June and July, lasting for few hours usually. Momentous flood events have been recorded in Accra in 1973, 1986, 1995, 1999, 2001, 2011 and recently 2015 coming along with property damage and various forms of pollution in flood-prone areas such as *Alajo, Circle, North Kaneshie, Santa Maria* among others.

What then is the link between flooding and climate change? It is an accepted fact that climate change does increase the probability of certain weather types. Climate scientists have observed over the years that as average temperatures have gone up, more rains have fallen leading to heavy downpours hence flooding. Why is this so? Why should more heat produce more downpour? The Union of Concerned Scientists in the USA explain it thus:

“This happens because warmer air holds more moisture. This fact is apparent when you see water vapor hanging in the air after turning off a hot shower. When warm air holding moisture meets cooler air, the moisture condenses into tiny droplets that float in the air. If the drops get bigger and become heavy enough, they fall as precipitation. If the emissions that cause global warming continue unabated, scientists expect the amount of rainfall during the heaviest precipitation events across country to increase more than 40 percent by the end of the century. Even if we dramatically curbed emissions, these downpours will still increase, but by only a little more than 20 percent. Regardless of what action we take to cut emissions, municipalities that are vulnerable to heavy precipitation events should plan for more flooding. Any efforts to reduce emissions would make it easier for them to adapt.” (www.ucsusa.org).

3.5. Unsustainable Development, Climate Change and Flooding

It is estimated that by 2030, Africa will have a majority of its citizens dwelling in the urban centres (Montgomery, 2008). However, majority of African cities are characterized by rapid growth rates estimated at 5 percent without the capacity to deal with them (Rain *et al.*, 2012). For example, it is estimated that Ghana’s coastal districts make up only 6.5 percent of the land area but is home to more than 25 percent of the total population; leaving an estimated 400 square kilometers of land and 137,000 at direct risk from storms and coastal inundation (World Bank report 2009).

The more significant impact of climate change for Africa with seasonal variability in rainfall will be drought, since 30 percent of the population live in dry areas and heavily dependent on rain-fed agriculture (Rain *et al.*, 2012). Over time, food security (and hence job security) in the rural parts of these areas will be threatened. With the threat, majority of rural dwellers will begin to move to the urban centres for greener pastures (for example, Myers (2001) reports this migration on a larger scale with about 10 million people fled the Sahel droughts by 1995). This results in the springing up of unplanned settlements such as slums and unsustainable development practices such as the conversion of vast forests into residential and industrial spaces that puts the cities at risk to a myriad of social and health ills. For example, unplanned settlements in low-lying areas and waterways or river floodplains with poor drainage and architectural designs will make the little rains that fall look substantive due to the excessive flooding that may occur. These floods could have been abated or prevented altogether. This is because though heavy downpours are the main cause of floods, the earth through its system of homeostasis is able to control the level and impact of flooding on the land. Two of these mechanisms are employed in natural forests and wetlands during downpour. Forests are able to soak up a lot of water through various mechanisms, whereas wetlands can act as sponges to soak up a lot of moisture from the local atmosphere. These natural mechanisms will ensure a reduction in the amount of storm water that reaches the inhabited land. But when development activities remove these forests and drain the wetlands for projects, humans become exposed and more vulnerable to the effects of climate change to be experienced here through flooding.

3.6. It may Get Worse

Accra continues to grow in territory without any formal planning (Grant and Yankson, 2003). Darko (2009) reports a study in 2009 by the Environmental Protection Agency, Ghana that predicted that Ghana’s cocoa production may suffer the effect of climate change (specifically drought) in the very near future. The research further estimated that over 800,000 families whose livelihoods depend directly on cocoa production could be out of business by the year 2020. This may lead to another major rural-urban exodus with Accra the most probable destination, to further compound the aforementioned problems – making the city more vulnerable to subsequent rain and flood events.

4. The way Forward

Over the years, several experts and expert committees have investigated individually and corporately the underlying causes of the persistent floods that Ghana faces in its urban centres and suggested various measures and necessary actions for their management to the Government. Nevertheless, in spite of the various steps undertaken by the Government over the past few decades, the trend of increasing damage and wreckage conveyed by floods has posed a challenge to the Government in particular and the populace as a

whole. The study will like to suggest some approaches to flood management presently exercised in other parts of the world faced with similar flooding issues and how far we can adopt some of these as a nation.

4.1. Solutions from Other Countries

Khalequzzaman (2000), in suggesting management practices to curb flooding in Bangladesh offered that:

“Formulating solutions to flooding problems requires a comprehensive understanding of the geologic settings of the region, and a better knowledge of hydrodynamic processes that are active in watersheds. Only solutions that take into account the underlying long-term factors contributing to flooding problems can prevail. Such contributing factors are as follows: unplanned urbanization, soil erosion, local relative sea-level rise, inadequate sediment accumulation, subsidence and compaction of sediments, riverbed aggradation, and deforestation.”

He further offered that a mere structural solution such as the building of embankments and drainage systems will not solve the problem. He reviewed instances that had failed when flood control measures were limited only to the building of embankments, polders, and drainage. This point is reiterated by Bhowmik (1998) who observed in the American situation that mere flood control embankments on the Mississippi and Missouri river basins either failed or overtopped during the floods of 1973, 1984 and 1993. The same failed structural designs were reported during flood events in different cities in Argentina (Maza *et al.*, 2004).

4.2. Suggested Remedies

Based on practices from other nations such as Argentina (Maza *et al.*, 2004), USA (Bhowmik, 1998), and Bangladesh (Khalequzzaman, 2000), the following suggested remedies are recommended for the Ghanaian situation.

1. Reduction in the extent of impervious surfaces
As earlier noted, impervious surfaces are materials that inhibit the infiltration of water into soils and these may include roads, sidewalks, cemented surfaces and compacted soils (Arnold *et al.*, 1996). If possible the government can, with legislation, start a program at the district and municipal levels to replace impervious surfaces such as cemented floors with lawns. This will facilitate the infiltration of rain water into soil so as to reduce that discharge that runs off to overload drainage channels. Human passageways or footsteps should also be strictly designated since the unrestricted general walking compacts the soil making the land impervious to water.
2. Redesign and long term reconstruction of current drainage systems.
Accra’s drainage systems should be redesigned with climate change impacts such as flooding in mind. The increasing population factor should also be factored into the design and engineering process. The design could also be done to harvest and redistribute flood waters through channels for multipurpose usage.
3. Legislation
Attitudinal changes are important but difficult to start or maintain. Legislations and enforcement with fines and penalties can serve as negative incentive to motivate the populace to chart the path of sustainable development. The government should ensure that environmental laws and conventions in the country are aptly complied with, with the necessary negative incentives to discourage people from flouting them.
4. Focus on rural agriculture and development
Since agriculture in Ghana is mainly limited to the rural areas, attention should be given to enhance agriculture and livelihoods in these rural communities. In so doing, the rural-urban exodus which is mainly due to failing agriculture and livelihoods in the rural areas may not genesis in the first place.
This could be combined with a national rural irrigation project to ensure the availability of water all use round in the rural communities for agricultural activities.
5. Demolition of structures
Buildings in waterways and river floodplains should be demolished along with slums that are scattered all over Accra. This aspect should not be politicized.
6. Increased awareness and education
Environmental education should be an integral and core part of our educational system. This is because everything we study in school can only be practiced in a sound environment. Therefore educating the masses with the environment in mind should be a step in the right direction. The leaders and heads of key institutions should have periodic education on the urgent need for sustainable urban development. Awareness creation about the environment should be stepped up on all fronts especially radio and television to expose the dangers of pollution (especially water pollution) and its contribution to flooding to the populace
7. Applying research findings
There have been numerous research findings with viable recommendations from the academia and corporate bodies. These recommendations range from non-structural to structural approaches that can be used to curb the flooding menace. Government institutions responsible should make it a point to fall on these researches and make use of the invaluable recommendations. This will also be incentive enough for these individuals and corporate bodies to do more as regarding this research area.
8. Regular dredging of urban water bodies and streams and cleaning of open drains
Water bodies such as the Korle Lagoon and the Odaw River in Accra and filled with debris all year round. Together with open drains, these bodies have become receptacles of all forms of waste from residents. A legislative requirement at the local

assembly or district levels for residents and the assemblies to clean drains and dredge water bodies on a weekly to monthly basis can be considered.

9. Improvement on flood warning/ preparedness systems

Early warning systems help communities to prepare for floods in diverse capacities thereby increasing urban resilience to the event. Early information on precipitation, wind speed and direction, flow rates among other vital parameters can help both individuals and the disaster management bodies to avert otherwise catastrophic events. Equipment and technologies as well as technical advice needed for this are available worldwide. Companies such as Xylem Analytics based in the USA have provided such services to cities and towns in the past.

10. Proper land-use planning

In doing this, there should be an integration of flood risk management in the face of rapid urbanization. Planners could consider flooding risk as a key factor in deciding land zoning and land-use intensities.

11. Future studies should look at the technical issues involved such as the flooding propensity potential of the area. Such studies need to analyze land use practices in watersheds during the last few decades that have potentials to impact hydrodynamic behaviors of rivers, affecting three vital parameters: runoff, water carrying capacity and land elevations.

12. Check on deforestation practices and implementation of afforestation programs

A combination of education, legislation and enforcement can help in curbing deforestation practices in the region. Afforestation programs may be started by the concerned outfits to rejuvenate our forests.

13. Encouraging organizations to go green (tree planting exercises)

Organizations and companies should be encouraged to plant trees in and around their premises to serve as wind breaks to reduce the impact of strong windstorms that may otherwise directly hit buildings and other structures in the absence of vegetation. And added advantage is that the roots of these trees tend to hold the soil compact preventing them from being carried away by wind and runoff water to result in erosion and future degradation of the land.

5. Final Words

Urbanization should always be directed by sustainability goals, encouraging a balance among green environments, good transport and drainage systems, and good housing with proper land use planning. This will call for the concerted efforts of diverse public and private partnerships in order to create sustainable communities that will be resilient to the future impacts of climate change.

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