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Climate Change: Space Technology and Climate-Resilient Development in Nigeria

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Abstract

Nigeria, like other Sub-Saharan African countries contribute less to climate change but the country is vulnerable to climate change-induced dangers of desertification, corrasion, flooding and other bionomic complication. This paper appraises the use of space technology as an instrument in climate change tracking system in the effort to mitigate disaster in Nigeria to ensure sustainable development. The paper observed that if Nigeria had properly utilized its space resources, the effect of the natural disasters that ravaged the country in 2012 would have been significantly reduced. Also, lack of coordination impedes relief efforts in areas stricken by disasters and this is where the stupendous challenge of disaster preparedness reclines in Nigeria in defiance of all official planning and programming. In the light of the impediments in obtaining data in the right quality for disaster management in Nigeria, the National Geospatial Database Infrastructure (NGDI), as a data clearing house domesticated at NASRDA should be made utilitarian by relevant national legislation and support among others. Conversely, NASRDA should focus on acquisition of facilities and provision of services to aggrandize its capabilities.

1. Introduction

Climate change refers to any alteration in climate overtime, whether due to natural discrepancy or as a result of human dexterity (McCarthy, Canziani, Leary, Dokken, & White, 2001). It can also be seen as a reorder of climate which is ascribed squarely or incidentally to human activity that transfigures the configuration of the global atmosphere and which is in addition to observed natural climate variance over comparable time periods (Parry, Canzian, Palutikof, Van der Linden, & Hanson, 2007). Today the change as a prime issue is discussed worldwide. Many scientists regard global warming and its repercussions to human activities rather than to natural instability. The reasoning of this approach is the time scale of climate change. The present-day warming of the earth is considered to be abrupt compared to the time scale usually accompanied with natural climate change episodes. As obvious the Earth's natural climate changes occur progressively over a long period of time (tens of thousands to millions of years) but we are experiencing a swift change over the last 200 years. The primary basis is the industrial revolution having its principal source of energy as fossil fuel which is setting a steady emission increase of carbon dioxide and other greenhouse gases which trap heat causing an increase of temperature in the lower atmosphere. Unusually behaviors of the strong tropical storms, heavy precipitations causing a devastating floods, additional incessant heat waves, frequents droughts and other similar natural events are connected to a modern climate change.

Sub-Saharan Africa is one of the most stricken regions in the world notwithstanding its tiny contribution to climate change. Indeed the continent is highly exposed to climate change and its structural weaknesses result in lower resilience see Table 1 in Appendix for the impacts of climate change, vulnerability, and capacity for adaption in Africa). With 40 percent of the population living on arid, semi-arid or dry sub-humid areas (as cited in Adenle and Agboola (n.d)) Africa definitely is one of the extremely exposed parts of the world to global warming. During the last century, it encountered a warming of approximately 0.7°C and there still anticipation that the temperature will increase by 0.2°C (low scenario) to 0.5°C (high scenario) per decade in the future. Moreover, in the preceding 25 years as note by Hulme and Kelly (1997) the reduction in rainfall witnessed in the Sahel was the most significant and prolonged recorded within the period of instrumental measurements anyplace in the world.

A great percentage of Africans live in coastal areas: one-quarter of the populace resides inside the range of 100 kilometres of a sea coast (Singh et al., 1999). Because of climate variability and sea levels increase combination, this population will be increasingly exposed in the next decades. Nicholls, Hoozemans, and Marchand (1999) found that the sea level progression could expand the sum total of people in Africa affected

by flooding from 1 million in 1990 to 70 million in 2080 (simulating a 38 cm global rise of sea level throughout this period).Not only is the continent a greatly exposed region, so it encounters structural challenges that make worse the outcome and restrict its ability to command efficacious results.

Space technologies have led to several inventions that benefit the environment and save energy. Vehicles carbon dioxide emissions are being reduced by satellite-based systems, wind turbines are more efficient as a result of remote sensing technology and solar cells produce more energy based on information from weather satellite. These are just some examples of how spin-offs from space technology and satellite service can make a difference.

Nigeria is subject to climate-induced dangers including desertification, erosion, flooding and other ecological problems, just like many other countries. Considering the strong nexus between climate change and development, Nigeria is highly at risk considering the issue of food and nutrition, poverty and hunger reduction, and especially, economic development (Ogbo, Lauretta, & Ukpere, 2013).

In the realization of rapid sustainable socio-economic development, Nigeria's disaster management is now a primary focus of Government at the Federal, State and Local levels. Given the position of space technology in the issue of disaster management, Nigeria's Federal Government took a bold step by putting in place a space policy and space science and technology programme. Subsequently, in 1999, an institutional framework, the National Space Research and Development Agency (NASRDA), was established. The approval of the National Space Policy in 2001 and the execution of the programme enunciated in it climaxed in the launching in September 2003 of an earth observation satellite.

The aim of this paper is to show the essence of using space based information to assess, monitor and counter climate change related disaster risks and integrate space technology into long-term disaster risk diminution efforts with respect to ambient of climate resilient development in Nigeria. In section two, relevant theoretical issues are reviewed concerning climate change manifestation in different climate criteria inclusive of cloud cover, precipitation, temperature ranges, sea levels and vapour pressure. The third section centres on the effect of climate change on disasters, and international agreements. Also, the breakthroughs in space technologies and methods explored were captured in the section. The fourth section examines the institutional framework for disaster management in Nigeria, application of space technology and the resilience of Nigerian Economy and forecast over the coming period. Section five takes a look at the hindrances in Nigeria's space programme towards climate resilience while section six concludes by summarizing the policy implication that requires the attention of national governments and relevant organizations towards successful climate resilience in Nigeria.

2. Theoretical Foundation

In recent times, climate change has turned out to be a worldwide concern visible in alternative form of dissimilar climate criteria inclusive of cloud cover, precipitation, temperature ranges, and sea levels and vapour pressure (Ministry of Environment of the Federal Republic of Nigeria, 2010).

The disparity in climate criteria exerts influence on various sections of the economy including [but not limited to the following]: agriculture, health, water resources, energy etc. The main cause of climate change has been attributed to anthropogenic (human) activities. As an illustration, developed nations' increased industrialization has resulted to the initiation of great quantum of greenhouse gases (GHGs), inclusive of carbon (IV) oxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) into the atmosphere. These GHGs are the primary causes of global warming (Ogbo et al., 2013).

The rise in CO_2 concentration worldwide is mainly owing to fossil fuel utilization and land utilization change, while those of CH_4 and N_2O are majorly as a respect of agriculture. Most definitely, the earth is becoming warmer and human beings are by and large to be held accountable (Spore, 2008). With reference to sub-Saharan Africa, there is aggrandizing interest on the distinctly possible impacts of climate change on agriculture, economic growth and sustainable development. The world has risen to the challenge and has started to set in motion legal and institutional mechanisms and measures to collectively tackle the issues of climate change. The most prominent of these are the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (Ogbo et al., 2013). Interventions to contend with climate change impacts demand the involvement of stakeholders at national and local levels. Adaptation requires the active involvement of divergent player/actors and responses at multiple levels. Broad scientific agreement now exists that continued accumulation of heat-trapping "greenhouse" gases in the atmosphere is contributing to changes in the global climate, and in the climates of regions around the world (Crosson, 1997).

The earth has warmed an average of 0.60C based an analysis of temperature record over the past 100 years (Environment Canada (EC), 2008). The warming is real and significant and have been principally caused by greenhouse gases, its severances has varied from decade to decade, from region to region and from season to season (Crosson, 1997). As shown in the growing concurrence in the scientific literature, in many regions and countries, higher temperatures and changing precipitation levels attributed to climate change will be adverse for crop growth and yield over the coming decades (Yesuf, Difalce, Deressa, Ringler, & Kohlin, 2008).

Disaster risk and climate change buttress each other and they are both threats to human well-being. As such, in this century, they represent some of the greatest challenges to humankind. Emerging from the fusion

of natural and human factors and subject to exacerbation or reduction by human agency, disaster risk is an inherent characteristic of human society. While the adverse impacts of climate change on society may increase disaster risk, disasters themselves erode environmental and social resilience, and thus increase susceptibility to climate change (O'Brien et al., 2008).

Climate change and the likely surge in disasters threaten to block pathways out of poverty in developing countries especially those in Africa. Any increase in disasters, whether large or small, will threaten development gains and hinder the implementation of the Millennium Development Goals (International Strategy for Disaster Reduction (ISDR), 2008). Development gains and implementation of the Millennium Development Goals will be endangered by any rise in disasters, whether immense or negligible (ISDR, 2008).Climate change is presumed to aggravate the risk of disasters, not only from more persistent and fierce hazard events but also through substantial assailability to the existing hazards, in the next few decades (ISDR, 2008).

The diminution of human vulnerability under changing levels of risk has to be reviewed in the tactics toward the management of climate change impact. A key challenge and opportunity therefore lies in building a bridge between current disaster risk management efforts aimed at reducing vulnerabilities to enormous events and attempts to promote climate change adaptation (Olorunfemi, 2008). Vulnerability to disasters relates to the extent to which a socio-economic system or physical assets are either prone or irrepressible to the impact of natural hazards (Birkmann, 2006).

UNDRO (1991) defined it as "the degree of loss to a given element at risk or set of elements at risk resulting from the occurrence of a natural phenomenon of a given magnitude and expressed on a scale from 0 (no damage) to 1 (total damage)". Blaikie et al. (1994) on the other hand define vulnerability as the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from impacts of a hazard", while UNDP (2004) said that it is "human condition or process resulting from physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given hazard". The synthesis of various facets determined it including the condition of human settlements and infrastructure, awareness of hazards, public policy and administration, the wealth of a given society and organized abilities in all fields of disaster and risk management (Adedeji, Odufuwa, & Adebayo, 2012).

The long term horizon of climate change and current scientific uncertainties pose special challenges. Strategies that address challenges recognize that the best solution cannot be found. Thus climate change has been labelled as the "modern times defining challenge". Its impacts are already showing and will intensify over time if left unaddressed. If left unattended to, its impacts will intensify, already it is showing. Understanding and forecasting climate change requires a long-term, multivariate oceans and terrestrial observing system. In the context of climate change, the application of satellites to monitor processes and trends at the global scale is indispensable.

The theoretical framework that is best suitable for the understanding of climate change and space technology is transformational theory; this is because transformational theory deals with the creation and change of a whole new form, function or structure. To transform is to produce/design something new that has never existed before and could not be predicted from the past. Transformation is a "change" in mindset. It is based on learning a system of intellectual knowledge and taking actions based on leading with knowledge and courage (Ogunyemi & Babalola, 2012).

When leaders design a vision for a system to regularly question and challenge beliefs, assumptions, patterns, habits and paradigms with the aim of recurrently developing and implementing management theory, through the lens of the system of insightful knowledge, which is transformation in occurrence. Transformation takes place when people overseeing a system concentrate on engendering a new future that has never existed before, and going by repeatedly learning and brand new mindset, execute actions dissimilar to the past. A theory of transformation means there will be a profound change in structure that creates something new (Ogunyemi & Babalola, 2012). The technique for transformation is made available by the system of profound knowledge. A system of constant questioning, provocation, investigation, findings, appraisal, verification, and construction of an organization's management theory and application bring about transformation. Starting with the consciousness or declaration that the organization's current thinking (i.e., management theory) is imperfect, restricting, distorted, or even worse – ruinous (Ogunyemi & Babalola, 2012).

The assumption as far as transformation is concern is that destination is unknown, and that never has the journey been embarked on. It is uncertain and unpredictable. It accepts new learning and actions are executed on the basis of new discoveries for leading transformation, Dr. W. Edwards Deming provides the system of insightful knowledge as our new lens. It involves admiration for a system, apprehension about variation, theory of knowledge, and theory of psychology (Marcia & Sheinberg, 2005). Climate change and space technology give room for new innovation that incorporates new changes. New changes are the framework of transformation.

In communication, national security, natural resources management as well as prediction, navigation and management of natural disasters, space exploration and space resources exploitation are now predominant

factors (Adetoro & Aro, n.d). New items, brand new concepts and solutions in medicine, manufacturing industry, agriculture, microwave engineering, food technology and material science which have been generated are the spin-offs of space exploration. Thus space technology can impact on the socio – economic development of any Nation when integrated into the development strategy (Adetoro & Aro, n.d).

3. The Impact of Climate Change on Disasters

In the lives of many people in the world, most especially the poor, climate-related stresses and shocks so far are noticeable. People are often left with horrific experience especially after experiencing natural events such as droughts, floods and storms. These events lead to substantial life loss, numerous livelihoods destruction and millions of people traumatized. Climate change is likely to compound the risks of disasters by repeated and vigorous hazard events, and also via extreme vulnerability to the existing hazards, in the next coming decades.

During the last 20 years, the total of recorded disasters has doubled from approximately 200 to in excess of 400 per year (ITCCIASC & ISDR, 2008). Flood disaster are more persistent(from approximately 50 in 1985 to in excess of 200 in 2005) and destroy substantial areas compared to twenty years back. Extreme climate variability and its effects are probably to become the norm in future as portrayed by current trends. More recurring and severe storms, along with ascending sea levels increasing the risk of flooding are the significant human implications

One tenth of the global population(i.e., virtually 634 million people) – reside in at-risk coastal areas a couple of meters overlooking existing sea levels, three quarters of which are situated in the Asian flood-prone river deltas or in low-lying small island states (ITCCIASC & ISDR, 2008). Practically two-thirds of mega-cities with populations higher than 5 million fall, at least partly, in low-lying flood-prone areas. In least developed nations, 21% of the urban populations live in such environments (ITCCIASC & ISDR, 2008). Between 1991 and 2005, 3,470 million people were affected by disasters, 960,000 people died, and economic losses were US$ 1,193 billion (ITCCIASC & ISDR, 2008). Due to inherent vulnerabilities to hazards and relatively low potentials for risk reduction measures, poor countries are unduly stricken. Grenada's losses of 919 US$ million due to Hurricane Ivan in 2004 were equal to 2.5 times its GDP, invariably; small countries are especially vulnerable also (ITCCIASC & ISDR, 2008). 76% of all disaster events were hydrological, meteorological or climatological in nature; responsible for roughly 45% of the deaths and 80% of the economic losses caused by natural hazards, in the last two decades (1988-2007). The chances of heightened weather extremes in future brings serious worry that the quantity or magnitude of weather-related disasters will also rise.

Nigeria encounters diverse hazard risks. Droughts, floods, sea level rise, and coastal erosion are currently the natural hazards that pose the greatest threats; causing more damage and higher number of casualties. Available literature on Nigeria depicts the presence of spatial differences as far as the nature of disasters is concern. While oil and gas pollution is principally a Niger Delta complication, drought alongside quella birds plague happen in the Sudano-Sahelian states (e.g. Kano, Sokoto, Katsina, Borno and Yobe) (Olorunfemi & Adebimpe, n.d). However, soil erosion, rainstorm and flood disasters are prevalent in virtually all the states. Several disasters accompanied by numerous casualties including property damage have the nation witnessed. In 2009, almost 90% of all disasters were weather –related, 99% of victims and 80% of deaths were due to weather related disasters (Iguisi, n.d).

Climate-Resilient Development and the Reduction of Vulnerability

The Bali Action Plan in paragraph 1 (c) (i) calls for international cooperation to support the urgent implementation of adaptation actions, including through various ways to enable climate-resilient development and reduce vulnerability of all Parties. The crucial and expeditious needs of developing countries were specially noted especially those vulnerable to climate change unfavourable effects.

Techniques/methods aimed also to build resilience and reduce vulnerability are inclusive of disaster risk reduction strategies and risk management, and consequently they proffer capacities to encourage adaptation, in connection with coping with extreme events such as drought, floods and storms besides tackling longer term problem such as ecosystem degradation that increase vulnerability to these events (ITCCIASC & ISDR, 2008).

Underlining this, at the international level, the concurred plan for minimizing disaster risks and disaster losses, the Hyogo Framework for Action 2005-2015 is subtitled "Building the Resilience of Nations and Communities to Disasters" and regards *inter alia* the incorporation of risk examinations into sustainable development and the building of establishments, procedures and potentialities at all levels to comprehensively invigorate resilience to hazards. The execution of the Hyogo Framework hence confers a formidable tool to encourage adaptation, via developing resilience and lessening vulnerability to climate-related hazards. The instrumental part of the UNFCCC as envisaged in the Bali Action Plan will directly be also nourished (see paragraph 1(c) (v).) As declared by the United Nations Secretary-General, nonetheless, "While some advancement has been made, the enormity of resources accessible for disaster risk reduction is far below what

is needed to make certain that the resilience of nations and communities is constructed (ITCCIASC & ISDR, 2008)."

Advances of Space Technologies and Methods: Remote Sensing and Geographical Information System

The gradual increase in temperature of the earth's atmosphere has become the foremost reasons of increasing the rate of occurrence and gravity of climate-related disasters, specifically drought, flooding, and catastrophic storms. Climate change impacts are reflected on ecosystems, forest and wetland conservation, water supply and sea level change, etc. In the meantime the utilization of advances in information systems, satellites imaging systems and improved software technologies open a wide opportunities for investigation of tremendously delicate natural phenomena. The incorporation of this data provides a wide scale of analysis tools and information products by virtue of developed geographical information system (GIS) created on application of space technology (Rustamov, Salahova, Hasanova, & Zeynalova, n.d). Since disasters that bring about immense social and economic interference usually devastate wide-reaching region or enclave and are connected to global change, the application of traditional and conventional methods for management of the natural disaster impact cannot be efficaciously executed for initial data collection with the further processing. Magnificent chances of gathering critical data are made possible by space technology or remote sensing tools. The ability of this technology for gathering data worldwide and regional levels swiftly and recurrently is the principal reason. This is indisputable benefit of the space methods and technology.

The satellite or remote sensing techniques can be employed to monitor the current situation, the situation before going by the data in sight, besides after disaster occurred. Baseline data can be derived from them in which future variations can be equated while the GIS techniques gives an acceptable framework for incorporating and examining the numerous categories of data sources demanded for disaster monitoring (Rustamov et al., n.d).

4. Institutional Framework for Disaster Management in Nigeria

According to Otero and Marti (1995) some intrinsic elements of the nation, society, or economy affected have, in general, upshots for the efforts needed to face the emergency, undertake reconstruction, and finally, surmount the results of the disaster. Relative size of the economy affected, the magnitude and depth of the event, and the economic and socio-political conditions of the country at the time are some of these elements. In response to the upsurge in disasters, the Federal Government of Nigeria through Decree No. 12 of 1999 established the National Emergency Management Agency (NEMA) as the apex public sector agency for emergency management (Olorunfemi & Adebimpe, n.d). This legal instrument was fashioned after the USNEMA law, but its operation has been handicapped by several factors among which are inadequate funding and equipment, weak executive capacity and lack of decentralization. The enabling legislation contains concepts like co-ordinate, liaise, monitor and collect, etc. which presupposes that NEMA is a coordinating agency. Although Nigeria has signed up to the United Nations Framework Convention for Climate Change (UNFCCC), and is widely recognized to be unprotected from climate change, much still needs to be done to develop local awareness, knowledge and expertise (Olorunfemi & Adebimpe, n.d).

Climate Change, Vulnerability, Space Program and Application of Space Technology in Disaster Management in Nigeria

Climate change, which is attributable to the natural climate cycle and human activities, has adversely affected productivity in Nigeria (Ziervogel et al., 2006). Climate change is worldwide by the same token is its impacts as available evidence depicts; developing countries are sure to face the most negative effect, predominantly those located in Africa, attributable to their coping capabilities level which is low (Nwafor, 2007). The developing countries are inclusive of Nigeria (Odjugo, 2010). As the earth experiences warms, rainfall sequences alter, and dangerous events such as droughts, floods, and forest fires happen often (Zoellick, 2009) which culminate in imperfect and unreliable yields, thus causing farmers to be more vulnerable notably in Africa (United Nations Framework Convention on Climate Change (UNFCCC), 2007). Unfortunately, farmers account for a large number of the poor in Africa and they experience the likelihood of distressing crop failures, decline in agricultural productivity, hunger rise, malnutrition and diseases (Zoellick, 2009). As a result of climate change in Nigeria, crop yield is projected to by 10-20% by 2050 or even up to 50% (Jones & Thornton, 2003) mainly in view of the fact that Nigerian agriculture is primarily rain-fed and consequently basically relies on unexpected and inexplicable variation in weather. In the effort of alleviating Nigerians from poverty and advance economic growth, this circumstance threatens to intensify vulnerabilities, erase hard-won gains and earnestly compromise possibility for development (Ogbo et al., 2013) hence the need for concerted effort towards tackling this menace. The constant reportage of disasters occurring in Nigeria in the print and electronic media signals the enormous vulnerability of Nigerians to day-to-day natural and human-induced hazards.

Recent Nigerian history is replete with various accidents and mishaps which reveal the shortfall of readiness of this populous State to deal with emergencies. Nigeria's inadequate disaster management systems were even more harshly exposed when the nation endured a series of air crashes from 2005 to 2006 and

beyond (Ogbo et al., 2013). All the violent conflicts and civil disturbances which ubiquitously flared up in many regions of the country in recent years were characterized by the slow response of the security, emergency and relief agencies to crisis spots, and the resultant unnecessary protraction of the agony of people who had been affected by them.

As Nigeria marked the tenth anniversary of the 2002 Ikeja ammunition depot explosion disaster, and as the world continues the mop up activities following the recent massive earthquake devastation of Haiti, it is now imperative for Africa's most populous State to radically reorganize its disaster response capability, and to prepare a specific plan to make better the response capacities of the local people, improve their livelihood in everyday life, for example, by strengthening and improving housing quality, gainful employment and access to income (Ogbo et al., 2013). Given the fact that the country is within an earthquake-prone zone; hence the seriousness of these tasks (Muanya, 2010). That Nigeria lacks the most basic standards of disaster risk prevention, management and reduction is a subject that has received considerable attention. Ascribed to its geography, climate, vegetation, soils, economic structure, as well as population and settlement, energy demands and agricultural activities, Nigeria is vulnerable to climate change impacts.

The location and size of, and the characteristic relief in Nigeria brought on a variety of climates ranging from tropical maritime climate characterized by the rainforest along the coastal and southern region to the tropical hinterland climate related with the Sahel in the north eastern region of the country. One irony in climate change as a global problem is that developing countries who contribute the least to cause the problems are the most vulnerable to its impact. They are the most vulnerable due to the fact resource wise they are endowed the least and technology to counter the challenge and their economies are established principally on natural resources –dependent sectors that are climate sensitive. Nigeria happens to be one of those countries. Poor countries are so vulnerable due to their location as opined by Mendelsohn, Morrison, Schlesinger, and Andronova (2000) and Mendelsohn, Dinar, and Williams (2006). Countries with low latitudes start with very high temperatures.

There are various reasons why Nigeria is vulnerable to climate change apart from being a developing country. For instance; it is established that every country is affected by climate change, but the degree with which it is impacted to produce damage differs, depending on geographical conditions, the ability with which to resist the impact and the nature of the economy. Owing to it location in the tropics and from different socioeconomic, demographic, and policy trends dwindling its capacity to adapt to change, Nigeria becomes so vulnerable to climate change. NEST (2003) indicated that persistent destruction of forest cover and biodiversity in Nigeria is connected to global warming and climate change. Diverse ecological problems are plague Nigeria and are linked to changing climate. Due to existing low level of coping abilities in the country, the effect is expected to be more dominant in Nigeria and other parts of Africa (NEST, 2003).

The recent flood disaster in Nigeria in 2012 revealed the extent of vulnerability of communities, most especially, the river banks and coastal areas communities. This calls for efficacious, efficient and swift approach to avert recurrence.

Against this backdrop, the Nigeria Space Research and Development Agency (NASRDA), the agency in charge of space mission in the country collaboration with World Bank to highlight the function of space technology in disaster management and the essence for more collaborative efforts by disaster-control agencies to utilize the enormous satellite images and technologies to reduce their work burden and achieve faster results (Muhammad, 2013).

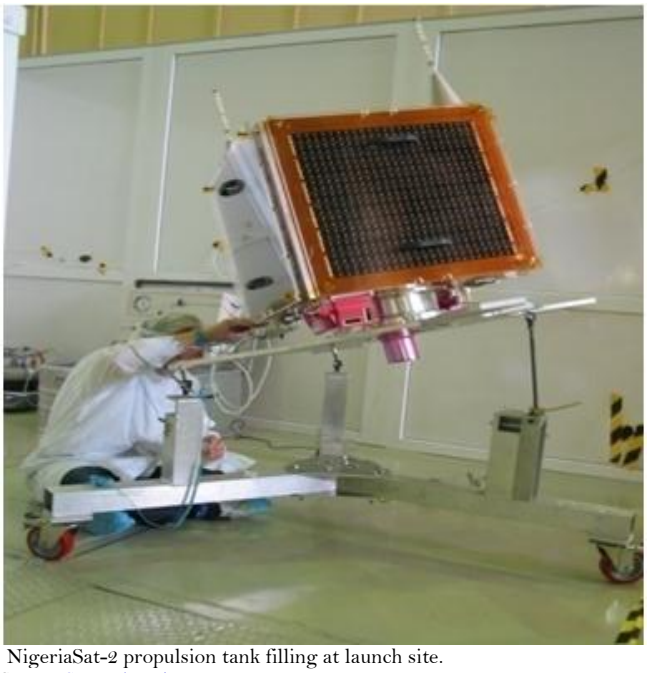
Photo of Lokoja flood.
Source: Information Nigeria (2013).

Residents of an affected community wading through flood water.
Source: Punch (2012).

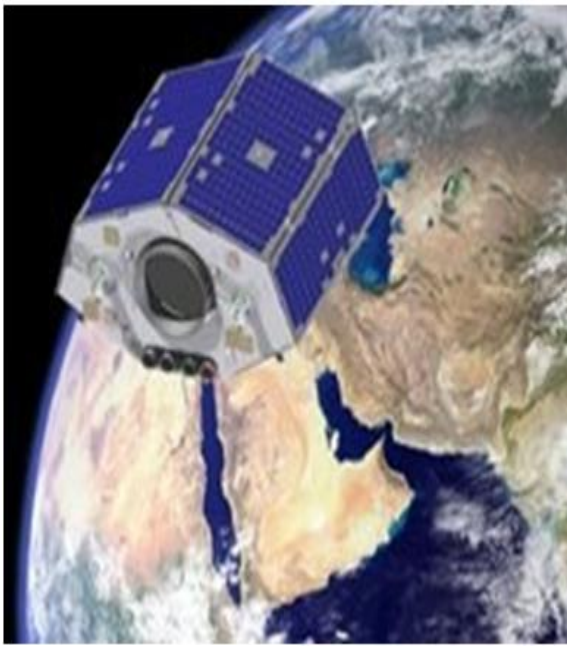
Different techniques are employed by various agencies in the event of disaster. This is done all in the effort to proffer solution. Satellite technology and science utilization according to popular belief have influenced the ways things done, i.e., from obsolete and time wasting to more efficient and effective, hence expanding the scope of research and development which culminates swift outcome. In earnest, embracing the

application of satellite technology for disaster management is very imperative for Nigeria. Satellite use is now the most effective method of disaster monitoring and managing around the world.

Space based technology inclusive of earth observation satellite, communication satellite; meteorological satellite and global navigation satellite system take significant position in early warning, disaster monitoring, assessment and management. Nigeria, thus, needs to accept and integrate the application of satellite technology based solutions. According to the Minister of science and technology, Professor Ita Okon Bassey, space technology reveals the complete power of a nation and is the compelling power behind the economies and security of countries like USA, Russia, China, Britain and India. These developments could present the yard stick for Nigeria to accept space science and technology as a device for defence and security, and socio-economic development (Muhammad, 2013). Via NASRDA, Nigeria has been seriously working towards achieving the attainment of space abilities as indispensable means for Nigeria's sustainable development. Since the creation of NASRDA in 1999, attempts with respect to the accomplishment of space capabilities by Nigeria have cantered on research and scrupulous space education, engineering development, design and manufacture of satellite instrumentation and software development rocketry and small satellites, satellite data acquisition and digital image processing, remote sensing and geo-information and communication technology, and analysis and management of associated software and space applications, etc.



NigeriaSat-2 propulsion tank filling at launch site.
Source: Surrey (2013).



NigeriaSat-2 Mission Objectives.
Source: Surrey (n.d).

The influence of space accomplishments on human advancement and social progress is increasing. Regarding accomplishing the Millennium Development Goals (MDGs) in Africa, space technology is mainly profound where satellite solutions and products can be proven effective and efficient.

Due to growing awareness about space technology by many African countries, there are emerging joint efforts in space and other fields of human endeavour; among them is the African Resources and Management Constellation (ARMC). The NigeriaSat-2 is a portion of the satellite platforms for the ARMC. As a result of its high geometrical resolution, multi-spectrality, high radiometric sensitivity, revisit capabilities, wide area imaged by a single frame and the accurate geometrical processing that is realizable, NigeriaSat-2 data is a strategic source of information for a variety of applications connected to urban areas (Muhammad, 2013). Between 2010 and 2012, NASRDA has supported NEMA with the mapping of zones affected by flood. The map shows precisely the areas affected by flood enabled other national agencies and state Government to rehabilitate those affected by the flood. Some satellite images of Sokoto state flooding and Ibadan city in Oyo State flood disaster are presented in Appendix.

Resilience of Nigerian Economy and Forecast over the Period 2013-16

The Nigerian economy was anticipated to grow modestly in 2013 under the presumption of resilience witnessed in 2012. This was mainly projected on the indicated intent by government to focus on macroeconomic stability in 2013. A review of economic developments in Nigeria and trends in the major macroeconomic variables during 2012 vis-à-vis 2011 is presented here. The variables discussed include Gross Domestic Product (GDP), inflation, the value of total trade, imports and exports.

Overall economic activity in Nigeria in 2012 was impacted based on the various encounters. In both the oil and non-oil sectors, decreases in the real growth rates of economic activity were witnessed. On the basis of security challenges, and floods which happened towards the end of the year, oil production was reduced, while the non-oil sector (notably Agriculture, Wholesale and Retail Trade) was majorly hit by the floods and that weakened consumer demand. Real GDP grew by 6.34 percent in the first quarter and 6.39 percent in the second quarter of 2012 see Table 2. The rate of economic activity was to some extent greater than the earlier estimates of 6.17 percent and 6.28 percent respectively, as presented in early 2012 (NBS, 2013). Nevertheless, the amended growth rates were lower than those documented in the corresponding quarters of 2011, which is 6.96 percent and 7.50 percent respectively. Consequently the economy dropped by 0.62 percentage points and 1.11 percentage points correspondingly in the first two quarters of the year compared to corresponding quarters in 2011 (NBS, 2013).

Oil production was estimated at 2.37 million barrels per day (mbpd) during the first half of 2012, as against 2.48mbpd produced in the first half of 2011according to the Nigerian National Petroleum Corporation (NNPC) (NBS, 2013).Disturbances in production as a result of incidents of oil theft and vandalization in the oil producing regions were the primary reason for the 4.4% drop in crude production levels. Meanwhile, non-oil sector was affected by the occurrence of flooding, as well as muted consumer demand for the most part of the year, as seen in the Wholesale and Retail Trade, Telecommunication and Post sectors while infrastructure challenges still hampered Manufacturing. Nevertheless, the positive developments in the power sector made Manufacturing sector record a slight improvement in the second quarter. In the same vein, Real Estate, besides Building and Construction sectors performed better than anticipated. Table 2 provides sectoral growth rates for 2011 and 2012.

Table-2. Sectoral Growth Summary for 2011 and 2012.

Sectoral Growth (%)	**2011**				**2012**			
	Q1		**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4[f]**
Agriculture	5.31	5.7	5.76	5.68	4.37	4.21	3.89	3.83
Solid Mineral	12.9	11.85	12.43	12.85	11.65	11.72	12.61	12.68
Crude Petroleum & Natural Gas	0.05	0.98	-0.26	-0.08	-2.32	-0.73	0.08	-0.17
Manufacturing	6.13	7.2	7.84	7.63	5.17	7.59	7.78	7.71
Telecommunication & Post	32.14	34.1	35	36.39	34.06	29.38	31.57	32.5
Finance & Insurance	4.07	4.37	4.04	3.42	3.57	5.01	4.08	3.47
Wholesale and Retail Trade	10.06	11.43	11.8	11.92	8.42	8.65	9.62	10.76
Building and Construction	13.19	11.98	10.88	12.09	13.28	12.73	11.52	12.6
Hotel and Restaurants	12.2	12.39	11.96	12.01	11.45	12.3	12.33	12.69
Real Estate	9.51	10.54	10.86	11.16	9.34	10.81	10.24	11.1
Business and Other Services	8.62	11.03	8.52	9.81	7.67	11.26	9.11	10.69
Other sectors	4.68	4.6	5.04	5.5	4.97	4.84	5.25	5.78
Real Growth at Basic Prices	6.96	7.5	7.37	7.76	6.34	6.39	6.48	7.09
Non - Oil Growth	8.52	8.72	8.76	9.1	8.14	7.63	7.55	8.23

Source: (NBS, 2013).

The projected growth rate of real GDP in 2013 was forecasted to reach 6.75% compared to 6.61% estimated for 2012 (NBS, 2013). According to NBS (2013) real GDP was anticipated to average a growth rate of 6.9% during the period 2013-16.

Taking notice of evident realities in the macroeconomic environment in the country, this forecast seems to portray a steady growth pattern (in relation to previous statistics). This is in addition to the slowly surpassing productive base of the economy. Furthermore, government's continued effort towards revamping the economy is expected to drive higher growth during the period. Some of the various sectoral policy reforms put in motion include energy reforms, consolidation and post-consolidation exercises going on in the banking and sub-banking sectors, agricultural reforms and oil sector reforms. See Table 3 in Appendix for projected quarterly growth rates for the period 2013 to 2016.

For the period 2013-16, the inflation rate was expected to moderate significantly in relation to price. 12.0% inflation rate was recorded in December, 2012 when compared to January 2012 record of 12.6% (NBS, 2013). Nearly 9.8% inflation rate average was projected to be maintained over the period 2013. Based on the assumptions that CBN will steadily promote moderate monetary policy and domestic fuel price stability, these projections were made. In the same vein, a fairly stable trend over the period 2013-16 was portrayed by the external sector. Even though import decline may pull down the value of total merchandise trade over 2013, exports were projected to improve significantly by contributing more proportionally to total merchandise trade than imports. Obviously, a favourable balance of trade position for the economy is inevitable.

Total merchandise trade growth is projected on the average at 23.1% beyond 2013 owing majorly to growing demands for both exports and increasing imports (NBS, 2013).See Table 4 in appendix for historical and projected annual growth rates for real GDP, inflation and total trade.

5. Space Programme and Climate Resilience in Nigeria: Hindrances

Space is now the ultimate venue for the growth of national power and socio-economic development within many of the world's emergent states (Harding, 2012). Indeed, Nigeria like other African nations is steadily marking its own space aspirations and assembling the specialist skills required to attain these plans. Despite the multiples of benefits space programme present in Nigeria, it still has some detractors. Magnificent accomplishments would have be recorded by government in the area of healthcare or education in the country given the quantum of funds expended on space exploration. This is the focal point of critic's argument. Space satellites remain expensive, launches remain expensive, and returning information is only slightly less expensive. The price of entry is high and the cost of developing infrastructure from the bottom basically restrictive.

Most maps available in Nigeria today were produced in the 1960s and 1970s, as such; there is severe issue of geoinformation in the country. As far as the issue of layers for current natural and artificial resources distribution in Nigeria is concern, there is absolute need to make available key fundamental maps. As a result of limited standard up-to-date maps of some regions in the country, there is lagging behind in terms of: water resources and drainages, land use and land cover, soil, topography and geomorphology, geology and mineral, forestry/ecology, land resources/agriculture, and settlement and urban sprawl.

The impact of the natural disasters that ravaged the country in 2012 would have been significantly reducd (Nwoko, 2013) had Nigeria properly utilized its space resources. Although via NASRDA, it has been strongly pursuing the accomplishment of space capabilities as indispensable device for its sustainable development

Confusion and lack of coordination have been identified as the greatest challenges disaster respondents encounter in providing relief (Anderson, 1997; Hultman, 2006). Relief effort is restrained in regions affected by disasters due to lack of coordination and there lies the huge challenge of disaster preparedness in Nigeria in spite of all official planning and programming (Olowu, 2010). Whereas, NEMA is structurally indisposed, the condition is deteriorating at the state and local levels. Each state in Nigeria is directed by the 1999 NEMA Decree to acquire a fully equipped emergency management agency, however, in earnest it is yet to be achieved (Olorunfemi & Adebimpe, n.d).

6. Conclusion and Policy Implications

The governments, businesses and the public in general have been forced to pay serious attention to climate change and its impact on national economic growth and development. This was as a result of extreme temperatures, major and increasingly storms as well as earthquakes and other natural disasters resulting in massive losses of life, livelihoods and assets all around the world. Nigeria is no different. Whilst the Nigerian economy has witnessed enormous growth rates of an average of 7% in the past 5 years, if effort is made now to make the economy more climate-resilient, climate change will probably compound Nigeria's present vulnerability to weather swings making the objectives of Vision 20: 2020 tough to accomplish (This Day Live, 2013).

Space technology is worth investing in because of its advantage of lessening disaster harm, greater forecast, precise and prompt destruction assessment, and better resolution making in planning stages. With the new generation of very high-resolution satellites, like, Nigeriasat-1 and Nigeriasat-2, the future is promising and many more coming future years. The daily high-resolution imaging of the world will be made available to track natural and human-made disasters.

Spending on Nigeria's space programme must be regulated to safeguard climate-resilient development in Nigeria. The expenditure must be proportional to the advantages to the citizenry that such a project may generate so that projects do not draw condemnation from the public. Measures must be mounted in order to dissuade and pinpoint corruption or embezzlement, especially with such enormous sums at stake.

For the demands to be met for multi-thematic decision making for sustainable country-wide resource inventory, planning and development, it is of significance to institute and preserve a space-based integrated natural and artificial resource information system known as IMSD. This will intensify rapid and sustainable resource mapping, planning, monitoring and management.

NASRDA being the storehouse of all geospatial data for the whole nation makes it a one-stop shopping centre for collecting extra data required for processing and analyzing enormous scale disaster management models. Certainly, it is essential for other agencies to utilize the instituted and preserved databases which NASRDA has made available. Given the challenges in acquiring correct and high quality data for disaster management in Nigeria, and as a data clearing house domiciled at NASRDA, the National Geospatial Database Infrastructure (NGDI) should be made effective by relevant national legislation and support among others. NASRDA on the other hand should focus on acquisition of facilities and provision of services to enhance its capabilities.

As far as the Nigeria space programme is concern, private sector should be involved to invest more alongside government. In particular, stakeholders in various development planning process should be spearheading researches. For example, national, state and local governments are to look at changes in flood risk; public water corporations, relevant government agencies, as well as government regulators, should look at the impacts of climate change on water resources. Also, government agencies along with non-governmental

organizations should research on the impacts of climate change on ecology, land management and the environment.

Economic activities that are tertiary in nature and generate little greenhouse gases should be the emphasis of Nigeria. Similarly, a technology should be designed and developed that can capture most of the carbon emitted by industries which are discharged into the atmosphere. More so, there should be earmarking or apportioning of spaces in rural areas for rigorous and extensive tree planting. In the light of that, a heightened public awareness regarding the danger connected with climate change should be embarked on, early warning system should definitely be provided and resettlements be approved in certain regions of the nation. Additionally, in flood prone areas development should be limited and new facilities/infrastructure should not be located very close to the sea in order not to be affected by sea level rise. Immediate relocation of any already threatened infrastructure/facilities should be done.

Adoption and adaptation of integrated climate risk management is equally essential. Hazards and vulnerabilities which configure particular risk scenario would both be addressed with this concept and would range in scale from actions to manage the local manifestations of global climate risk, through to global measures to reduce hazard (for example, by reducing greenhouse gas emissions) and to reduce vulnerability (by increasing the social and economic resilience of a vulnerable country like such as Nigeria). Integrated climate risk management would need to include elements of anticipatory risk management (ensuring that future development reduces rather than increases risk), compensatory risk management (actions to mitigate the losses associated with existing risk) and reactive risk management (ensuring that risk is not reconstructed after disaster events). Moreover, it will have to take into account both potential impacts on socio-economic and environmental systems (Ogbo et al., 2013).

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Appendix

Table-1. Impacts of Climate Change, Vulnerability, and Adaptive Capacity in Africa.

Likely Regional Impacts of Climate Change	Vulnerability and Adaptive Capacity
Increase in droughts, floods, and other extreme events would add to stress on water resources, food security, human health, and infrastructure, constraining development.	Adaptive capacity is low due to low GDP per capita, widespread poverty (the number of poor grew over the 1990s), inequitable land distribution, and low education levels. There is also an absence of social safety nets, in particular after harvest failures.
Changes in rainfall and intensified land use would exacerbate the desertification process (particularly in the Western Sahel and Northern and Southern Africa).	Individual coping strategies for desertification are already strained, leading to deepening poverty. Dependence on rain-fed agriculture is high.
Grain yields are projected to decrease, diminishing food security, particularly in small food importing countries.	More than one quarter of the population lives within 100 kilometers of the coast and most of Africa's largest cities are along coasts vulnerable to sea level rise, coastal erosion, and extreme events.
Sea level rise would affect coastal settlements, flooding and coastal erosion, especially along the eastern Southern African coast.	Climate change has to be recognized as a major concern with respect to food security, water resources, natural resources productivity and biodiversity, human health, desertification, and coastal zones.
Major rivers are highly sensitive to climate variations and may experience decreases in run-off and water availability, affecting agriculture and hydropower systems, which may increase cross boundary tensions.	Adaptive capacity will depend on the degree of civil order, political openness, and sound economic management.
Increase in frequency of some extreme events in some places.	

Source: PCC (n.d).

Table-3. Projected Quarterly Growth Rates for the period 2013- 2016 (%).

	2013Q1f	2013Q2f	2013Q3f	2013Q4f	2014Q1f	2014Q2f	2014Q3f	2014Q4f
Real GDP	6.63	6.66	6.71	6.96	7.44	7.34	7.24	7.15
Inflation	10.61	9.77	9.39	9.27	9.36	9.45	9.53	9.61
Total Trade	-24.61	-25.11	-21.64	23.59	26.15	25.37	24.71	24.14
	2015Q1f	2015Q2f	2015Q3f	2015Q4f	2016Q1f	2016Q2f	2016Q3f	2016Q4f
Real GDP	7.06	6.97	6.89	6.80	6.73	6.66	6.59	6.52
Inflation	9.67	9.73	9.79	9.84	9.89	9.93	9.97	10.00
Total Trade	23.65	23.20	22.77	22.35	21.93	21.48	21.01	20.50

Source: (NBS, 2013).

Table-4. Historical and Projected Annual Growth rates for real GDP, Inflation and Total trade (%).

Year	2008	2009	2010	2011	2012f	2013f	2014f	2015f	2016f
Real GDP	5.98	6.96	7.98	7.43	6.61	6.75	7.27	6.93	6.62
Trade	16.88	-3.00	57.49	47.87	-11.57	-11.94	25.09	23.00	21.23
Inflation	11.98	11.97	13.59	10.91	11.98	9.76	9.49	9.76	9.95

Source: (NBS, 2013).

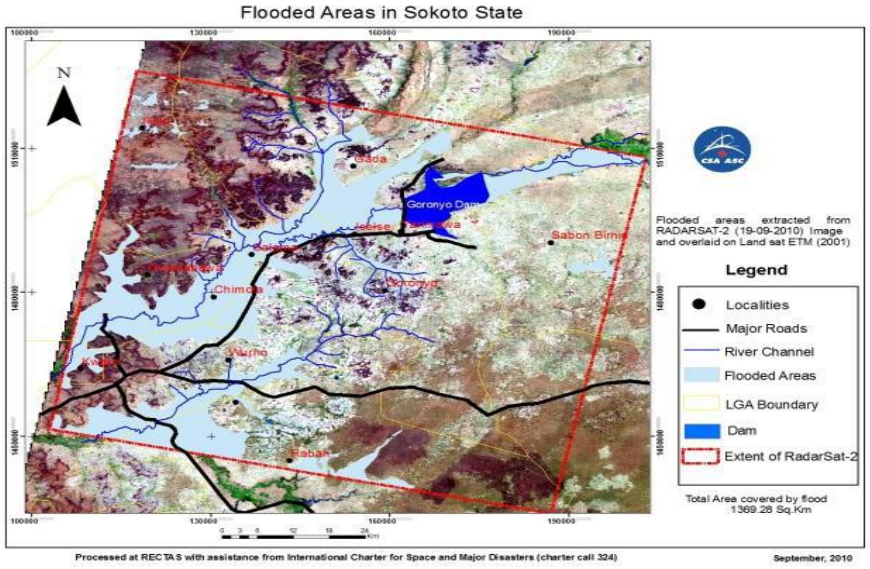
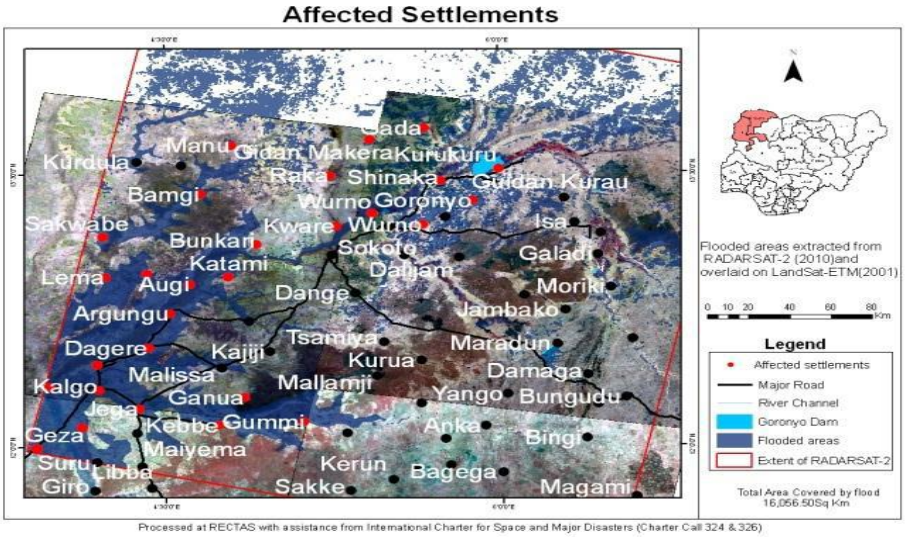
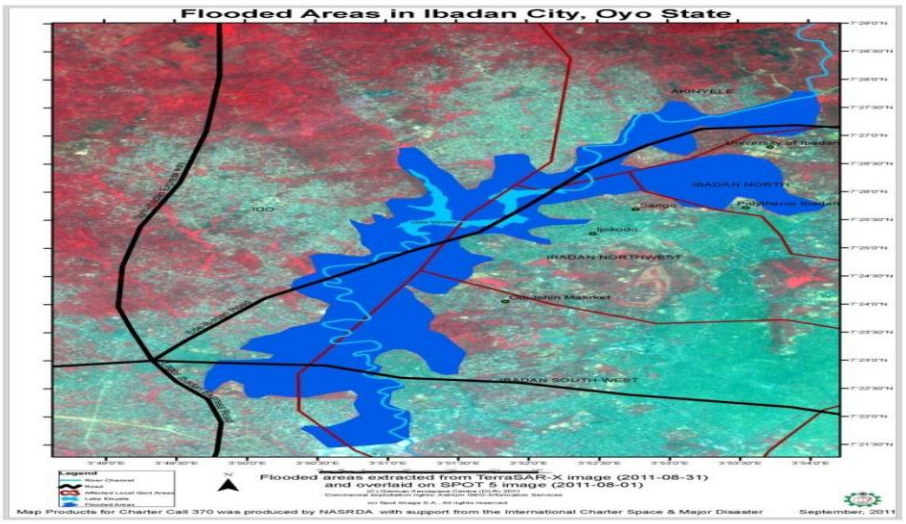


Figure-1. Satellite images of flooding in some parts of Nigeria.
Affected Settlements from Charter Call 324 and 326.
Source: James et al. (2013).



Affected Settlements from Charter Call 324 and 326.
Source: James et al. (2013).

The flood disaster occurred on the 9th of September, 2010 affecting Sokoto and Kebbi States in North-West Nigeria. The flood disaster was driven by heavy down pour of rain in the days leading up to the 9th of September. The results indicated that 17,425 Sq. Km area was inundated while some of the settlements along the floodplain of the River Rima affected include: Gada, Shinaka, Goronyo,Katami, Wurno, Augi, Kalgo, Gummi, Geza, Arugungu.



Ibadan Flooded Areas derived from Charter call 370.
Source: James et al. (2013).

On Friday, 26th of August 2011, torrential rain resulted in severe flooding in Ibadan, the Oyo State capital in south western Nigeria. Following the flood disaster, NEMA activated the ICSMD on the 29th of August 2011 (Charter Call 370). The map product generated above show that the local government areas affected by the flood were Oluyole, Ibadan North, Ibadan South East, Ibadan South West, Egbeda, and Ido. The following communities were severely impacted: Bodija, Odo-onaOke Ayo, Odo-onaElewe, Apete, Oluyole Industrial Estate, Onipepeye, Eleyele Dam Area, OlogunEru, Ogbere Idi Obi, The Polytechnic-Ibadan, University of Ibadan and Agbowo.