Geospatial Technologies For Sustainable Development

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Abstract
Previous studies have established that the purpose of sustainable natural resource management and development is to ensure that resources are utilised in a way that does not adversely affect their ongoing quality for current and future populations. But it is noted that factors such as climate change, population growth, environmental pollution, agricultural intensification, and urban expansion can seriously affect the use and availability of resources for future generations. Therefore, the appraisals of critical developmental issues call for methodologies and technologies that will enable assessment of current natural resource systems, risks and needs, and provide a means for ensuring sustainability in the future. To this end, Geospatial Science such as spatial analytical techniques, earth observation satellites (active and passive), Volunteered Geographic Information and crowd sourcing are new and existing technologies to map, monitor and sense our scarce natural resources for environmental sustainability.

Keywords: Sustainable Development, Geospatial, Earth Observation Satellites, Volunteered Geographic Information, Crowd Sourcing

Introduction
Man has always sought for ways to manage and conquer his environment. Understanding human evolution is key to understanding how man has shaped his environment, especially in the cultural and biological aspects (Ehrlich, 2000). The history of man's relationship with his environment can be narrowed to determinism; where the environment determined man's cultural and biological interactions, and possibility; where man makes his choices and bends the environment to suit his needs (Lewthwaite, 1966).

Human evolution has brought about the ability to utilize resources provided by the environment. Due to industrial revolution, human activities started to produce new impacts on natural resources whereby factories were built, producing new sources of pollution on air, water and soil; many towns and cities started to grow, generating social, human and health problems. For most of the last couple of hundred years the environment has been largely seen as external to humanity, mostly to be used and exploited, with a few special areas preserved as wilderness or parks. Environmental problems were viewed mainly as local. On the whole the relationship between people and the environment was conceived as humanity's triumph over nature (Hopwood et al., 2005). However, this has posed another problem: how to utilize the environmental resources without depleting or permanently damaging it. Thus, scientists have determined that man needs to sustainably utilise available resources. Hopwood et al. (2005) opines that the concept of sustainable development represents a shift in understanding of humanity's place on the planet.

With recent global environmental problems, there is an increasing number of research organizations, companies, industry groups, communities, government planners, non-governmental organizations (NGOs), building and facility owners around the world are presently exploring sustainable development. They are seeking creative approaches to integrate their pursuit of economic prosperity with the assurance of environmental protection and quality of life for current and future generations. With the recent adoption of the Sustainable Development Goals (SDGs) and the call by UN Secretary General for a "revolution" in the use of data for sustainable development, geospatial technologies have tremendous potential to effectively and efficiently monitor SDG progress (Sachs, 2015).

Sustainable development, a widely used phrase and idea, has different meanings and therefore provokes different responses. For instance, the United Nations Report of the World Commission on Environment and Development defines sustainable development as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This definition was based on two concepts; the concept of need and the idea of limitations imposed by technology and the environment (Brandtland, 1987). Daly (1990) argues that "sustainable development means qualitative, rather than quantitative, improvements of an environment or
urgency in the entire world. Sustainable development is particularly important because of the growing importance of biodiversity.

The concept of sustainable development has developed as a result of the growing awareness of the global links between mounting environmental problems, socio-economic problems, and concerns about a healthy future for humanity (Hopwood et al., 2005). It links environmental and socio-economic issues. Brundtland (1987) definition and the ideas expressed in the report recognized the dependency of humans on the environment to meet needs and well-being in a much wider sense than merely exploiting resources. The concept of sustainable development is becoming even more interwoven – locally, regionally, nationally and globally. The report highlighted the fact that humanity is dependent on the environment for its basic existence, security and longevity. It also points to the dangers of the planet’s situations: environmental problems are not local but global, so that actions and impacts have to be considered internationally to avoid placing problems from one area to another by actions such as releasing pollution that crosses boundaries, moving polluting industries to another location or using up more than an equitable share of the earth’s resources. Environmental problems threaten people’s health, livelihoods and lives and can cause wars and threaten future generations.

The Brundtland Report (1987) has led to worldwide concern over sustainable development. Building on the United Nations Millennium Development Goals (MDGs) which had its target for 2015, the United Nation at the Sustainable Development Summit in 2015 adopted a set of 17 Sustainable Development Goals. The goals are: no poverty, zero hunger, good health and well-being, quality education, gender equality, clean water and sanitation, affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, reduced inequalities, sustainable cities, responsible consumption and production, climate action, life below water, life on land, peace and justice, and partnerships for the goals (Barclay et al., 2015). The idea of the SDG is particularly important because of the growing urgency in the entire world. Sustainable development is particularly important to regions that are undergoing rapid economic development.

Policy and decision making in the context of sustainable development requires rapid, effective and efficient information. A number of appropriate current information from a wide range of sources and disciplines (Li and Yeh, 2000; Xiwan, 2002). Developing a strategy to ensure sustainable development requires careful study and analysis to fully understand sustainability-related opportunities and threats. Technology and innovation are key elements of sustainability-focused strategies. Governments need to integrate their pursuit of economic prosperity with the protection of the environment. The relationship between mounting environmental problems, socio-economic problems and concerns about a healthy future for humanity (Hopwood et al., 2005). It links environmental and socio-economic issues. Brundtland (1987) definition and the ideas expressed in the report recognized the dependency of humans on the environment to meet needs and well-being in a much wider sense than merely exploiting resources. The concept of sustainable development is becoming even more interwoven – locally, regionally, nationally and globally. The report highlighted the fact that humanity is dependent on the environment for its basic existence, security and longevity. It also points to the dangers of the planet’s situations: environmental problems are not local but global, so that actions and impacts have to be considered internationally to avoid placing problems from one area to another by actions such as releasing pollution that crosses boundaries, moving polluting industries to another location or using up more than an equitable share of the earth’s resources. Environmental problems threaten people’s health, livelihoods and lives and can cause wars and threaten future generations.

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Campagna (2005) opines that whatever the planning paradigm adopted, a knowledge based approach is required to carry on sustainable development processes. Thus geospatial technologies are important drivers in the technical and socio-organisational implementation of knowledge-based open and integrated platforms for information analysis, collaborative problem solving, planning and decision-making. Sustainable development is a multi-actor process that involves all levels of society, globally and locally. Sustainable development requires comprehensive processes which deal with multiple dimension problems aiming at achieving balanced economic development, environmental protection, social equity and welfare. The process is inherently collaborative and participatory in its own nature. Senior government decision makers at the international to the local level, organizations, entrepreneurs, interest groups and citizens are involved and should have access to information and tools for decision making.

For geospatial technologies to support sustainable development, it requires availability of data and tools to support decision making. Geospatial World (2015) reported that governments need to integrate their pursuit of economic prosperity with the protection of the environment. The growth in spatial data availability and the development in geospatial science and technology allow us to carry on informational planning processes (analysis, design, evaluation, decision, management and communication) (Campagna, 2005). The technology provides useful tools to deal with complex spatial problems, taking into account methodological and technical, as well as organizational and social issues related to the use of GIS to solve complex problems faced by practitioners in planning and implementing sustainable development objectives. It is an already proven tool which properly offers effective support to spatial planning and decision making, because the geographical component of the problem at hand is a determinant when dealing with sustainable development.

Geospatial technology has evolved over time from physical description of geographic space (where is what) to combining layers of mapped data for interpretation (what and why), to spatially characterizing and communicating spatial relationships (why and what if). Over the last few years, geospatial technology has evolved and converged with a variety of information technology disciplines. Geospatial technology includes remote sensing/earth imaging, geographic information systems, GPS, location based services and navigation systems. This technology has been deeply embedded through availability of broadband internet, portable devices and computers, and the ever-evolving environment of the World Wide Web. In fact, geodata is rapidly becoming a commodity used to aid all types of activities which is increasing characterising the digital world (Jackson, et al., 2009). Since the 1960s, spatial decision-making process has become increasingly quantitative and qualitative, incorporating mathematical models, spatial and statistical analysis, multimedia, and multiple layers and data sources. In the last four decades it has evolved from an emerging science to a fabric of society that depends on its products getting directions to major political and environmental decision making.

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Geospatial Technologies and Management of Natural Resources

Geospatial technology changes how information is viewed and decisions are made. Wright et al. (2009) opines that the technology blurs the boundaries between science and non-science, leading to a form of ‘social power’ in the form of providing improved access to data and maps. Geospatial World (2015) reported that in this age of social media, world has become a global village. It reported further that geospatial technology provides decision-making tools for modelling and policy framework, both in scientific research and day-to-day planning. The report emphasized the agricultural issues of depleting ground water, land degradation, climate change and other similar problems and solutions and proposed new tools and techniques for future challenges. Geospatial technology (2015) reported that geospatial technologies offer greater impetus to the matrix of natural, social, cultural variations and prepare a roadmap for future development. It is an already proven tool which properly offers effective support to spatial planning and decision making, because the geographical component of the problem at hand is a determinant when dealing with sustainable development.
sustainable with tolerable damage to the environment is one that should do the following:

a) Facilitate accurate location and definition of the geographic distribution of resources;
b) Provide data about the richness of the resources;
c) Allow a determination through interpretation on how best to explore the resources;
d) Permit the identification of the actual and potential impacts of exploiting the resources for the communities located near the resource;
e) Assist in determining regional and global impacts on environment and society.

Adesina (2005) goes further to reveal that the information referred to here, is not simply the data sets generated on the environment. It is in actual fact, a product of some processing of such data sets. This subtle distinction must be well understood to forestall the possibility of emphasizing either the data sets at the expense of the end products i.e. the information or vice-versa. The earth observing satellites generate environmental data but specialists including scientists and spatial analysts transform those data into forms that are intelligible to other people particularly the stakeholders. Therefore, the following are some of the specific application of geospatial technologies in sustainable developments.

Application of Geospatial Technology in Sustainable Development

According to Adesina (2005) the information required on natural resources to make their exploitation sustainable with tolerable damage to the environment is one that should do the following:

Water and Sanitation

Effective water quality monitoring is critical to water resource management programme. Without accurate, intensive and long-term data acquisition, the state of the world’s water resources cannot be adequately assessed, effective preservation and remediation programs cannot be run, and program success cannot be properly evaluated. Geospatial technology advances have resulted in progress in remote monitoring capabilities for water quality. As a result, the ability to characterize dynamic hydrologic properties at adequate temporal and spatial scales has greatly improved. These advances have led to improved statistical and mechanistic modelling in monitoring of water quality trends at local, watershed and regional scales for freshwater, estuarine and marine ecosystems. In addition, they have greatly enhanced rapid (e.g., real-time) detection of hydrologic variability, recognized as a critical need for early warning systems and rapid response water related issues (Glasgow et al., 2004).

Source: https://www.geospatialworld.net/article/agriculture-gets-a-makeover/
Remote Sensing Advanced Technology (RSAT) Lansat satellite imagery developed to assess the biological, chemical and physical properties of coastal waters and coral reefs along the Florida Keys. (B) A 30-m resolution zoom from Lansat satellite imagery showing the shallow waters and underwater reefs along the northeast coast of Florida. Source: Glasgow et al. (2004)

**Biodiversity**

Since the days of Darwin and Wallace, ecologists and evolutionary biologists have sought to explain the distribution of species or groups of species, and to discover why certain places are especially rich in species. Today, conservation biologists rely on estimates of species richness as they race to determine areas in which to spend limited resources in an age of rapid biodiversity decline. Scientifically sound environmental management requires frequent and spatially detailed assessments of species numbers and distributions. Geospatial technology provides imageries and data at varying scales. This allows was biodiversity assessments at local to global scales. Advances in the spatial and spectral resolutions of sensors now available to ecologists and conservationists are making it remote sensing of various aspects of biodiversity possible (Turner et al., 2003). Through this technology, various direct and indirect detection and analysis of diversity, patterns and relationships can be studied. Various environmental parameters can also be incorporated in studies of diversity.

**Disaster Management**

conventional GIS (geographic information systems) disaster responses by governmental agencies and relief response organisations and the means for geospatial data-sharing have been transformed into a more dynamic, more transparent, and decentralised form with a wide participation (Kawasaki et al., 2013). In this and in other crises, the ability to synthesise information from multiple sources and to make available up-to-date maps and location information is of critical importance in ensuring a timely and effective response. Broader use of geospatial technologies, including Geographic Information System (GIS), Remote Sensing, and Global Positioning System (GPS), provide the key for doing so in the future.
Challenges

Data production is often the costliest part of information system development. Within GIS, beside traditional field surveying techniques, remote sensing data have proven to supply at a relatively lower cost for the end user, the analyst and maintain large datasets in terms of spatial footprints and time series. However, there is still need for improved techniques for semi-automatic data processing and thematic information production. More sophisticated data models and analysis tools are required to integrate the time dimension with geographic geometry and attributes.

Many at times independent researchers in Nigeria want to carry out scientific investigations but as a result of data unavailability it becomes almost impossible to achieve this feat. This brings us to question and serious concern on the achievements of Nigeria National Geospatial Data Infrastructure and the Geo-spatial data policy of the country. Information Technology (IT) also gives serious room for concern over the core activities of National Space Research and Development Agency (NASRDA) who are appointed as the data clearing house of the country and also the conflicting roles of the National Mapping Organization of Nigeria (OSGOF) in roles and responsibilities, definition and specifications.

Previous researchers that have employed geospatial technology techniques fail to either properly document their data and methodologies based on a number of reasons e.g. acquisition of their respective geospatial data (geo-data) which can be very uneconomical and this could have led to them not acquiring for solving environmental problems. Furthermore, it promotes participatory visualisations using the powerful tools embedded in its user interface, which help in the overall assessment of environmental impacts and also play important roles in physical planning of the environment in Nigeria. However, with the emerging trend in 3D and 4D geospatial information, visualization techniques will be better operated.

References


