



Distribution: GENERAL
E/ECA/CODI/4/9/Add.3

18 April 2005

**UNITED NATIONS
ECONOMIC AND SOCIAL COUNCIL**

Original: English

ECONOMIC COMMISSION FOR AFRICA

Fourth Meeting of the Committee
on Development Information (CODI IV)
Addis Ababa, Ethiopia
23 – 28 April 2005

GEOINFORMATION AND NATURAL RESOURCES EXPLOITATION IN AFRICA

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ABSTRACT

Natural resources are endowments of a country or a region which can be exploited to improve national or regional wealth in terms of creating socio-economic opportunities and generating foreign exchange earnings. These resources include vegetation cover and the biotic life they support, agricultural land and its soils, fresh, coastal and underground water resources, mineral deposits, landforms such as mountains, hills and valleys and land itself as a base for putting up infrastructure including housing. Many environmentalists would today, add to this list, the atmosphere. Human activities have over the centuries been affecting the components of the atmosphere as well as the processes going on in it. These have in turn, been impacting negatively on many earth-based phenomena such as the timing and intensity of rainfall as well as the duration of the rainy season among others.

Throughout history, man has depended on the natural resources for livelihood. Indeed all human civilizations derive their base - sometimes also their credibility - from the ability to use the natural resources to the advantage of their societies in one way or the other. Many ancient civilizations grew in the banks of great rivers like the Euphrates and Tigris, Nile and Niger. Even when man was essentially a wanderer, living on what ever he can find to eat in the wild, the natural resources of his environment provided the base for daily living. Historians are quick to remark that one of the factors that have profoundly influenced international relationships today was the quest to expand access to these invaluable but spatially differentiated gifts that come from nature. Initially, it was mainly a contest for agro-based raw materials. Later others particularly minerals and regional hydrological resources became significant. The dependency on natural resources has continued and has in fact been exacerbated by many factors such as rapid growth of population in many parts of the world. The economies of several countries particularly in the African continent, rest almost completely on the opportunities that the environment offers especially in terms of mineral resources, flora and fauna, hydrological characteristics as well as agro-ecological parameters. Zambia is dependent on copper and cobalt for her hard currency; Kenya's economy is driven significantly by the proceeds from her vast tourist potentials and to mention a few, Nigeria derives more than 90 percent of her foreign exchange earnings from the sale of crude oil in international market.

All of these utilization of natural resources even in their most basic forms, require a variety of information for the decision makers, the professional who would be directly involved in the exploitation and the beneficiaries as the case may be. The information required in the past was usually simply on whether a resource can be got in economic quantities that would justify investments in its exploitation. There was little concern, arguably because of the limits set by technology, about the overall cost-benefit-analysis of the exploitation particularly with respect to the communities whose livelihood may be negatively affected. Today, the storyline is changing rapidly. The information required on natural resources is one that would facilitate accurate location and definition of the geographic distribution and extent of resources as well as capture the implications of exploiting the natural resources for the local communities that may suffer the direct negative impacts of the exploitation, and in terms of regional and global impacts. 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 distinction must be well understood to forestall a tilting of emphasis to either the data sets or the end products i.e. the information. 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 politician. Undeniably, one of the tasks proper of the scientist is to be able to present his findings in such a way that decision makers can understand and use them. Geoinformation is a specific type of information that results from the interpretation of spatially referenced data. The primary sources of these data today are the earth observing satellites. By providing data that facilitates fuller knowledge of stock, distribution and potential environmental impacts of exploiting natural resources, geoinformation adds value to natural resources. For example it helps the decision maker to appreciate when further exploitation will bring negative economic returns.

This paper focuses primarily on three areas: a review of the state of natural resources utilization with reference to the African continent, the international efforts at achieving sustainable development in particular the New Partnership for African Development (NEPAD), and the crucial role and economic benefit of geoinformation in moving the various countries forward especially in addressing the Millennium Declaration Goal (MDG). Referring to examples from Nigeria's oil producing region and similar locations in the continent and regional disagreements on the use of rivers such as Niger and Nile that traverse many countries, the paper underscores the haphazard character of the natural resources exploitation in the continent. A significant factor in all this is the absence of adequate geo spatial information on the distribution, stock, quality and the potential environmental and social impacts of exploiting the resources. The absence of relevant and adequate environmental information prepared in a format that can be readily understood and appreciated is responsible for a seeming assumption by many that natural resources are inexhaustible. In many African countries, private land developers continue to have a field day with little or no restrictions as to how much of the threatened rural lands can be converted into urban uses! The attitude that when certain resources are exhausted, some others will be discovered among African politicians also stems partially from this. The paper also considers this dearth of geo spatial information within the context of international initiatives in sustainable development of the African

environment. The establishment of African Information Society Initiative (AISII) by the United Nations Economic Commission for Africa (UNECA) in 1996 was in line with the recognition of the significance of geoinformation in pursuing sustainable development goals in Africa. NEPAD's concerns for the environment are bold, well conceived and commendably comprehensive. Key programme areas of the initiative includes Combating land degradation, drought and desertification; Conserving Africa's wetlands; Prevention, control, and management of invasive alien species; Conservation and sustainable coastal and freshwater resources; Combating climate change in Africa; Transboundary conservation or management of natural resources. To pursue these programme activities geospatial data are simply basic. As suggested by Craig A. Schwabe (2003), this type of information would also be required in evaluating the impact of the NEPAD initiatives. The existing arrangements for addressing these issues are still inadequate as many countries are yet to make any appreciable progress in developing their spatial data infrastructure (SDI). Concerted national and regional efforts are therefore needed to achieve the set goals particularly as they relate to obtaining required geoinformation. At the policy level, the critical issues have been well articulated in the literature. These include expanding awareness of GIS value and relevance, establishing National Geospatial Information Policies, strengthening the Policy Dialogue Process, strengthen local capacity for handling spatial data and expanding access to geo-spatial Information. To these may be added greater commitment in financing the launching of many more satellites in space by African countries. All of these need to be addressed in moving Africa forward in the spirit of sustainable development

The role of the local community is critical in reaching the targets of NEPAD. It is so readily forgotten that the regional environmental problems of today represent an aggregate of the individual person's negative action in the environment. It stands to reason that the control of environmental degradation can be effective if followed from the level of individual. This will require appropriate grassroot sensitization at the level of the individual country.

INTRODUCTION

The world today is already in the mainstream of another revolution – the information revolution. This is bringing about monumental changes to life and living, providing new insight into how to advance the frontiers of previous revolutions especially those of agriculture and industry. Development experts now know for sure, that the problems which the world had had in sustaining the gains of earlier revolutions were associated with the absence or limitedness of critical information particularly about the environment and the likely impact of the activities that the revolutions could have. For example, under green revolution, farmers had remarkable growth in their annual harvests by adopting all sorts of farm productivity enhancement methods such as cropping all year round under extensive irrigation schemes. However, for many decades, it was simply difficult to appreciate that irrigated lands could become unsuitable for further cropping as a result of such factors as accumulation of salts from irrigation water.

Since the past two decades or so the world has been experiencing unprecedented growth in information generation, gathering, storing and sharing on practically all aspects of human endeavour. From the time of the emergence of what Al Gore had described as a superhighway (Al Gore 1998), through which almost limitless quantum of information flows per day, the barriers between nations and communities set by physical features such as oceans and difficult terrains have virtually collapsed and the whole world has suddenly become a global village. Knowledge is expanding daily in this area resulting in increasing opportunities for unfettered access to almost all sorts of information especially through the internet. Natural resources utilization and management have gained a lot from this development especially with respect to engendering sustainability. With respect to sustainable development, The Nairobi statement on spatial information for sustainable development in 2001 observed that

“Development is the managed process of change designed to improve the conditions of members of a society. Sustainable development implies that this process should balance the exploitation of resources, the direction of investments and the advancement of technology in a manner that affords the same opportunity to future generations”.

If we accept this declaration with its moral responsibility of providing for the future generations today, then it is easy to understand that unlimited access to information which the revolution affords is a most needed vehicle for improving the living conditions of men and women around the globe and for preserving the environment. This is because the information revolution offers great opportunities for the development and implementation of efficient strategies for the sustainable use and management of natural resources.

I have been requested by the organizers of this workshop, to address the topic “Information and natural resources”. I am however persuaded that the discussions on a topic like this cannot be completely new to the distinguished participants here present. I therefore do not in any way assume that I am addressing an uninformed audience. As is always the case in meetings like this, I guess that the organizers would like the paper to stimulate further, our thinking on information as an economic resource. To do justice to this, I have focused on the basic component of the topic – information and natural resources management - bringing out the importance of the former on the latter, and how the latter itself can be a raw material for the former in different settings. I also examined the various international efforts at achieving sustainable development such as the New Partnership for African Development (NEPAD) and Millennium Development Goals (MDGs), and the crucial role and economic benefits of geoinformation in moving the various countries of Africa forward.

NATURE OF NATURAL RESOURCES

Natural resources are endowments which a country or a region can harness to develop its economy in terms of creating wealth and socio-economic opportunities such as access to basic social facilities including in particular, health and education and creation of employment opportunities. These resources can be itemized as follows:

- vegetation covers (i.e. the varieties of plant communities such as grasslands and forests) and the biotic life they support;
- agricultural land typified by the vast plains of the world and their deep and fertile soils;
- fresh and ocean water resources;
- mineral deposits;
- landforms including mountains, hills and valleys among others, and
- land itself as a base for putting up infrastructure for instance housing and transportation routes.

Many environmentalists would today, add to this list, the atmosphere because this layer of gases immediately above the earth's surface affects important earth-based phenomena such as the temperature, timing and intensity of rainfall as well as the duration of the rainy seasons, among others. All of these affect the richness of the earth-based resources especially vegetation and water resources. Although man has very little control on the atmosphere, his activities over the ages have impacted negatively on it in terms of increasing its content of greenhouse gases and depleting the ozone layer. The consequence of this is understood to be manifesting today as "global warming" (see e.g. IPCC 2002).

As a resource, the atmosphere must be protected from further damage. Further damage would harm many processes including the hydrological cycle which in turn will severely constrain socio-economic development. We may adapt to new climatic regimes as a coping strategy with the new climatic environment but it is more important that the process of change is halted so that the change may not become too overwhelming to cope with. This is in part, what recent global initiatives in climate change control exemplified in Kyoto Protocol attempt to address. The Protocol subjects industrialized countries of the world to legally binding targets to limit their greenhouse gases emissions. To know whether or not the emission of greenhouse gases is being reduced, it is critical to know what exactly is going on in the earth's atmosphere in terms of its chemistry. and this we are getting as a dividend of information revolution.

Table 1: Environmental Parameters and their resourcefulness in Africa

| S/ N | Resources | Usefulness | Status in Africa |
|---------|--------------------|---|--|
| 1 | Vegetation cover | <ul style="list-style-type: none"> i. Wildlife habitats ii. Provides food and medicinal herbs; iii. Source of timber and firewood iv. Protect soil against surface run-off v. Biodiversity pool vi. Greenhouse gases "sink" vii. Control of water loss from the environment viii. Micro climatic effect ix. Aesthetics x. Biodiversity xi. Grazing in grasslands | Already severely modified. Large portion converted to other land uses; Several species of plants and animals have already been lost as their habitats get destroyed; Exotic species are becoming popular as replacement to lost native candidates; |
| 2 | Wildlife | <ul style="list-style-type: none"> i. Sources of meat especially in the rural areas; ii. Genetic Biodiversity pool, iii. Recreation, tourism iv. | Wildlife is threatened by over exploitation and habitat destruction; Except in east and southern African countries, wildlife conservation practices are generally poor. |
| 3 | Agricultural lands | <ul style="list-style-type: none"> i. Food and tree crop production; | Threatened by degradation due to overuse, soil acidification, soil erosion and invasive species |
| 4 | Water resources | <ul style="list-style-type: none"> i. Domestic and industrial ii. Food iii. Recreation & tourism iv. Irrigation | Fresh water largely inaccessible in many areas of great needs in Africa; Increasing dependence on under ground water; Problem exacerbated by unreliable rainfall; Transboundary rivers creating problems due to increasing water demand. |
| 5 | Mineral Resources | <ul style="list-style-type: none"> i. Fuel ii. Industrial uses | Several known deposits already depleted; mines are being closed e.g. tin and coal mines in Nigeria, gold mines in South Africa; land deformation is common; Oil spillages experienced especially |

| | | | |
|---|-----------|--|---|
| | | | around the Niger Delta. |
| 6 | Landforms | i. Influence climate indirectly ii. Tourism iii. Affects development | Relatively little utilized especially in West Africa. |
| 7 | Land | i. Infrastructural development including housing | Badly managed in many areas; Conversion of large areas from rural uses; |

SIGNIFICANCE OF NATURAL RESOURCES

Throughout history, man has depended on the benefits that natural resources offer (see Table 1). Indeed all human civilizations derive their base - sometimes also their credibility - from the ability to use the natural resources in their locality to the advantage of their societies in one way or the other. For instance, several ancient civilizations grew by exploiting the waters of great rivers like the Euphrates and Tigris, Nile and Niger. Even when man was essentially a wanderer, living on what ever he can find in the wild, the richness of the natural resources in his immediate environment defined his peripatetic limits at any given period in time. Historians would readily remark that one of the factors that have profoundly influenced African political space today was the quest the colonialists to expand access to these invaluable but spatially differentiated gifts that come from nature. Initially, it was mainly a contest for agro-based raw materials. Later others particularly minerals became significant.

Man's hunger for natural resources has remained unabated. If anything, it has been exacerbated by the need to meet the demands of a rapidly growing world population, reduce poverty and control the spread and impact of diseases. As a matter of fact, the economies of several countries in the African continent, rest almost completely on the opportunities that the environment offers especially in terms of mineral resources and ecological parameters. Huge irrigation schemes in many parts of Africa including the Chad Basin, the Sokoto-Rima river basin and the Nile valley for example are thriving on water supply from large drainage basins in the continent. The Republic of Zambia is dependent on her copper and cobalt for her hard currency; Kenya's economy is driven significantly by the proceeds from her vast tourist potentials, the Republic of Congo is what it is because of her vast deposit of solid minerals, Republic of Chad depends on her newly found oil wealth and to mention a few, Nigeria derives more than 90 percent of her foreign exchange earnings and 40% of her GNP from the oil and gas sector of the economy.

All of these exploitations of natural resources even in their most basic forms depend on a variety of information for the politician who has to make the decision to permit the exploitation of the resources and the professionals who would have to, as in the case of minerals, open up the bowels of the earth to bring out the resources. Many centuries and perhaps decades ago, the information that people thought they needed and sought for was simple. It was as in the case of minerals, whatever would enable an investor to determine

whether it was economically wise to invest in the exploitation of a particular resource. There was little or no concern about the environmental effect of the exploitation particularly with respect to the well being of the communities whose livelihood may be negatively affected. This arguably, was because of the limits set by technology as well as a poor understanding of the behaviour of the various environmental parameters. Today, the storyline is changing rapidly. The information required on natural resources to make their exploitation sustainable with tolerable damage to the environment is one that should do the following:

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

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 politician. Undeniably, one of the tasks proper of the scientist is to be able to present his findings in such a way that decision makers can understand and use them. Geoinformation is a specific type of information that results from the interpretation of spatially referenced data. The primary sources of these data today are the earth observing satellites. By providing data that facilitates fuller knowledge of stock, distribution and potential environmental impacts of exploiting natural resources, geoinformation adds value to natural resources. For example it helps the decision maker to appreciate when further exploitation will bring negative economic returns.

STATE OF NATURAL RESOURCES IN AFRICA

It is a fairly difficult task to endeavor to do a comprehensive analysis of the status of natural resources in Africa in a paper like this. The paper does not pretend to do so. Attention is rather focused on a few relatively significant resources across the continent to provide a basis for discussions. These are mineral resources, vegetation cover, fresh water and land for physical development. This, it has to be said, does not imply that others are less significant to the life of people in Africa.

Africa is blessed with large deposits of a wide range of fuel and non-fuel minerals. The list is lengthy but includes significantly petroleum and natural gas, coal, uranium, limestone, gold, diamond, copper and cobalt, aluminum, tungsten, tin and iron ore. The exploitations of many of these resources date far back in human history. Archeological evidences for example, have shown that in many parts of Africa, extensive iron smelting

had taken place from about the mid 9th century (e.g. Chirikure and Rehren 2004). By examining the characteristics of excavated materials from different sites, archaeologists have been able to show that slag was most probably moved around in substantial quantities from areas of large deposits to smelting sites in the different parts of the continent many centuries ago. Another illustration is provided by the use of bitumen in the past. Although there are no detail records about the history of the use of the mineral, some sources suggest that bitumen may have been exploited for more than 5000 years in Africa (Nigeria Consulate in New York) “when the ancient Egyptians mummified their dead with bandages wrapped in natural pitch”. The material has also been used by many communities for boat building for a long time. The story is similar for other mineral resources such as sand, stone and clay that are used for building houses and making domestic utensils.

Modern exploitations characterized by the extraction of resources in economic or large quantities may have started around the 15th century (see Hochschild, 2002; Bundy, 1988). In Africa, this phase had to await in many instances, the advent of the colonialists. The colonialists came to Africa primarily to source raw materials for their home industries. They got the resources almost at no cost but in many cases, left the local communities impoverished by dispossessing them of their lands and forcing them to provide cheap labour in the mines. Hochschild (2002) has described the pre-independence exploitation of resources in Africa as nothing short of a plunder of Africa’s wealth arising from the way the mines were operated without concern for the environment. Unfortunately, the trend has remained largely the same in many African countries after independence. The national governments have continued to behave very much like the colonialists in their approach to the management of natural resources. Figure 1 gives a picture of a rather unique aggressive drive to have a share in the enormous mineral resources of the Democratic Republic of Congo. Resources are carted away by outside interests leaving the local communities poorer for it. The plea of the inhabitants of the Nigeria’s Niger Delta for better management of the region which has gained world wide attention is somewhat well placed considering the rather inadequate care given to the environment by the giant oil companies which had been exploiting oil and gas in the region for more than fifty years. Oloibiri, a community located east of the Niger, from where the first barrels of crude oil were extracted in 1956 in Nigeria is now virtually an abandoned and desolate site. Similar gory stories are told of hundreds of mines that have turned around to become a curse to the local communities in which they were located. Lives are lost everyday due to mine collapse as local people illegally work old mines for remnants in depleted mines.

The exploitation of Africa’s vegetation resources particularly the tropical rain forests have in no wise been significantly different. The actual rate of deforestation is debatable but in certain countries like Nigeria in West Africa, it could be as much as 400,000 hectares per annum! At that rate, all of the tropical forests are expected to disappear completely very soon (Adesina et al 1999). Much of the deforestation particularly within the last five decades or so has been by Africans themselves for developmental purposes. Vegetations have been deliberate removed to make way for mineral exploitation, development of infrastructures such as roads and railway and expansion of settlements. The trend in de-vegetation of many areas has however been strengthened by the growing

demand for tropical hard wood and veneer in the world market. Local demand for timber has in addition, gone up tremendously due to expansions in construction industries to take care of the increasing population of the various countries of Africa. Also, households across the continent have continued to rely on fuelwood for domestic energy supply as the costs of common alternative energy i.e. kerosene and natural gas, go farther and farther beyond the reach of the common man.

Loss of vegetation resources has great implications. It implies destruction of wildlife habitat, depreciation or outright wiping off of genetic pool, loss of food and medicinal herbs that hitherto came from the wild, and promotion of desertification and drought, among others.

While there are pressures on vegetation resources which are driven by increasing demands for forest products as well as a rapidly growing population, there are management constraints evidently influenced by the absence of requisite information on the state of the forest resources. For example, there are areas designated as forest reserves in the various countries within which exploitation of forest products are either subject to some stringent conditions or completely prohibited. However, incursions into such reserves by local communities are a common practice and governments in many instances appear to have lost the battle with poachers of logs and wild animals in the forest reserves. Much can still be achieved in the efforts at protecting the forest reserves and preserving the relics of the vegetation covers particularly the tropical forests in the continent, if countries are able to rise to the demand of effective management and monitoring.

Land as a resource is important in that it carries physical development in human societies including housing and other socio-economic infrastructures. The use of the land in this way began around the time when man started to live in settlements. This use involves the conversion of parcels of land from agricultural uses and under vegetation cover into other uses. The trend has become phenomenal in recent times as population growth and unprecedented urbanization claim more and more parcels of land for non-rural uses. Many cities in Africa especially are expanding rapidly and annexing large numbers of erstwhile rural settlements around them. This of course has implications for the sustainability of the urban centres. For example in large urban centres like Lagos, Ibadan, Accra and Cotonou in West Africa, vacant lands in the periphery of the cities previously used for market gardening for the urban markets are rapidly being lost to urban growths. The expansion of land use in this way has been strengthened by the fact that in many urban centres, the development of new neighbourhoods is poorly controlled (see e.g. Karanja, 2004). Unlike what obtains in the other parts of the world where cities expand vertically, most African cities are growing laterally partly because the development of residential units is left in the hands of private individuals who decide on their own the way they would use the land irrespective of what others may prefer.

Land use management in many African countries is affected by the absence of cadastral maps showing the location and ownership of properties. The Survey's departments that are statutorily charged with carrying out this responsibility usually do not have the

resources needed to do the job. The absence or inadequacy of this database is creating serious social and economic problems in many areas. Effective rate collection is difficult and disputes about ownership of parcels of land are common. In addition, it is often difficult to implement Town Planning regulations since proper definitions of land parcels are not possible in many areas. It is thus not uncommon for people to build along the right-of-ways.

The exploitation and management of hydrological resources in the continent presents a different scenario. This arises from the fact that water resources are exploited largely for the benefits of the African continents. Vast areas of the arid and semi-arid parts of the continent are under irrigation and daily consumptive use of water by domestic animals and man continues to rise. However, water resources in the continent have some daunting problems. First is the inaccessibility of a large proportion of the African communities to fresh water. As rightly pointed out by Donkor (2003), the bulk of the fresh water resources of Africa are located in the humid region within a few degrees of latitudes north and south of the equator. A lot of water coming as rain in this zone is emptied into the oceans without being utilized, while large areas outside the zone never had enough water round the year. There is also the problem with the exploitation of transboundary basins such as Congo, Nile and Niger. The greatest of concerns today is with river Nile which drains eight countries including Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda. The increasing demand for water in virtually all the eight countries prompted by rising population and decreasing rainfall in the region makes it difficult for the nations to continue to respect the 1929 Treaty which gave Egypt the right to most of the water coming from River Nile. UN-Water Africa (2003) has summarized the critical issues affecting water supply in the continent as follows:

- The multiplicity of trans-boundary water basins;
- Extreme spatial and temporal variability of climate and rainfall, coupled with climate change;
- Growing water scarcity, shrinking of some water bodies, and desertification.
- Inappropriate governance and institutional arrangements in managing national and Transnational water basins;
- Depletion of water resources through pollution, environmental degradation, and deforestation;
- Failure to invest adequately in resource assessment, protection and development;
- Unsustainable financing of investments in water supply and sanitation.

Efficient management of regional water resources especially in dry environment requires a balance consideration of surface and underground sources (e.g. Bunu 1999). In many areas, underground water is extensively exploited for domestic and industrial purposes. Little is known about how much water is tapped from this source but it is bound to be substantial. There is certainly a need to evolve an effective water management plan for the African region in the spirit of sustainable development. Not only should access to fresh water be guaranteed, peace must also be assured among countries along trans boundary drainage basins. The way to achieve this is to have reliable information about

water resources in the continent as a basis for planning redistribution and harmonious use of the resources.

GEOINFORMATION AND ITS SIGNIFICANCE IN RESOURCE USE AND MANAGEMENT

The state of natural resources exploitation in Africa as discussed above is worrying. To say the least, it does not make for sustainable development. The general concern in every country appears to be about whatever can be got from the environment now rather than how to exploit the environmental resources to take care of the interest of both the present and future generations. Or how else does one explain the continual dependency of many African countries on one or two minerals for their financial resources without any apparent consideration of how to survive when the stock of the resources are exhausted. This attitude must change and it has to be without any further delay. We must realize that resources are finite in terms of their stock and changing needs as well as new discoveries may reduce the significance of certain mineral resources in the future. If these happen, countries that are over-dependent on the affected mineral resources are bound to suffer. Attitudes however, can be significantly modified when people get properly informed. Certainly, perceptions can change when the ruling class is sensitized about the limits of the stock of the resources or rather still about resources that have been exploited to exhaustion in other parts of the world. Good sensitization about the impacts of natural resources exploitation such as the devastating effect of oil spill on aquatic life and farmland, deadly trenches that developing from subsurface excavation, vast areas of devastated farmlands resulting from many years of salt deposit from irrigation water, near surface dispersion of industrial pollutants especially in the early morning and sudden floods in low land areas arising from the de-vegetation of watersheds are likely to drive home the message.

With respect to the above, geoinformation which has been described as the backbone of any serious natural resources management has a major role to play. As earlier noted, no exploitation even at the most pedestal level can go on in the absence of some form of information. The particular information of interest here are those spatially referenced data articulated to provide basis for making informed decision about the management of natural resources. The benefits of this type of information in natural resources exploitation have been well demonstrated in a major collection of works on African experiences edited by Adeniyi (1999) (see also the Proceedings, of the 5th AARSE conference held in Nairobi, Kenya, in October 2004). When spatial data are mounted in appropriate GIS environment, it is possible to develop scenarios particularly about future trends or likely impacts of the use of specific resources.

The sources of data for developing geoinformation are many and they include ground surveying, aerial and space photography as well as earth observing satellites. Of the three main categories, the latter is generally becoming more significant as many more satellites are launched into space with a wide variety of vastly improved sensors which are able to collect environmental data at increasingly higher levels resolution. At the beginning of 2005, it is estimated that about 68 satellites are in space generating data about the earth

and its environment together with the influence of man on the earth's surface (CEOS 2005). The data cover a wide range of geophysical parameters which are of significance for socio-economic development in the various parts of the earth's surface. Some of the specific data that the earth observing satellites collect with improving sophistication in terms of accuracy and repetitiveness include

- Atmospheric humidity and temperature profiles
- Atmospheric winds (through cloud tracking)
- Multipurpose imagery for both land and sea
- Sea surface temperatures
- Chemistry and dynamics of atmosphere including long-term global measurement
- Measurement of soil moisture and ocean salinity
- Information on global land surface processes
- Estimates of global biomass and carbon stock
- Measurements of ocean currents

With respect to mineral resources, geoinformation can provide basis for estimating stock and potential as well as a actual impact of exploitation of resources. Kinabo (1999) has demonstrated this in the gold mine of Tanzania. He showed among other things, that remotely sensed imageries are able to provide data on the severity of water pollution coming from the gold mine as well as the extent of soil damages resulting from the mining activities. The near linear pattern of occurrence of bitumen deposits which runs from areas a little bit west of River Niger to Lagos in southern Nigeria and the occurrence of limestone deposits across a section of the coast of West Africa from Ewekoro, in south western Nigeria to the eastern part of Ghana, have been mapped from various remotely sensed images. Satellite sensors are also effective in tracking oil spillage in the various parts of the world.

Forestry resources can also be evaluated and monitored with remote sensing data. On SPOT image for example, green vegetation registers in red. The depth of redness corresponds to the chlorophyll level or the "greenness" of the vegetation. This can be exploited to track changes in the areal extent of vegetation cover and by proxy, alteration in the outline of forest reserves from time to time (Adesina and Amamoo-Otchere, 1994). The imagery can also be analyzed to assess changing intensity of timber exploitation in forest reserves. Furthermore, on processed remote sensing imageries, the Normalised Difference Vegetation Index (NDVI) can be computed to assess the characteristics of the vegetation. NDVI is very useful for measuring relative changes in the condition of vegetation in an area over time. It can also give useful information with respect to the health of the vegetation.

Water resources management has several aspects that require inputs from geoinformation. First, availability of water on the earth surface is associated with the global water cycle. The earth observing satellites as shown above collect relevant data on the parameters of hydrological cycle which can be used to predict water availability on the earth's surface. This is critical to gaining insight into fresh water budgeting for the various parts of the world. Apart from this, geoinformation is useful in planning surface water use. With satellite data it is possible to have adequate information about water use

in the various parts of a drainage basin. Such information can be used to ensure that each country on a transboundary basin has a fair share of the hydrological resources of the basin particularly in terms of withdrawal/consumptive usage of the water for irrigation. Monitoring of surface water storage as well as the status of water dams are also made possible through the use of geoinformation. Water bodies register distinctively on satellite imageries and changes in their outline over time can be easily monitored. A good illustration of this is the data on the state of Lake Chad. The most convincing evidence that the Lake is disappearing came from the data obtained by NASA's Earth Observing System Programme. Such data can be obtained for other water bodies and can show the changes in water levels in the dam at various times of the years. They can also be used to monitor the distribution of water weeds such as water hyacinths on lakes and rivers. The overwhelming significance of geoinformation in water resources management may explain why TIGER, a new Initiative from the European Space Agency is providing assistance to researchers working on water resource management issues in Africa to have better access to satellite data (Williams 2004)

Geoinformation is also useful in evaluating land cover/land use changes in a given area. This is one area where this type of data has gained ready application. Repetitive coverage of an area by regular passage of satellites can help to identify changes taking place in land use/cover of an area. The assessment can also be made with multi-source spatial data. With appropriate software, the area of each category of land use/cover can be computed and loss or gain in area by that category can be estimated. It is also possible to project future land use changes based on the data available on hand. Using geoinformation for this purpose is usually affected by the difficulty of recognizing finer categories of land uses particularly because land use is generally complex in many parts of Africa. However, as resolutions of imageries improve, this limitation is becoming less significant. Another dimension of the relevance of geoinformation in land use matter is in the preparation of cadastral map for urban land use management. Geoinformation provides the solution to the problems of developing property database in rural and urban areas. The Bathurst Declaration on Land Administration for Sustainable Development (1999) had emphasized the need for spatial data and information, and the need for a land information infrastructure. A land information infrastructure is a subset of a spatial data infrastructure. Some cities in Africa now have cadastral maps prepared in GIS environment making access to basic data on urban centre an easy task. A good example is the newly implemented Abuja Geographic Information System (AGIS) which created a data base for all land parcels in the city.

GEOINFORMATION AS AN ECONOMIC RESOURCE IN NATURAL RESOURCES MANAGEMENT

The intention here is simply to pass a few comments that are helpful in focusing the theme of this meeting which is "Information as an Economic Resource". If we accept economics as a science concerned with allocation of scarce resources, then our discussion above has indeed shown geoinformation to be an economic resource. One thing that geoinformation allows us to do is to make informed decisions about the natural resources. This of course means that we minimize wastes and optimize the benefits derivable from the resources. A particular natural resource may be available in a country in economically attractive quantity. However, geoinformation on the environment may suggest that the

potential impact of exploitation is considerable. On the basis of this, a country may delay exploitation until it is able to develop appropriate response to the anticipated impact.

Geoinformation also reduces costs of monitoring while at the same time offers the advantage of obtaining necessary data in real-time. Using geoinformation based on imageries with high resolution, the forest resource manager does not need to be on the field to update his data about the resources in his forest reserve. Where data retrieval is critical as in urban land use management in which it is often necessary to use data on property ownership, geoinformation saves time and money. At the same time it ensures that the available data are accurate. Geoinformation facilitates prediction such as the potential impacts of flooding in a particular drainage basin. When this is accurately done, occupants of the basin can be provided with early warning which will enable them to vacate high risk areas before the flood water comes. Advances in ICT facilitate data sharing and transfer. Processed geoinformation archived in a metadata framework such as provided by ENRAEMED Metadata Collector, can be paid for by potential users. In this sense, geoinformation becomes a commodity which is paid for by the user.

MOVING AFRICA FORWARD - GEOINFORMATION AND DEVELOPMENT INITIATIVES

Africa, the second largest continent has remained one of the least economically developed in the world. This problem is compounded by the fact that population everywhere is growing and urban centres in many areas are busting at the seams. The concerns are legion. Malaria has yet to be effectively “rolled back”, AIDS/HIV is creating anxiety in the society, food insecurity is growing and among other things, regional conflicts sometimes in contest for natural resources utilization exist in parts of the continent.

In response to all of these, development agencies are pursuing various development initiatives towards achieving sustainable development. These include the New Partnership for African Development (NEPAD), the Millennium Development Goals (MDGs) and the implementation of the World Summit on Sustainable Development (WSSD). The programmes of actions of these initiatives are capable of changing the face of Africa if well implemented. For example, the key programme areas of the New Partnership for African Development (NEPAD) includes Combating land degradation resulting from mining and agricultural use, control of desert expansion and frequency as well as intensity of droughts, protection and conservation of Africa’s wetlands; Prevention, control, and management of invasive alien species; Conservation and sustainable exploitation of coastal and freshwater resources; Combating climate change in Africa; Conservation and management of trans boundary natural resources. The Millennium Development Goals (MDGs) are equally laudable and include reduction of poverty, reduction of child and maternal mortality, incorporation of environmental education into primary education curricula, and among others control of diseases. The WSSD targets are expectedly broader but they share in the visions of both NEPAD and MDGs.

To pursue these programmes of activities geospatial data are simply basic. The significance of geoinformation in these projects has been very well articulated in ROOF-

AFRICA. The ROOF-AFRICA project would generate relevant geoinformation that would help in achieving the developmental objectives of the initiatives. The overall objective of the ROOF-AFRICA project is to “contribute to better environmental management and hence wealth creation and the concomitant reduction of poverty, by establishing a Regional Ocean Observing and Forecasting System for Africa (ROOFS-AFRICA) to improve forecasts of environmental change and disasters management”. Thus, data from this project should help to effectively target the objectives of the initiatives. As suggested by Schwabe (2003), geoinformation would in addition to addressing developmental projects provide the basis for evaluating the impact of the various initiatives in the African region.

Many countries in the continent are already addressing the demands of setting up a National Geospatial Data Infrastructure (NGDI). Kufoniyi and Akinyede (2004) have described the excellent progress made in Nigeria in this respect. This effort has gained impetus from the launching of NigeriaSat1 in 2004 and the positive activities of the National Space Research and Development Agency (NASDA) in that direction. The development of NGDI is crucial to acquiring geoinformation for achieving the goals of development initiatives in the various countries. The establishment of NGDI will among other things, facilitate coordinated production and utilization of Geospatial Data which are common to multiple applications to eliminate duplication of efforts and wastage of resources. It provides a frame work by which all stakeholders can provide and have access to geoinformation. Concerted national and regional efforts are therefore needed accelerate the development spatial data infrastructures in various countries.

At the policy level, the critical issues associated with acquiring requisite geoinformation have been well articulated in the literature. These include expanding awareness of GIS value and relevance to local and national development, establishment of National Geospatial Information Policies, strengthening the Policy Dialogue Process, strengthening local capacity for handling spatial data and expanding access to geo-spatial Information. To these may be added greater commitment in financing space research and development in African countries. Countries who maintain an earth observing satellite would surely have greater if not unlimited access to geospatial information. Not only should we be interested in launching satellites in space, we must put resources into upgrading local capability to handle the data that these satellites will generate. All of these need to be addressed in moving Africa forward in the spirit of sustainable development

The role of the local community is critical in reaching the targets set in the various initiatives such as those of NEPAD. It is so readily forgotten that the regional environmental problems of today represent an aggregate of the individual person's negative action in the environment. It stands to reason that the control of environmental degradation can be effective if followed from the level of individual. This will require appropriate grassroot sensitization at the level of the individual country.

CONCLUSION

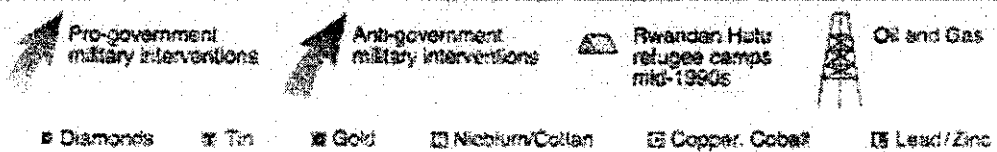
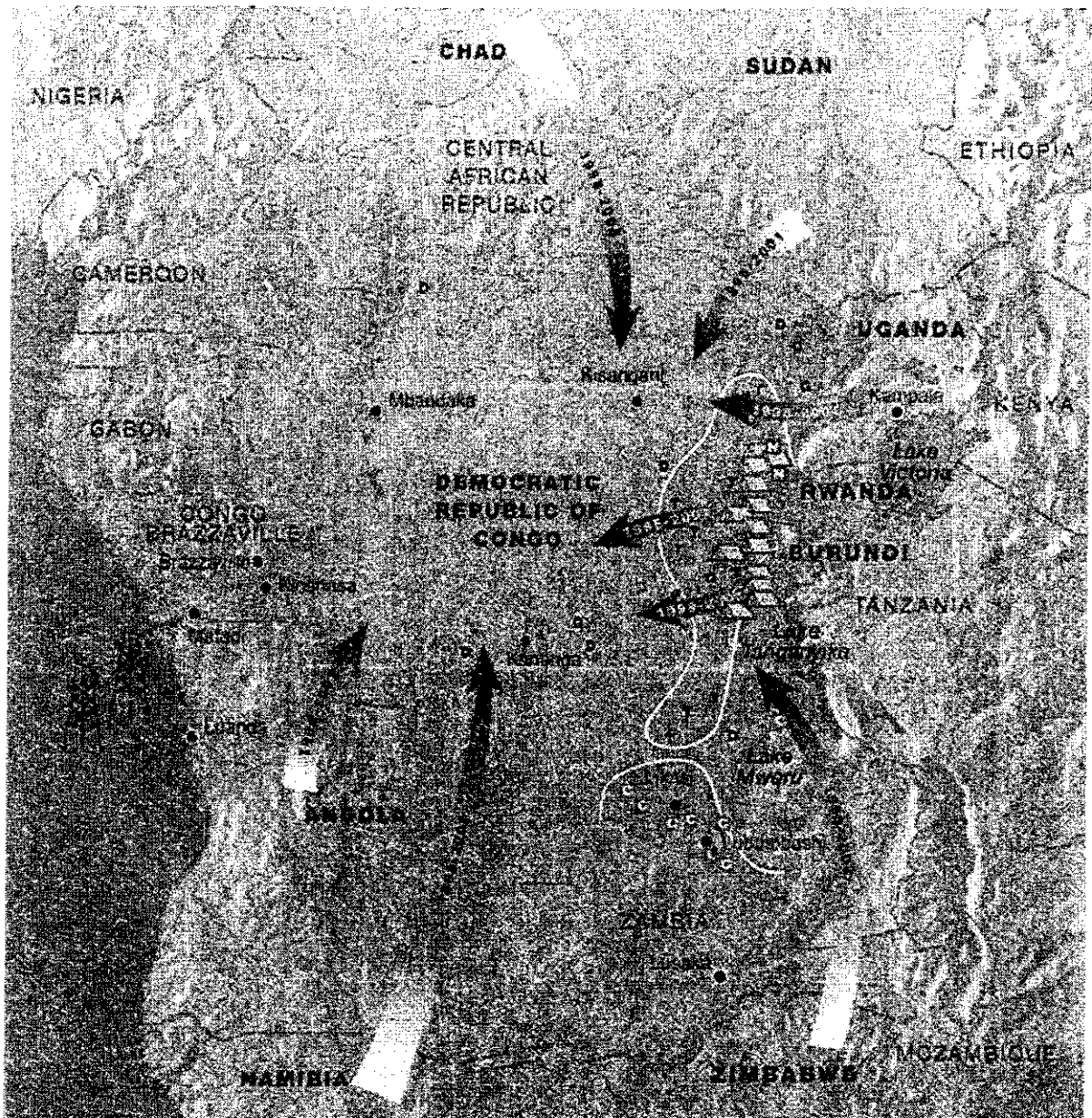
In this paper, we have looked at the critical roles which geoinformation is playing and could still play in the awakened global desire for sustainable development with respect to the use of natural resources. Our analysis of the state of natural resources in Africa tells much about the need for decision makers to have access to information on the environment. Not only does information provide needed data about the characteristics of the resources which are crucial to their effective exploitation, it allows deep and rich insight into the environmental and social consequences of exploiting the resources. Geoinformation, it has further been shown, can change the rather negative attitudes of many African leaders towards resource utilization and especially with respect to wanton permission of unplanned and unguided use of land resources. All of these provide the ingredients needed to make resource utilization both economic in terms of justifying necessary investments and sustainable with respect to future needs. The various socio-economic development initiatives are geared towards achieving this. As shown in this paper, the initiatives can only make necessary impact by having access to various details and characteristics of geoinformation.

The main problem facing Africa in these regards is the access to and production of relevant geoinformation. This requires suitable policy reorientation to recognize the needs. Africa no doubt, will continue to enjoy the benefits of advances already made elsewhere in the world in the production of geoinformation. However, we need to develop appropriate capability that will enable us make meaningful contribution to the development process in the information revolution. In this regards, countries that have the resources should make it a point of duty to start developing space research. Regional cooperation can also be exploited to develop Africa in this aspect. Each country in addition, should pursue the establishment of a NGDI to mainstream environmental data nationally and across the continent.

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