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Watershed Management and Sustainable Development in Nigeria

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ABSTRACT

Nigeria environment today is being confronted with myriads of ecological problems, which have resulted in serious degradation of many watersheds. These environmental problems are occurring at increasing and alarming rates and are being accelerated by man's activities such as urbanization, increased agricultural activities, deforestation, bush burning, civil construction works, over-grazing and poor water resource management among others. These land-use transformation activities most times disrupt the natural processes of a basin thus triggering the occurrence of accelerated erosion, sedimentation, slope failure, flooding, drought, desert encroachment and pollution. Response to these problems in the recent past in the country has not been good, hence this paper. Effective and efficient basin management is a perquisite for reduction of natural disasters and achievement of sustainable development.

KEYWORDS: *User's age-group classification, security, finger on touchscreen*

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1. INTRODUCTION

Drainage basin (watershed or catchment area) refers to topographically defined areas within the total catchment area of a major river system (Edwards et al. 2015). Kinghton (1984) described it as a well-defined topographic and hydrologic entity that is of fundamental importance. It is an area limited by drainage divide and occupied by a drainage network (Figure 1).

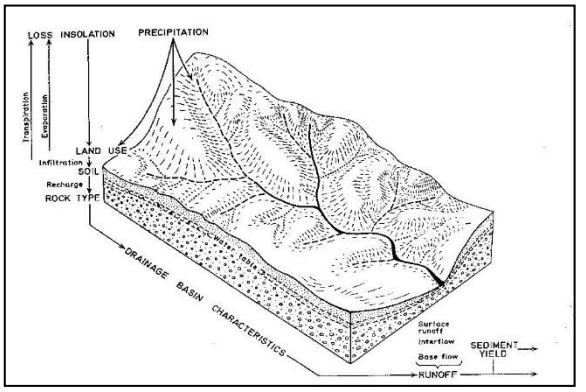

Figure 1. A Geomorphological View of the Drainage Basin
Source: Gregory and Walling (1973)

A drainage basin represents the soil, the water bodies and vegetation within a catchment area. It represents the segment of earth surface set apart from adjacent segments by a less clearly defined boundary. USEPA (2012) sees it as an area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community. According to World Bank (1993), subsurface water flows including underground aquifers are also part of the basin. River basins can be typically large, crossing not only private property lines, but regional and international boundaries as well (Lee and Dinar, 1995). A watershed provides an ideal unit for managing lands because the hydrological cycle within it provides an ideal unit for managing lands because the hydrology cycle within a watershed drives many of the physical, biological and environment processes in the catchment (Edwards et al., 2015).

One of the most important characteristics of a drainage basin is that, it is an open system where energy supply for its maintenance and preservation is represented by input of solar radiation. This is balanced by constant removal of material and energy represented by river discharge and re-radiation. Adejuwon and Jeje (1975) regard it as a system which is similar in many aspects to the ecosystem of the ecologist.

The recognition of a drainage basin as a basic unit of the landscape represents one of the major landmarks in hydrologic research. Within a drainage basin, hydrological, geomorphological and ecological data can be collected, organized and analyzed. Recognition of a drainage basin as a basic unambiguous unit of landscape owes largely to morphometric system of Horton (1945) which was subsequently elaborated by Strahler (1957), Faniran (1972) and others. Drainage basin is now increasingly being adopted as a suitable areal (spatial) unit for development planning (Ayoade, 2003) because the boundaries of the drainage basin are stable, natural and well defined, and because of the systematic attributes it exhibits. According to Sale (1985), if sustainable integrated area development is a goal, it is more likely to be achieved working with coherent region such as river basins. Both UN 1992 conference on environment and 1992 Dublin Conference on Water and Environment called for comprehensive management of resources, using the river basin as the focus. According to Scuddder (1994), over seventy percent of the world's land area can potentially be influenced by river basin development. While many countries have access to resources of at least one river basin, some countries can access the resources of several basins (Lee and Dinar, 1995).

However, the uses to which man put various aspects of the drainage basin considerably interrupt the tendency of a drainage basin to

achieve equilibrium within its components. Such action of man includes increased agricultural activities, deforestation, civil construction works, overgrazing, bush burning, drainage blockage, poor water resource management, urbanization increased population pressure on land and other associated anthropogenic activities. These activities which usually result in degradation of the basins are occurring at increasing and alarming rates and are being manifested in form of soil erosion, flood, drought, desertification and sedimentation among others.

A report by United Nations (2015) observed that the world is currently facing an increasing frequency and intensity of disasters with devastating impacts. According to the report, the last one decade have seen 478,100 people killed, more than 2.5 billion people affected and about US$690 billion in economic losses. The report further observed that disasters triggered by hydro-meteorological hazards accounted for 97 percent of the total people affected by disasters which amounts to about 60 percent of the total economic loses.

Though hydro-meteorological condition has been fingered as a factor responsible for most disasters, the environmental conditions of drainages basins remain a formidable catalyst in the occurrence of such disasters. Today, Nigeria watersheds are faced with a number of challenges some of which according to Aremu et al. (2010), Iroye (2015 and 2008) Jimoh (2003) and Okoko and Olujimi (2003) include:

i. Flooding in low-lying belts of coastal regions, and in the plains of small and large inland rivers.
ii. Coastal and marine erosion
iii. Gully erosion in south-east and north central states.
iv. Land subsidence in coastal and marine areas
v. Extensive deforestation
vi. Contamination of surface and ground water
vii. Inappropriate land use practices such as pavement especially in urban residential areas
viii. Bad agricultural practices such as shifting cultivation overgrazing, over cropping, shifting cultivation etc.
ix. High rate siltation of lakes and dams
x. Drought and desertification in northern fringes

Inadequate intervention and neglect to control the degradation process have contributed to the magnitude of ecological problems within the drainage basins in Nigeria (Ofomata, 1991; Faniran and Jeje, 1983; Faniran; 1991; Jimoh, 2003; Okoko and Ohijimi, 2003; Nabegu, 2005; Adedayo, 2007; Iroye, 2010; Aremu and Sule 2010; Eniolorunda, 2010), hence the call in this paper for its comprehensive management; this is because, how the river basin is developed and managed will have a major impact on present and future living standards of its inhabitants and on the ecosystem (Srinivas, 2015; Lee and Dinar, 1995).

2. COMPREHENSIVE BASIN MANAGEMENT

Comprehensive basin management involves coordinated use and integrated management of land, water vegetation and other physical resources and activities within a catchment area (Gardiner, 1994; Tilakasiri, 1980). This is to ensure minimal degradation of the resources, minimal soil erosion, minimal impact of water yield and quality and other features of the environment such as air. Effective and efficient basin management is thus not only a prerequisite for reduction of natural disasters, but also a right effort in the achievement of sustainable development. It encompasses activities which, although within the drainage basin, can be distant from the river channels and may involve resources other than or in addition to river water (Barrow, 1998). Lee and Dinar (1995) observed that a river basin system is comprised of many components with interdependencies, piecemeal approaches to river basin development and

management have often fail to lead to an optimal outcome, resulting in inefficient resource use, economic losses and environmental degradation.

Catchment management ensures effective coordination of activities that affect the conservation, sustainable use and management of every component part of watersheds such as water, soils and vegetation. Watershed management as a concept thus take into consideration, the various activities, needs, hopes and aspirations of users of land within a drainage basin by creating among them, the awareness in ensuring that all activities are carried out in manner that will have minimal impact on the environment. It is dedicated to solving watershed problems on a sustainable basis (Erdogan, 2013); it provides an ecologically sound economic base for the watersheds and its people (Rawat, 2014). According to Clapp (1965), the concept is not only relevant for water resource development as it is erroneously believed in Nigeria; but for total environmental planning and management. This is what Faniran (1972) calls Comprehensive River Basin Development (CRBD), Cunningham (1986) and Irwin (1986) call it Total Catchment Management (TCM) and Barrow (1998) calls it River Basin Development Planning and Management (RBDPM). River Basin Development Planning and Management according to Barrow (1998) seeks to integrate the following interrelated, but separately evolved concepts:

i. multipurpose development;
ii. an integrative role for draining basin unit; and
iii. the acceptance of intervention to promotion development (typically seen to be improvement of social welfare or regional conditions)

Le Moigne (1994) listed the advantages associated with comprehensive approach to river basin development to include ability to:

i. meet short and long term demands in an economically efficient manner,
ii. benefit from cost reduction through economies of scale,
iii. identify efficient solution to water and pollution problems
iv. include activities and objectives that are not always economically and technically feasible in separable approaches, and,
v. facilitate action of reaching a consensus among the riparian's, thereby reducing tension and conflicts.

The Barilla Centre for food and Nutrition (2009) listed a number of criteria for successful functioning of basin organization. These criteria include:

i. A well-defined mandate and good legal, political and administrative power to carry it out
ii. Adequate staffing and capacity building, especially for environmental issues, which are often new and informed by limited data availability.
iii. Strong, broad-based political and stakeholder support
iv. Sustainable funding

3. STAKEHOLDERS IN WATERSHED MANAGEMENT

Freeman (1984) define stakeholder as any group of individual who can affect or is affected by the achievement of an organization objectives. Stakeholders in watershed management according to Erdogan (2013) include all regulatory or resource agencies with responsibilities for protecting and managing the water body at local, state and federal levels and all the parties whose authority will be needed to implement management plan. Others are nongovernmental organizations such as watershed associations or councils, river watch citizen groups, volunteer monitoring groups, educational and research institutions industries and agricultural associations. Stakeholders

according to him also include landowners, those who use watershed and those whose participation is essential to successful management. These groups of people are important in the planning of the natural environment where human activities and natural process are multilayered combined. Wamalwa (2009), classified stakeholders in watershed management by their possession or attributed possession of between one and three of the following attributes:

i. the stakeholder's power to influence life on the watershed,
ii. the legitimacy of the stakeholder's relationship with the watershed region, and
iii. the urgency of the stakeholder's claim on the watershed area.

Stakeholders possessing the three aforementioned attributes according to Mitchell et al. (1997) can be classified as 'definitive' while those posing two or one of the attributes can be classified as expectant and 'latent' respectively. Because watershed assessment is complex, especially at the planning phase due to its overlapping multiple jurisdictions that are managed by organizations with divergent goals and responsibilities and inhabited by numerous stakeholders with varied interests (Erdogan, 2013; Glicken, 2000), there is the need to carry along the groups in every decision making process. Inadvertent exclusion of a stakeholder group may influence a group's decision to accept or reject the outcome of the process (Erdogan, 2013). Thus, the involvement of every stakeholder needs to be balanced against the limited resources available for watershed assessment and management (USEPA, 2001).

Okeola (2013) observed that the new trend across the world today in basin planning and management is the involvement of public and private sectors such as environmental agencies, civil society, regulatory bodies and service providers in agricultural, municipal, tourism and industrial sectors. According to him, the appropriate institutional arrangement for a particular basin will depend on its scale (local, national or trans-boundary); the stage of basin development; the main water management challenges to be addressed and the existing social, economic, political and institutional arrangement.

4. HISTORICAL DEVELOPMENT OF WATERSHED MANAGEMENT

History of river monitoring according to Barrow (1998) dates back to almost 5,000 years ago while the first suggestion that a river basin be used as a planning and administrative unit was made in AD. 1752 (Chorley, 1969). River basin management further developed in the 1990s with the idea of Sir Williams Wilcoks to regulate the flow of Nile River. This project was undertaken in order to coordinate the demands made within the basin. The establishment of Tennessee Valley Authority (TVA) in 1933 however presents a radical departure in the river basin management from simple resource exploitation to that which integrates with other aspect of development, and directed at improving human welfare (Barrrow, 1998). The body which was set up by United State Government seeks to purse the following major objectives:

i. promote flood control on the Tennessee river system,
ii. improve navigation on the river system,
iii. establish hydroelectric power stations, and,
iv. achieve proper use of marginal lands.

From its inception till date, the TVA has made progress in comprehensive river basin development; controlling floods, generating and distributing electricity, improving navigation, simulating industrialization and employment, extending education and welfare, controlling soil erosion and improving agricultural production (Finer, 1994; Newson, 1992; Ayode, 1988).

5. THE TENNESSEE VALLEY AUTHORITY: EXAMPLE OF COMPREHENSIVE WATERSHED MANAGEMENT

The United State Tennessee Valley Authority (TVA) was established by the 1933 Act, and has recorded unprecedented level of success (Clapp, 1965). With the establishment of TVA, the Tennessee River which was previously an uncontrolled stream has now been brought under complete control. The impounded waters now make the river navigable at all times and facilitate the generation of hydro-electricity at a number of pints along the water course. In addition, flooding in the catchment has been brought under complete control while agriculture, industrialization and planned settlements have witnessed marked progress. According to Faniran (1972) TVA is not only concerned with the development of the basins water resources, but also with the development of available resources within the almost 50,000 square km basin area involving seven state administrations. Hence, Friedmann and Weaver (1979) hail its establishment as the first practical example of regional development in USA.

Resources developed within the basin include coal, petroleum, metals, chemical, ceramic material, fertilizer ingredients, timber and farmland. Development of coal has made it possible to maintain standby steam generators which are usually used during periods of high power demands or when an extended drought reduced available power. Development of petrochemical industries has had tremendous effects on agricultural development both within and around the basin while the planned development of the entire basin has minimized the incidents of pollution, accelerated runoff, flooding and erosion resulting from deforestation and farming activities within the watershed. TVA thus clearly depicts a good example of watershed management.

6. THE CONCEPT OF SUSTAINABLE DEVELOPMENT

Sustainable development refers to development that meets the needs of the present without compromising the ability of future generation to meet their own needs (Loucks, 2000). It is a development that continues forever. The term sustainable development according to Sule (2003) first came into focus sometimes, in the early 90's and the concept has since then become a subject of debate and discussion throughout the world with the 2002 World Summit having it as its main theme. Sinha et al. (2008) defined it as a regularly maintained development while United Nations World Commission on Environment and Development refer to it as development which must meet the needs of the present generation without compromising on the ability of the future generations to meet their own needs and aspirations. These definitions thus imply that it is possible to have development without destroying the environment. This is however only possible when man ensures that his rate of usage of renewable resources does not exceed their regeneration.

The need for sustainable development arose because the global resource base is exhaustible. This implies that there is a limit beyond which the rate of increasing exploitation of natural resources to meet the ever increasing demand of goods and services will affect the ability of future generations to meet their own needs.

Sustainable development can be regarded as economic development which takes into consideration, the sustainability of the natural environment. Without environmental sustainability, it will be virtually impossible to achieve sustainable development (Tilakasiri et al., 2012). This thus suggests that environmental issues must always be included in development policies, activities and planning of any nation. Sinha et al. (2008) enumerated a number of principles for sustainable development among

which includes, creation of global alliance, provision of framework for development and conservation, conservation of earth's vitality and biodiversity and keeping within the earth's carrying capacity; other principles according to them include respect and care for community, rational usage of non-renewable resources and changing of personal attitudes and practices.

7. WATERSHED MANAGEMENT MEASURES AND SUSTAINABLE DEVELOPMENT

The success of watershed management efforts largely depend on the conditions and processes operating within a drainage basin. Factors such as amount and distribution of rainfall, topography, soil types, existing vegetation cover and economic activities of farming and grazing practices largely influence the state of a watershed. Attempt to achieve sustainable development in any region thus calls for understanding of the combined roles played by all the aforementioned factors. This can be successfully carried out by analyzing these causal factors and the processes they influence, result of which can be used in comprehensive management of drainage basins.

As a watershed transform from rural to urban setting, the percentage paved area in such a catchment drastically increases. This situation negatively impact infiltration process; hence overland flow quickly delivers precipitation to streams. Storm hydrographs in such a catchment typically rise and fall faster when compared with rural catchment due to high volumes and transitory nature of surface runoff. Not only that urban watersheds usually contain many potential sources of contaminants, including municipal and industrial wastewater discharges, combined and sanitary sewer overflows, and chemical storage and disposal. Storm water runoffs in such a catchment do increase the loading of micro-organism, nutrients, metals and sediments into source waters.

Good watershed management aims at retaining more rainfall on the land and improve river regime by reducing flood peaks and sediment transport. This can be successfully carried out through afforestation programme, improvement in cultivation methods, controlled urban development and engineering construction. However, for effective basin management to be realized, information is required from such catchments on hydro-meteorological and environmental attributes including geology, soil, vegetation, land use as well as settlement and human activities.

Availability of these sets of data will assist greatly in achievement of sustainable development in any given catchment through:

1. Domestic Water Supply: The provision of good domestic water supply to the people still remains a big problem that calls for urgent attention in the tropical environment. Misery, sickness and death occur in most of these countries due to infectious diseases related to inadequate water supply both in quantity and quality (Oyegun, 1982, Faniran, 1991). Not only this, statistics shows that about 80 countries are suffering from acute water shortages, and thus, scarcity of water has become a limiting factor to both economic and social development of most nations. In an effort to improve this gloomy record, the UN designated 1980-1990 as the International Drinking Water and Sanitation Decade 'with a goal to provide all the people with adequate water of safe quality and basic sanitary facilities by 1990. This goal however, remains a mirage up till date, mainly due to basin degradation process amongst others. Health of the watershed has direct effect on the quality of water which drains in the watershed area (Giri et al., 2012). Thus, the various watershed retaining management techniques highlighted in this study will thus help in retaining more on the land, especially during the raining season, which can subsequently be used in augmenting dry season water supply shortages in the basins.

2. Irrigation Development: Irrigation is artificial supply of water to soil for plant growth. This practice is of paramount importance in basins marked by seasonal variation in rainfall distribution in time and space. Sule (2003) linked the success story in agriculture in developing countries to several factors amongst which is efficient irrigation practice. According to him, agriculture uses 70 percent of fresh water through natural rainfall and irrigation practice. Thus, storage reservoirs and flood detention structures constructed along the rivers for the purpose of basin management against flood can be used for irrigation activities. Hence, farming activities which hitherto may have been carried out only during the rainy season can be extended to dry periods in most basins. Not only this, the seasonal problem of drought being experienced by farmers will be minimized, thus helping to solve the problem of food shortage

3. Industrial/Health Care Development: Water is an essential part of manufacturing industries, as accessibility to it remains one of the major factors guiding any industrial location. Industry, according to World Water Development Report (2015) accounts for more than 20 percent of water withdrawal worldwide; a figure which is growing astronomically in developing countries that are industrializing. Efforts directed at drainage basin management will thus aid in conserving the excess storm flow from the basins during rainy season for usage in dry periods, rather than being allowed to waste.

4. Fishing Development: Fishing is very important as fish aids in diet improvement needed by the body. Hence, catchment management efforts through dam construction will aid fishing activities, thus, helping to improve not only the protein intake of the people, but also providing employment for the citizenry and revenue for the government.

5. Recreation Development: The construction of water retention reservoirs in high runoff discharge basins, apart from helping to conserve water for usage, can also be used to support pockets of wildlife, thereby giving recreational opportunities for the people. Through this practice, more government revenues can be raised, most importantly at this period when the global attention is on sustainable development.

8. CONCLUSION AND RECOMMENDATIONS

Watershed management in the past, especially in developing countries has not received the attention it deserves. Even now, the importance of river basin development has not being fully recognized. Sustainable river basin management will significantly reduce economic losses due to flooding; protect the catchment area from erosion, maintain a fairly more uniform stream flow, help the natural ecology of the river catchment, enhance infiltration process and thus ground water storage, provide additional source of water and income for the people and consequently higher standard of living. In all these great benefits lies the value and importance of watershed management for sustainable development.

As a way of ameliorating the high rate of degradation process taking place in different catchments within the country, this study thus recommends the following measures for adoption:

i. Afforestation programme: Afforestation influence catchment hydrological processes through its biological, thermal and physical effects. This is because the thick litter produced by trees in afforested basin will promote the activities of soil organisms though increase in soil organic matter, thus, opening up soil pores resulting in high infiltration rate, hence low runoff discharge. Not only that, the infiltrated water promoted by trees during the rainy season will aid in maintaining ground water recharge, thus helping to sustain dry season discharge which hitherto may have been very low in such basins. Hence afforestation programme, apart from helping to solve basin degradation process of flooding (Vertessy, 2003) erosion (Jimoh,

2003; Adediji and Jeje, 2004) and sedimentation (Oyegun, 1987); the measure will also aid in conserving water for dry season usage (Iroye, 2008).

ii. Improvement in Cultivation Methods: Improved cultivation methods and practices on cropped land and in the watershed should be encouraged. This is because; such activities can reduce substantially the rates of erosion and sediment generation. Farmers operating within each catchment should be encouraged to dedicate certain percentage area of their farms for the cultivation of crops with high root density and high litter production as a way of increasing infiltration process.

iii. Controlled Urban Development: Urbanization process remains one of the major anthropogenic distortions to the theoretical operation of hydrological cycle, and its greatest consequence according to Delleur (1982) is as a result of paved surface. Efforts should thus be made by authorities concerned to zone each drainage basin for future development. This will entail dedication of a certain percentage of the land areas as parks and gardens where tree could be grown. Buildings erected on floodplains should be removed while stream channel should be enlarged and deepened to facilitate easy flow of runoff as earlier recommended by Akinola (1966).

iv. Engineering Construction: This management technique is better adopted where land deterioration has progressed too far that biological improvement measures, even when combined with better farming and forest management methods, will not be sufficient to check such degradation process. Measures that can be adopted in this technique include trenching, terracing, construction of spillways in terrace banks, gully check, drains, runoff interception canals and small tanks and ponds. All these are integral parts of comprehensive watershed management. However, advantages and disadvantages of any engineering method chosen will have to be balanced, the double objective being improvement in use of land in the watershed and improvement of the river regime and sediment transport.

v. Improvement in hydro-meteorological facilities: Paucity of data remains one of the biggest problems in basin hydro-meteorological research in developing countries. This factor accounts for the reason why most drainage basins especially in Nigeria cannot be properly managed (Faniran, 1991). According to Ayoade (1971), fewer than 300 of the 1,058 rain gauging stations established by 1965 by the Nigerian Meteorological Services were found to have, as of 1971, any form of reliable record extending for l0 years or more. This data gave a network density of 1 to almost 900sq.km, instead of the recommended 1:50. The situation is even less satisfactory according to him with evaporation measurement where just 70 recording stations were known to exist all over the country, many of which were poorly operated and maintained. Data problem in watershed management still persist till date in Nigeria (Londip, 2013).

vi. Use of natural boundaries: For effective basin management in Nigeria, government should base the development and management of water resources on natural basins rather than on political or administrative boundaries. It is in so doing that the adoption of aforementioned watershed management techniques will not only aid in ameliorating degradation process in the country but, will also assist in the achievement of sustainable development.

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