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Agricultural Resource Management: A Panacea to Sustainable Food Production in Nigeria

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ABSTRACT

The study conceptually assessed available literature on sustainable agricultural land and water resource uses and noted that increasing world population will come with an increase in food demand which agricultural production must contend with in the face of diminishing water resources and decreasing arable land due to urbanisation and other factors. Sustainable Agriculture and natural resource management activities must seek to increase food production and other forms of agricultural productivity through practices that sustain long term ecological and biological viability of natural resources through the efficient use of land, water and other resource. Sustainable land and water management in this context embraces the use of land and water resources for productive activities to meet human needs and simultaneously ensuring the continued productive potential of these resources and the maintenance of balanced ecological and environmental functions. Agricultural resource management and maintenance will involve embracing land and water use methods that enable us maximize both economic and social benefits of land and water while enhancing the environmental support functions of these resources. Sustainable agricultural resource use must embrace a holistic response to raising the bar in adequate food production and keeping a healthy ecosystem through the integration of physical and biological needs and values.

Keywords: *Agriculture, Resource, Sustainable, Food.*

INTRODUCTION

Our agriculture is dependent on the available natural resource base which is either renewable or non-renewable. Land and water are resources that play important roles in the production of food and industrial raw materials for man and in ecosystem balances, essential to humans and the environment by supporting primary production through nutrient cycling, climate stability by regulating the carbon and nitrogen fluxes, checking of the environment .The availability and diversity of soil biota can be limited through land use intensification which has direct consequences on the ecosystem that anchors on the soils and water. Intensive cultivation of the soil decreases soil organic carbon content which plays an

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important role in stabilising soil aggregates and reduces soil losses (Eririgo et al, 2016).

Factors that cause resource deterioration are many and could be directly and indirectly linked. Direct causes are land clearance for agriculture, fuel wood harvesting on non-sustainable manners, overstocking and overgrazing, inappropriate farming practices, shortened fallow period and loss of shelterbelt from changes in economic conditions, uncontrolled population growth with the attendant urbanizations and resultant high demand for fuel (charcoal) and food which come from rural and semi-rural areas (Megudu, 2006). For agricultural resources to continue to perform optimally there is need to use them sustainably.

Sustainable resource management in agriculture defines the optimal use of agricultural sources for present benefits and leaving the same resources in a re-useable form for future generations. The rate of agricultural land degradation is a threat to the livelihood of farmers, biodiversity and habitat loss for wild life. Increase in population pressure and pervasive poverty has exacerbated food insecurity in many communities in third world countries. Contending with this population pressure will require raising agricultural productivity by 60 to 70 percent by 2050. Unless we rethink the management of land and water for food production, protection and preservation of our biodiversity, the ecosystem may be heading for a precipice from which we may not recover or will be costly to recover from (Nyandiga and Currea, 2017).

Sustainability as a term in agriculture may vary widely by definition and includes a wide range of varied food and fibre production systems that is suitable to be given environmental conditions such as the humid tropics where Nigeria belongs. The systems aim at keeping the productivity of natural resources in tandem with population growth, economic demands and at the same time protecting if necessary and maintaining environmental quality (National academies of sciences, engineering and medicine (NASEM), 2019). Keeping agricultural productivity in tandem with population growth must be emphasized because statistically, it is estimated that human activities have impacted 83% of the world's terrestrial land surface and degraded about 60% of our ecosystems in the last 50 years (Seoul National University, 2010). This is not very healthy.

The estimated increases in world food demand will pose a huge challenge with respect to agricultural crop and animal yields and will significantly impact natural resources and the ecosystem as contemporary realities suggest (Wattenbach and Friedrich, 1992). Water and land needs of contemporary agriculture practices may be less than global reserves however; local shortages are common which may significantly impact food security. Expanded global trade may have

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ameliorated some of the effects of the variability in food supply however; it has limited impacts on low-income populations who depend on subsistence agriculture supported by local resources (OECD) (2010). The environmental effects of increases in food production in these local populations will include sustained depletion of water and soil resources, significant changes in nitrogen and phosphorous cycles, human health challenges that may result from nutrient use inadequacies and the loss of habitats that contribute to agricultural productivity and stability. Typical case studies in China illustrate connections between increased food production and environmental stress. Decreasing food demand and increasing production are sustainable options (Wattenbach and Friedrich, (1992). However doing these will include eliminating unsustainable practices, closing yield gaps through controlled expansions of fertilizer applications, and control of pest resistance through advances in biotechnology, moderated expansions in rain fed and irrigated agriculture. These measures may meet the food demands of the increasing world population while maintaining environmental balance (McLaughlin and Kinzelbach, 2015).

Food production must be such that sustains the environment it depends upon. This means that methods employed in food production must preserve the quality of water, land and ecological resources (Eririogu, Eze, Emenyonu and Ibeagwa, 2016). Sustainable food production will involve moderation in agro-practices intensification, limited increases in agricultural land area, a reduction in the use of land for non-food crop production such as bio-fuels, better monitoring and control of fertilizer application, modified irrigation use that reduces water use while eliminating salinization, tillage practices that improve soil quality, development of transgenic crop varieties of higher yields and reduced water use (Wattenbach and Friedrich, 1992). All these measures will provide sustainable crop production. A sustainable method of food production will need to combine improved technology, improvements in agricultural management and reforms in public policy and the need to produce more food while protecting natural resources will require greater investment in agriculture, farmer education and research (McLaughlin and Kinzelbach, 2015).

Nigeria's population has increased significantly in recent times, and consequently, there is the need to produce more food. The record population growth means, however, that feeding these additional millions will depend largely on expansion of arable land with the attendant depletion of natural resources, habitat loss to wild life and agitating the ecosystem. The Pressure on the natural resource base and the consequential environmental stresses appear to have increased dramatically over the years as is evident in unfamiliar natural disasters

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and occurrences and in addition to the magnitude of these are various economic and social problems. These effects are of great importance because of the adverse impacts on the ecosystem and influence on crop production. Adverse environmental impacts can threaten agricultural water supplies, crop yield, and valuable ecosystem services such as pest predators. Inappropriate Agricultural resource management can also impact human health in the areas of safe drinking water and forms of atmospheric contamination. A balanced assessment of food production must put into consideration the effects on the environment of current and future agriculture and the availability of water, land and nutrients.

Does Nigeria have enough natural resources to feed her teeming population? In terms of quantity of needed resources yes, however the sustainability of the productivity of these resources will depend on how we manage these resources. If we continue to release pesticides and other chemicals into the environment, deplete groundwater, practice unsustainable irrigation methods, we are likely to experience critical resource impairment. Ultimately, the issue of food production is as much about people as about resource impairment. Increases in food production should not be at the detriment of the environment and ecosystem. Rehabilitation of degraded lands can enhance food security but improving on land use practices can as well be a better option in preserving soils quality and optimizing the use of water (Nyandiga and Currea, 2017).

Land Degradation, Resource Uses and Sustainable Agriculture

Land degradation is the anthropogenic or natural deterioration of the soil productivity and fertility ranging from forest cover losses, erosion of range land and impaired ability to produce food, raw materials to maintaining a healthy ecosystem (Nyandiga and Currea, 2017). Land degradation limits the productivity of available arable land area. Land can be degraded beyond productive capacity and this leads to clearing more forested areas and tampering with natural ecosystems. Land degradation is also known to change land uses (Medugu, 2006). For example, turning degraded crop lands into grazing lands. Human population growth has also contributed to land degradation among developing economies where lands are continuously cultivated without appropriate replenishment and maintenance of the soil nutrients. It is observed that arable land areas in Sub Sahara Africa has reduced more than what is obtainable in any other regions of the world (Seoul National University, 2010). This calls for a proactive measure to check the menace.

A common form of land degradation in many African states is desertification and erosion. The crop yields of some lands in the Africa sub-

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region according to Dregne (1990) has reduced by 50% because of soil erosion and desertification. Erosion causes reductions in yields in the range of 30% to 90% as observed in some West Africa States (Mbagwu, Lal and Scott, 1984; Lal, 1987). Lal (1995) reported that from previous erosions, yield reduction in Africa may range between 2% to 40%, and perhaps a mean loss of up to 8.2%. He further warned that unabated erosion may by 2020 cause a further decline in yield by about 16.5% and noted that reduction in 1989 of about 8.2 million tons for cereals, 9.2 million tons for roots and tubers and 0.6 million tons for pulses was observed.

Soil degradation also results from compaction and appears to be a worldwide problem, especially because of mechanized farming. Compaction was observed to have caused reductions in crop yield within the range of 25% to 50% in some European nations and North America as reported by Ericksson, Hakansson and Danfors (1974). Charreau (1972), Kayombo and Lal (1994) have reported a 40% to 90% of same effect in West Africa. Recent statistics may not be very favourable because of so much emphasis on mechanized agriculture without proper impact analysis on the various soil types. Land degradation of this sort may encourage serious nutrient losses especially when the soil is stripped bar because of mechanization without proper education on the *modus operandi* of the processes and procedures. Land degradation through nutrient depletion has reasonable effect globally especially in Sub-Saharan Africa. Annual nutrient loss of soil was estimated at 22kgN, 3kgP and 15kgK/ha. In South Asia, the value of the loss was estimated at US$600 million annually by erosion alone and US$1,200 million from depletion (Stocking, 1986; UNEP, 1994 in Eswaran, Lal and Reich, 1998). Africa as a continent is placed 2nd in most degraded vegetation and land mass assessment as shown in the table below.

Table 1: Estimates of all degraded lands (in million km^2) in dry areas

Continent	**Total area**	**Degraded area †**	**% degraded**
Africa	14.326	10.458	73
Asia	18.814	13.417	71
Australia and the Pacific	7.012	3.759	54
Europe	1.456	0.943	65
North America	5.782	4.286	74
South America	4.207	3.058	73
Total	**51.597**	**35.922**	**70**

† Comprises land and vegetation.
Source: Dregne and Chou (1994) cited in Eswaran, Lal and Reich (1998)

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Estimates of the causes of land degradation have indicted water erosion as the most pronounced culprit. The table below shows the extent and indicates why water erosion should be treated as a matter of urgent emergency.

Table 2: Estimates of the global extent (in million km ^{2}) of land degradation

Type	**Light**	**Moderate**	**Strong + Extreme**	**Total**
Water erosion	3.43	5.27	2.24	10.94
Wind erosion	2.69	2.54	0.26	5.49
Chemical degradation	0.93	1.03	0.43	2.39
Physical degradation	0.44	0.27	0.12	0.83
Total	**7.49**	**9.11**	**3.05**	**19.65**

Source: (Oldeman (1994) cited in Eswaran, Lal and Reich (1998)

Population Growth and Land Degradation

Ramankutty *et al*. (2002) and Bruinsma (2009) in Seoul National University (2010) have noted that Population growth is a significant driver of agricultural expansion. They observed a positive correlation between population growth and crop production in terms of increases in the demand for food. This increased demand for food has resulted to clearing more forest lands or the introduction of improved technology in some cases. Moreover, people tend to migrate into areas with fertile soil for agriculture (Seoul National University, 2010). The clearing of more forested lands in most cases has led to nutrient depletion, losses in bio-mass, ecosystem disruption and imbalances and pressure on natural resources. Nigeria's population has been witnessing statistically significant growth, increases the demand for food and consequently deforestations with the attendant losses in bio-diversity and disruptions in the ecosystem. The agricultural systems and methods may need restructuring to be sustainable even as emphasis on regulating the population will be welcome.

Increasing Income and Land Degradation

Seoul National University Report (2010) stated that rising income with the consequent changes in food menu preferences may be affecting the quantity and type of foods that we eat. Citing Buchanan *et al* (2010), it was observed that in the past 60 years, the global yearly average per capita increase in food and consumption and also fibre demand linked to income growth was 0.27%, the growth in developing countries is even reported to be higher than in high-income countries. Increases in incomes have induced a rise in the demand for foods that

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initially were limited in our menu such as meat, exotic fruits and vegetables. Also citing Delgado *et al*. (1999) the report observed that the demand for milk especially in developing countries will be increasing yearly by 3.3% from 1993 to 2020 with Southern Asia accounting for about 60% and Sub-Sahara Africa only 17%. Increases in meat and meat products demand will raise the demand for land and water for livestock far greater than the land demand for crops. Their report noted that while 15 m^3 of water will be required to produce one kilogram of beef, just 0.6 m^3 of water will be required for the same kilogram of cereals (Seoul National University, 2010). Note that the frequent clashes between the Pastoralists and crop farmers in the north of Nigeria has been bloody because increasing demand for more land by the herders and shrinking grass land up north forcing migrations down south.

Infrastructure Development and Land Degradation

Seoul National University (2010) has also noted that road development may ease access to natural resources; however, road development leads to deforestation in some cases especially in countries that have weak institutions as obtainable in developing nations. Citing Kamara (2008), Foster and Briceno-Garmendia (2010) stated however, that road accessibility, power and communication infrastructures have very positive correlation to agricultural factor productivity. This by implication suggests that poor road networks and these other factors can lead to low productivity in agriculture which could lead to deforestation impacting the ecosystems; poor road infrastructure however could hamper timber logging though. Citing Central Africa as an example they believed that the low rate of deforestation has a correlation with poor road infrastructures, opining that poor road infrastructure in Sub-Sahara Africa has contributed to low agricultural productivity which has led to deforestation for food production. Sub- Sahara Africa they noted has a huge infrastructure deficit compared to other developing countries and this has contributed to the low yields in agricultural production from 1961-2005 and to significant decline in per capita arable land.

Food Prices, Price Elasticity of Demand and Land Degradation

Rise in food prices encourages farmers to increase food production which can be accomplished in our clime by acquisition of more land. In contemporary Nigeria high food prices have encouraged land grabbing. Domestic need of certain products in some developed nations such as biofuel production from cereals has also triggered the demand for land in the third world countries (Rosegrant *et al*

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2008; Baffes and Hanniotis 2010 in Seoul National University (2010)). The trend they noted shows that wealthy countries having arable and water deficits have acquired lands in developing countries with sufficient arable land and water for these cereal crops production to meet bio-fuel demand. This will have socio-economic and institutional effects on the small-holder farmers. According to Deininger *et al (*2001) and Toulmin *et al (*2011) in Seoul National University (2010) report, about 46.5 million ha of land globally were grabbed between 2004 and 2009 in 81 countries. These actions impacted livestock production patterns, forest resources and large scale mono-cropping which is subscribed to impacts biodiversity negatively.

When social and economic conditions encourage resource depletion and short-term economic gain, farmers resort to shorter production and harvest cycles which often lead to complete loss of production potential and land abandonment. FAO (2019) noted that it was just recently our knowledge of the production potential of the world's land resources emerged from being crude. They observed that 20 percent of land surface was taken to be too cold, 25 percent very dry, 20 percent very steep or shallow, 5 percent wet and 10 percent of low fertility for agricultural production. Questions that have not being answered it noted hinge on the location of the arable lands, their sustainability and what effects changes in land use will have on them?

McLaughlin and Kenzelbach (2015) citing Galloway and Cowling (2002), Erisman et al.(2008) and Smil(2000) posit that increases in fertilizer use may have increased world crop output; it has also affected water and land resources. The effects on agriculture on the nitrogen cycle and on reactive nitrogen in water, soil, and atmosphere are very evident. These changes cause the contamination of groundwater, greenhouse gas emission and soil acidification. Studies also suggest that fertilizer use has increased the amount of phosphorous in the soil which is affecting aquatic reservoirs. Nutrient augmentation is a common practice in agriculture; it is likely that overall fertilizer applications will increase rather than decrease with the attendant side effects. It is therefore important that farmers minimize the effect of active nitrogen and phosphorous residues not used by crops. A sustainable means that can measure the amount of applied active nitrogen that the crops can use (harvested biomass and soil) must be developed and taught the rural end users. This can be adopted for any type of fertilizer applied on the soil. Efficient use of nutrients must be developed to obtain better yields without increasing the amount of reactive chemicals into the environment. Better understanding and monitoring of the use and method of application of these fertilizers will be germane to this.

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The effects of expanded food production on land resources are varied. They can reverse all that has been gained and can threaten yield increases obtained from nutrient enrichment. Degradation effects from agricultural activities that are more prominent outside loss of vegetation (forest cover and bio-diversity) on land are erosion, weathering and salt accumulation (Lal et al., 1989). Estimated area with moderate to severe soil degradation is about 13 million km^2, recent studies have attempted to be more specific stating the extent of soil degradation. However, there is a need for much better quantitative data on soil degradation and how it affects long-term changes in arable land and crop production (McLaughlin and Kenzelbach, 2015). While soil degradation may become a threatening problem if not handled carefully, studies suggest it can be reduced substantially through good management practices (Matson et al., 1997).

Analysis of environmental impacts should be the first step in finding the pathways toward more sustainable land uses. For example, traditional low-intensity shifting cultivation systems remain a viable option where population pressures are low. Agro-forestry, agro-pastoral and silvo-pastoral systems and other labour-intensive mixed cropping systems are better suited to lands that are more fragile or under greater population pressure. More capital-intensive systems such as cattle ranching, perennial crop operations, forest plantations and upland agricultural crop systems, while often been environmentally destructive in the past, can present important opportunities for land restoration and improved land management. To be viable, they require secure land tenure, long-term investment, market access, and appropriate technologies (NASEM, 2019).

Water Resources Use and Sustainable Agriculture

According to Seoul National University report (2010), globally, there is a challenge to step up food production by 50% by 2030 and to double production by 2050. With growing urbanisation this lofty aspiration must be achieved with less water. It is therefore imperative that farmers increase water use efficiency and water use management since agriculture uses water significantly, accounting for almost 70% of freshwater withdrawals globally. Sustainable water resources management in agriculture implies ensuring that water resources are allocated efficiently and equitably. Agricultural water resource management covers: surface water; ground water; recycled wastewater; harvested rain water.

While water availability often are the focus of sustainability discussions in agriculture, the reduction in the quantity of groundwater due to excess use seem to be a much more serious long-term threat. Water resource effects on crop

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production are very different from rain fed and irrigated agriculture. A transition from natural vegetation to rain fed agriculture has little effects on evaporation or transpiration and groundwater. Irrigated agriculture makes use of more water than a rain fed agriculture and diverting natural rain water from the landscape into the atmosphere. Groundwater is easily accessible for irrigation as it is available throughout the year whenever needed. McLaughlin and Kenzelbach (2015) citing FAO (2011) and Scanlon et al (2012) have estimated that about 40% of irrigation water comes from groundwater. For the use of groundwater to be sustainable, pumping out the water should not exceed the aquifer's safe yield. They reported a notable example in the southern High Plains aquifer of the U.S., where yields of sunk wells have witnessed significant reduction because of falling groundwater levels which has the implication of farmers returning to rain fed agriculture, with the effect of lowered yield. This will limit the choice of crops grown making agriculture more vulnerable to climate variability. They noted that groundwater use has tripled in the last 50 years and excessive pumping from aquifers has become common.

CONCLUSION

Sustainable agriculture will depend on how agricultural resources are managed. If we subscribe to high meat-based diets, increased bio-fuel production, deforestation, release excessive amounts of nutrients and pesticides into the environment, use of groundwater beyond their yield capacity, promote unsustainable irrigation projects; our fertile lands will degrade and may likely hit critical resource limits, especially in the third world countries like Nigeria. But there is no reason to get these limits. Innovations and technology may enable us increase food production to meet our food needs in a sustainable way if we cautiously stay within the limits of the carrying capacity of our natural resources. Ultimately, the issue of food security is as much about people as about finite resources.

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