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Analysis of Sustainable Agricultural Resource Use in Nigeria: An Ecological Footprint Approach

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study analyzed sustainable agricultural resource use in Nigeria using the Ecological Footprint Approach. The results showed that the emergy density of the earth and the country were 3.10E+10 sej/m^2/year and 1.33E+11 sej/m^2/year respectively, indicating that a total energy of 3.10E+10 sej was used up per meter square of the total global hectares to provide for the ecosystem services. Given the interaction of the renewable resource flows a total energy of 1.33E+11sej was expended in the transformation of agricultural resources per meter square of the land area of the country. The demand for resources per capita were 5.25ha of arable land, 2.54 ha of pasture land, 0.816ha of water area, 0.131 ha of forest land, 2.6ha of fossil land and 0.0000481 ha of built-up area with a total ecological footprint of 11.3 hectares per capita; while carrying capacity per capita was 5.2 hectares, showing a deficit of -6.1 hectares per capita and indicating unsustainable agricultural resource use - hence sustainable development cannot be achieved. The study however recommended that ecological farming, organic farming and other sustainable agricultural systems that reduce the footprint for arable land should be adopted in the country, and that Nigeria should strategize ways of reducing the importation and consumption of foreign food crops and encourage

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local food crop farmers – as this will reduce the ecological footprint of the country, and to ensure that agricultural resources are sustainable every citizen of the country should adjust his/her lifestyle so as to reduce consumption by 6.1 hectares per person, preserve and conserve agricultural resources for the current use and the future generation – as this will not only secure sustainable use of agricultural resources but pave ways to achieving sustainable development in the country.

Keywords: Agricultural resources use; sustainability; ecological footprint; emergy; energy; sustainable development.

1. INTRODUCTION

Agricultural sector is dependent on the natural resource base [1]. Natural resources are either renewable (able to be replenished in the course of natural events within the limits of human time) or non-renewable [2]. The use of resource implies that there is one or more tangible or intangible benefits derived from the resource [3]. Resource use is either consumptive or non-consumptive, while indirect use values such as, soil and water conservation, genetic resources, landscape aesthetics, are also recognized. Consumptive use involves the removal or withdrawal of all, or part of the natural resource from its origin (biotic and non-biotic), non-consumptive use refers to the passive or non-use value of resources [4]. Soil as a resource plays an important role in the production system. It supplies many ecosystem services essential to humans and environment such as the support of primary production through organic matter and nutrient cycling, climate control through the regulation of carbon and nitrogen fluxes, control of pests and diseases for humans animals and plants, and decontamination of the environment [5]. The ecosystem processes such as plant production decomposition soil respiration invasion resistance and ecosystem stability are crucial and determine amongst others the amount of herbivore biomass that can be sustained [6].

The abundance and diversity of soil biota are reduced by land use intensification with direct consequences for ecosystem services provided by soils [7]. Intensive soil cultivation produces decreases in soil organic carbon (SOC) content [8] and the SOC content plays an important role in the stabilization of aggregates and the reduction of the soil losses [9]. Natural diverse vegetation contributes to an increase in soil biodiversity, while intense mono-cropping supports the growth of only a subset of soil microbes causing a decrease in biodiversity [10]. According to Tittensor et al. [11], biodiversity is declining at an exceptional rate driven in part by human pressure on ecosystems. This growing pressure on ecosystems creates disintegration and extinction of natural habitats and threatens the biological diversity and wellbeing of humanity [12]. In Nigeria, as at 1997, there were 5,081 plants species, out of which 0.40% were threatened and 8.5% endangered; 22,090 animal species (20,000 being insects), 0.14% of which were threatened and 0.22% endangered [13]. Akinbile and Adekunle [14] reported that the demand for agricultural produce is continuously rising due to the geometric rise in population, and this has resulted in the intensification of cultivable land in an attempt to increase agricultural productivity. It takes the earth one year and six months to regenerate what is used in a year [15]. According to Borucke et al. [16], the total earth's bio-capacity is estimated at 12 billion global hectares (or 1.8 gha per person) but humanity's ecological footprint has reached 17.6 billion gha (or 2.6 gha per person). Correspondingly, the number of planets (the number of earths it would take to support humanity's footprint) demanded by all humans has increased to 1.47 planets, which represents an increment of 2.4 times the demand for nature's renewable resources since 1961 [17].

World Wide Fund (WWF) in 2008 also reported that human civilization has exceeded the bio-regenerative capacity of the planet [18]. According to Wackernagel et al. [19], it is possible to exceed global bio-capacity because trees can be harvested faster than they re-grow, fisheries can be depleted more rapidly than they restock, and CO_2 can be emitted into the atmosphere more quickly than ecosystems can sequester it. The driving forces are the social processes such as population growth, migration, poverty, level of production, human behaviours and attitudes as well as their consumption pattern [20]. Considering the level of resource use and its attendants, depletion of available resources and growth in ecological overshoot, how then will the country continue to meet the needs of the people and the economy as a whole?

The world needs a new paradigm for the ways resources are used. The pertinent questions asked are: Should we eat less? Should we eat smarter (e.g., less protein of animal origin, with its high demands for energy, land, and water)? Should we create incentives to use fewer resources and implement legal directives to push for eco-efficiency? Should we put in place measures to control population growth? [21]. In order to answer these questions, agricultural productivity must increase if we are to meet the increasing demands of a growing and more affluent population for food, feed, fiber, and fuels in the context of limited land available for expansion of agriculture [22]. Achieving sustainable use of resources is cross-disciplinary and should be addressed at the confluence of the social, economic and ecological spheres, within a political framework [23]. Sustainability is enhanced if provisions are made for mitigation, remediation, compensation and/or rehabilitation when biodiversity loss results from overuse [24], and adopting sustainable agricultural systems that reduce footprint for agricultural resources.

Footprint approach is promoted to jointly measure planetary boundaries and the extent to which humanity is exceeding them [25]. Ecological Footprint measures the demand populations and human activities placed on the biosphere in a given year, given the prevailing technology and resource management of that year; and while bio-capacity measures the amount of biologically productive land and sea area available to provide the ecosystem services that humanity consumes [26]. Where the ecological footprint is significantly larger than a secure supply of productive land, the difference represents a sustainability gap and ecological deficit [27]. Zhao et al. [28] asserted that if the ecological footprint of a region is larger than the carrying capacity, the region runs an ecological deficit, and if the carrying capacity of a region is larger than ecological footprint, the region runs an ecological remainder. Lenzen and Murray [29] argued that ecological remainders or deficits do not reveal whether ecosystems in that country are managed sustainably or not. A remainder may be unsustainably used for exports, and therefore may not indicate remaining capacity. A deficit of a country may be entirely due to imports, with associated impacts outside its borders, while local ecosystems may be well preserved [29].

Past agricultural policies and practices in Nigeria have greatly undermined the bio-capacity of agricultural resources, which are currently marked with unsustainable use, low productivity, degradation, depletion and pollution. Therefore, the results of this study provided a platform for weighing policy options and pointing towards better agricultural shadow projects, such as ecological farming, organic farming, and other sustainable agricultural systems that reduce the footprint for agricultural resources. The broad objective of this study was to analyze the sustainable agricultural resource use in Nigeria using the Ecological Footprint Approach. The Specific objectives were to; estimate the global emergy and emergy density in Nigeria, determine the ecological footprint per capita in the country, analyze the per capita bio-capacity in the country, and ascertain the level of agricultural resource use, sustainability status and resource substitution in the country. The null hypothesis that the ecological footprint for agricultural resources is not significantly different from the composite index (carrying capacity) in Nigeria was tested.

2. METHODOLOGY

2.1 Study Area

Nigeria where this study was conducted is located in West Africa on the Gulf of Guinea and has a total area of 923,768 km^2 [30]. The country is bordered in the south by approximately 800km of the Atlantic Ocean on the West by the Republic of Benin on the North by the Republic of Niger and Republic of Cameroun on the East [31]. Nigeria lies between Latitudes 4° and 14°N and Longitudes 2° and 15°E [32]. There are 36 states and the Federal Capital Territory Abuja. In some contexts the states are aggregated into six geopolitical zones: North West North East North Central South East South South and South West [33]. The country's population is about 167.9 million persons [34] with urbanization rate of 5.3% [35]. According to the World Bank [36], Nigeria is classified as a mixed economy emerging market and has already reached lower middle income status. The country's oil reserves have played a major role in its growing wealth and influence [37]. Agriculture used to be the principal foreign exchange earner of Nigeria [38]. At one time Nigeria was the world's largest exporter of groundnuts cocoa and palm oil and a significant producer of coconuts citrus fruits maize pearl millet cassava yams and sugar cane [39]. The country is fraught with higher demand for agricultural resources which questioned its sustainability. Economically, Nigeria's per capita income is barely $1000 compared to South Africa with over $5300. However at current population growth rate and Gross Domestic Product (GDP) growth rate at 13% per annum Nigeria will achieve today's per capita income of South Africa in 2033 [40].

2.2 Analytical Techniques

The study was carried out using a modified method to Ecological Footprint analysis. The study relied on the use of 2011 aggregate national data for production export and import obtained from National Bureau of Statistics (NBS), Central Bank of Nigeria (CBN), Global Footprint Network (GFN), National Population Commission (NPC), ODINAFRICA (Ocean Data and Information Network for Africa), World Bank, International Energy Agency, UN agencies or affiliated organizations such as the Food and Agriculture Organization, and UN Statistics Division (UN Commodity Trade Statistics Database), for specific objectives. This base year data set was resorted to due to lack of complete aggregate national data in the country. Data collected were analyzed using descriptive statistical tool emergy evaluation technique transformity indices consumption footprint analytical tools bio-capacity analytical tools and t-statistical tool. The emergy densities for the earth and the country were obtained from the models stated in equations 1 and 2 [28]:

$$\rho_1 = \frac{Total\ emergy\ of\ the\ earth\ in\ one\ year\ (sej)}{Area\ of\ the\ earth\ (M^2)} \quad (1)$$

and

$$\rho_2 = \frac{Total\ emergy\ of\ the\ country\ in\ one\ year\ (sej)}{Land\ Area\ of\ the\ country\ (M^2)} \quad (2)$$

Where

ρ_1 = emergy density of the earth (Sej/M^2)

ρ_2 = emergy density of the country (Sej/M^2)

The ecological footprint for agricultural resources was achieved using the models stated explicitly in the equations 3 and 4 [28]:

$$ef = \sum_{i=1}^{m} \frac{c_i}{\rho_2} \quad (3)$$

This can be rewritten as:

$$ef = \sum_{i=1}^{m} \frac{\left[consumption_i(J) \times Transformity_i\left(\frac{sej}{J}\right)\right]/N}{\rho_2\left(\frac{sej}{m^2}\right)} \quad (4)$$

Where

ef = ecological Footprint per capita (ha/cap)
c_i = emergy amount of the i[th] resource per capita (sej)
ρ_2 = emergy density of the country (sej/m^2)
N = Population size (number)
m = Number of agricultural resource

In this case the annual per capita ecological footprint of each consumption item was analysed using the model stated explicitly in equation 5 [28]:

$$\pi_i = \mu_i + \gamma_i - \tau_i \quad (5)$$

While per capita consumption was obtained from the model stated as:

$$\omega = \frac{\sum_{i=1}^{k} \pi_i}{N} \quad (6)$$

Where

π_i = Annual consumption of i[th] item (Joules)
μ_i = Production of the i[th] item (Joules)
γ_i = Imports of the i[th] item (Joules)
τ_i = Exports of the i[th] item (Joules)
k = number of consumption items (number)
ω = per capita consumption (Joules)
i = level of consumption item (numbers)

The bio-capacity was realized using the emergy evaluation technique and Bio-capacity tool. This is explicitly stated in the equation 7 [28]:

$$cc = \frac{e}{\rho_1} \quad (7)$$

Where

cc = Carrying capacity per Capita (ha)
e = Renewable resource emegy amount per capita (sej)
ρ_1 = Earth emergy density (sej/m^2)

The resource use and sustainability status were determined using the model stated as:

$$Sustainability\ gap = \left[\frac{e}{\rho_1}\ \right]^* - \sum_{i=1}^{m} \frac{c_i}{\rho_2} \quad (8)$$

The hypothesis was realized using the t-statistical tool. The model is stated as:

$$t = \frac{\bar{x} - \bar{\varphi}}{\sqrt{\frac{S_1^2}{q_1} + \frac{S_2^2}{q_2}}} \qquad \sim t(q_1 + q_2 - 2) \quad (9)$$

Where

$$S^2 = \sqrt{\frac{\sum(x-\bar{x})^2 + \sum(\varphi-\bar{\varphi})^2}{q_1+q_2-2}} \quad (10)$$

The null hypothesis is stated as:

$$H_{o:}\ \bar{x} = 5.2\ ha/cap$$

Where

$\bar{x}$ = mean of ecological footprint for agricultural resources (ha/cap)
$\bar{\varphi}$ = Composite index (mean of carrying capacity ha/cap)
$S_1^2\ S_2^2$ = variances
$q_1\ q_2$ = Number of observations of ecological footprint for agricultural resources and carrying capacity respectively.

2.3 Decision Rule

The following decision rule was taken for this study:

1. The reference point for the sustainability of agricultural resource use was based on the value of the bio-capacity or carrying capacity of the country for the year. The decision was based on the following:

   a. $\left[\frac{e}{\rho_1}\right]^* \geq \sum_{i=1}^{m}\frac{c_i}{\rho_2} = Sustainable\ use\ (Strong\ Sustainability)$ or

   b. $\left[\frac{e}{\rho_1}\right]^* < \sum_{i=1}^{m}\frac{c_i}{\rho_2} = Unsustainable\ use\ (Weak\ Sustainability)$

3. RESULTS AND DISCUSSION

3.1 Global Emergy and Emergy Density in the Area

Table 1 shows the emergy amount of the earth. This is the sum of the emergy of solar insolation, deep earth heat and tidal energy.

From Table 1 the total emergy amount of the earth was 1.58E+25 Sej/a. Using the emergy density index, it was found that the emergy density of the earth was 3.10E+10 sej/m^2/year. This is an indication that a total energy of 1.58E+25 sej was used up either directly or indirectly to provide for the available renewable resources or the ecosystem services of the earth in one year. However, the emergy density index indicates that a total energy of 3.10E+10 sej was dissipated per meter square of productive land and sea areas of the earth in one year. It implies that a total energy of 3.10E+10 sej was used up per meter squared of the total global hectares, to provide for the ecosystem services or life support services of the earth in one year.

3.2 Emergy and Density of the Study Area

Table 2 shows the emergy amount of the study area. This was derived from the energies from the sun, rain, wind and earth cycle. In this case, the maximum emergy from these renewable resources was captured as the total emergy of the country. This is to avoid double counting or duplication in the analyses.

From Table 2, rain chemical potential had the highest emergy. This implies that the total emergy of the country was 1.23E+23 Sej/a. However, using the emergy density index, it was found that the emergy density of Nigeria was 1.33E+11sej/m^2/year. This is an indication that with the interaction of renewable resource flows, a total energy of 1.23E+23 sej was expended in the transformation of agricultural resources in one year. Moreover, the emergy density index indicates that a total energy of 1.33E+11 sej was dissipated per meter square of the land area of the country in one year, to provide for the needs and wants of her citizens. This implies that a total energy of 1.33E+11 sej was used up per meter square of the land area of the country per year. It means that with the interaction of renewable resource flows, a total energy of 1.33E+11 sej was expended in the transformation of agricultural resources per meter square of the country's land area.

3.3 Ecological Footprint of Nigeria

Table 3 shows the Ecological Footprint of the country, involving the population and consumption statistics, and emergy density of the country. This shows the level of agricultural resource use and the available resources appropriated for each person in the country, and expressed in arable land, pasture, water, fossil and built-up area. Resources were converted to joules per year, in order to determine their consumption energies and emergy. Table 3 showed the consumption on food crops, livestock, fisheries, forestry, natural gas, oil, coal, other solid minerals and electricity, with per capita of 5.25 ha arable land, 2.54 ha pasture land, 0.816 ha water area, 0.131 ha forest land, 0.000545 ha fossil land, 2.33 ha fossil land, 0.000327 ha fossil land, 0.266 ha fossil land and 0.0000481ha built-up area, respectively. This implies that each person in the country consumed 5.25 ha arable land, 2.54 ha pasture land, 0.816 ha water body, 0.131 ha forest land, 2.6 ha fossil land and 0.0000481 ha built-up land per year. It was then found that the ecological footprint for Nigeria was 11.3 hectares per capita. This is an indication that an average Nigerian consumes 11.3 hectares of land and sea to sustain their current life needs and wants per year. This ecological footprint came close to Qatar's per capita consumption (11.68 gha/cap) in 2008 as reported by Borucke et al. [16], and is quite higher than the consumption of an average Malaysian (3.0 hectares of land and sea) reported by Begum and Pereira [41]. This is also an indication that an average Nigerian mounts excessive pressure on the agricultural resources of the country in order to meet current needs and wants.

In addition, the results showed that arable land consumption (5.25 ha/cap) is the largest contributor to the ecological footprint in the country. This is an indication that food crop production in the country is the driving force triggering land degradation and erosion processes, as reported by Lal [42] that farming/cropping systems (rotations, soil fertility management, erosion control, grazing/stocking rate, water management) affect the type, rate and severity of soil degradation. Cerda` et al. [43] asserted that ploughing, burning and grazing result in soil erosion, compaction and organic matter depletion owing to unsuitable agricultural practices. This is also an indication of unsustainable intensification of agricultural lands.

3.4 Bio-capacity Per Capita

Table 4 shows the carrying capacity per capita given the available renewable resources and the ecosystem life support services in the Nigeria.

From Table 4, the renewable resources were found to be available per capita for the year at 0.0104 ha, 2.36 ha, 1.79 ha, 0.0185 ha and 1.03 ha of the sun, rain/chemical potential, rain/geo-potential, wind and earth cycle, respectively. It was then found that the total bio-capacity was 5.2 hectares per capita. This implies that the available resources that can support life were 5.2 hectares per person. This is an indication that the available resource flows that can support the needs and wants of each citizen for the year were 5.2 hectares of land and sea. Moreover, it also indicates that for the use of agricultural resources to be sustainable, each person's lifestyle and consumption should not exceed 5.2 hectares for the year.

3.5 Agricultural Resource Use Level and Sustainability Status

Table 5 shows the summary of the agricultural resource use and the sustainability status. The ecological footprint per capita shown in the Table 3 was subtracted from the Carrying capacity per capita shown in Table 4 to derive the sustainability status and level of agricultural resource use in Nigeria as reported in Table 5.

Table 1. Emergy amount of the earth

Energy items		Energy (J/a)	Solar transformity (Sej/J)	Solar emergy (Sej/a)
i.	Solar insolation	3.93E+24	1	3.93E+24
ii.	Deep earth heat	6.72E+20	1.20E+04	8.06E+24
iii.	Tidal energy	5.20E+19	7.39E+04	3.84E+24
Total				**1.58E+25**

Source: Adapted from Odum et al. [44]

Table 2. Emergy amount of the study area

Renewable resources		Raw data (Joules/Yr)	Transformity (Sej/J)*	Total emergy (Sej)
i.	Sun	5.42E+20	1	5.42E+20
ii.	Rain, chemical potential	4.03E+18	3.05E+04	1.23E+23***
iii.	Rain, geopotential	1.98E+18	4.70E+04	9.31E+22
iv.	Wind	3.94E+17	2.45E+03	9.65E+20
v.	Earth cycle	9.24E+17	5.80E+04	5.36E+22
Maximum emergy				**1.23E+23**

**Transformities were taken and modified from Odum et al. [44]; ***Maximum emergy; Source: Computed Results, 2015*

Table 3. Ecological footprint per capita

Agricultural resources	Raw data (Joules/Yr)	Transformity (Sej/J)*	Total emergy (Sej)	Emergy per capita (Sej)	Emergy per capita per emergy density of the country (P_2)	Ecological footprint per capita (Ha/Cap)[1]
1. Food crops	3.64E+18	3.22E+05	1.17E+24	6.98E+15	5.25E+04	5.25E+00 Arable land
2. Livestock	1.76E+17	3.22E+06	5.67E+23	3.37E+15	2.54E+04	2.54E+00 Pasture land
3. Fisheries	5.66E+16	3.22E+06	1.82E+23	1.08E+15	8.16E+03	8.16E-01 Water Area
4. Forestry	1.32E+18	2.21E+04	2.92E+22	1.74E+14	1.31E+03	1.31E-01 Forest land
5. Natural gas	2.07E+15	5.88E+04	1.22E+20	7.25E+11	5.45E+00	5.45E-04 Fossil land
6. Oil	6.11E+18	8.53E+04	5.21E+23	3.10E+15	2.33E+04	2.33E+00 Fossil land
7. Coal	1.14E+15	6.40E+04	7.30E+19	4.34E+11	3.27E+00	3.27E-04 Fossil land
8. other minerals**	5.36E+13	1.11E+09	5.95E+22	3.54E+14	2.66E+03	2.66E-01 Fossil Land
9. Electricity	3.34E+13	3.22E+05	1.08E+19	6.40E+10	4.81E-01	4.81E-05 Built-up land
Total ecological footprint						**11.3**

*** measured in grams/year; *Transformities were taken and modified from Odum [45]; Odum et al. [44]*

[1]Note:

Population	*1.68E+08 persons*	
Land area	*923768 sq. km*	*or 9.23768E+11 sq. m*
Total emergy of Nigeria	*1.23E+23*	*sej/a*
P_2	*1.33E+11*	*sej/sq.m/a*

Source: Computed Results, 2015

Table 4. Carrying capacity and ecosystem life support services per capita

Renewable resources	Raw data (Joules/Yr)	Transformity (Sej/J)*	Total emergy (Sej)	Emergy per capita (Sej)	Emergy per capita per P_1	Carrying capacity per capita (Ha/Cap)
1. Sun	5.42E+20	1	5.42E+20	3.23E+12	1.04E+02	1.04E-02
2. Rain, chemical potential	4.03E+18	3.05E+04	1.23E+23***	7.32E+14	2.36E+04	2.36E+00
3. Rain, geo-potential	1.98E+18	4.70E+04	9.31E+22	5.54E+14	1.79E+04	1.79E+00
4. Wind	3.94E+17	2.45E+03	9.65E+20	5.75E+12	1.85E+02	1.85E-02
5. Earth cycle	9.24E+17	5.80E+04	5.36E+22	3.19E+14	1.03E+04	1.03E+00
Total carrying capacity						**5.2**

**Transformities are taken and modified from Odum [45]; Odum et al. [44]; ***Maximum emergy*

Area of the Earth	*5.10E+14 sq. m*
Total Emergy of the Earth	*1.58E+25 sej/a*
P_1	*3.10E+10 sej/sq.m/a*

Source: Computed Results, 2015.

Table 5 showed that the sustainability gap was -6.1 hectares of land and sea per capita. It indicates that the level of agricultural resource use in the country is not sustainable, since the then population of 167.9 million persons [34] consumed more (-6.1 ha/cap) than was available to support their current needs and wants.

This is also an indication that the level of resource use in today's agriculture is resulting in high erosion rate, pollution and soil degradation as reported by Tesfaye et al. [46] that Sub-Saharan Africa, Nigeria inclusive is significantly affected by land degradation because of deforestation, poor land management and conversion of fragile natural habitats into fields for crops. As pointed out by Ellis and Pontious [47] that overgrazing and intensive agriculture on marginal lands are a major driver of land loss through degradation which are triggered by some processes as irrigation reported by Fallahzade and Hajabbasi [48], changes in vegetation recovery asserted by Busso et al. [49], and wind erosion reported by Houyou et al. [50]. Amosu et al. [13] added that these anthropogenic impacts associated with agricultural activities have led to heat stress, sea level rise and erosion, salinization of the soil, evapo- transpiration and desertification. The sustainability gap also indicate that the current agricultural practices are declining soil productivity due to soil compaction or loss of soil organic matter as asserted by Barua and Haque [51] and Rinivasarao et al. [52] that Soil Organic Carbon (SOC) can be depleted easily through the use of inappropriate management practices. According to Musinguzi et al. [53] proper management of SOC is the key for sustainable crop production since it can be used as a soil quality indicator for farmers, and good soil structure is important for the sustainable production of agricultural lands and for the preservation of environmental quality as reported by van Leeuwen et al. [54].

In addition the results showed that each person's lifestyle and consumption exceeded the available resources by 6.1 hectares in the country. This is an indication that the current generation has consumed additional 6.1 hectares of land and sea, part of what should have been left for the future generation. As a result sustainable development cannot be achieved with this level of agricultural resource use since sustainable development is one that does not compromise how the future generation gets satisfied with their needs as reported by World Commission on Environment and Development [55] and living well within the means of nature [56].

Table 5 also showed that there is 'weak' resource sustainability and ecological deficit. This is an indication that there is a high degree of renewable resource substitution. This means that reproducible agricultural resources are now substituting for the natural capital and that the environmental services and its functions can no longer assimilate the accumulated waste from present production and consumption. This in other words means that the rate of agricultural resource use (or withdrawal) exceeded its regenerative rate. This stems from the fact that as agricultural resources in the area become scare the benefits of its further use become greater to justify the use as opined by Mensah and Castro [57] and by that wastes accumulate more than can be assimilated by the environmental services.

3.6 Test of Hypothesis

Tables 6 and 7 show the means and the t-test for ecological footprint for agricultural resources, and carrying capacity.

From Table 7 the statistics associated with "equal variance not assumed" was considered for the t-test for equality of means. The p-value (0.780) for 2-tailed test of significance showed that the ecological footprint for agricultural resources is not significantly different from the carrying capacity. Therefore the null hypothesis was accepted and the study concluded that the ecological footprint for agricultural resources is not significantly different from the carrying capacity in Nigeria.

Table 5. Summary of the agricultural resource use and sustainability status

Item	Resources (Ha/Cap)	Sustainability gap	Sustainability status
Ecological footprint	11.3	- 6.1	Unsustainable
Bio-capacity	5.2(reference point)		(Weak Sustainability)

Source: Computed Results, 2015

Table 6. Means of ecological footprint for agricultural resources and carrying capacity

Items	N	Mean	Standard deviation
EF for agricultural resources	9	1.25932446	1.800128143
Carrying capacity	5	1.041780000	1.0498241005

Source: SPSS Computed Results 2015

Table 7. t-test results of the ecological footprint for agricultural resources and carrying capacity

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig	t	df	Sig (2-tailed)	Mean difference	Std error difference	95% confidence interval of the difference	
									Lower	Upper
Output:	Equal variances assumed	1.449	0.252	-0.245	12	0.810	-0.2175444444	0.8867867385	-2.1496867674	1.7145978
	Equal variances not assumed			-0.286	11.885	0.780	-0.2175444444	0.7618906686	-1.8793470277	1.4442581

Source: SPSS Computed Results 2015

4. CONCLUSION AND RECOMMENDATIONS

This study concluded that agricultural resource use in Nigeria is not sustainable, as the level of resource use and practices in today's agriculture are declining soil productivity due to soil compaction or loss of soil organic matter and resulting in high erosion rate, pollution and degradation. Each person's lifestyle and consumption in the country exceeded the available resources. This could be linked to agricultural intensification and high level exploitation of resources in the country resulting from population increase and pressure which increased the demand on and/or for resources as they became scarce. As a result ripping off part of what should have been left for the future generation. Sustainable development cannot be achieved with this level of agricultural resource use since sustainable development is one that does not compromise how the future generation gets satisfied with their needs. It was also concluded that there is weak sustainability in resource use and high level of resource substitution in the country and running an ecological deficit - as the reproducible resources are now substituting for the renewable or non-renewable resources in the country. In view of the fact that arable land consumption (5.25 hectares/cap) is the largest contributor to the ecological footprint for each Nigerian (46.64% of total footprint), ecological farming organic farming and other sustainable agricultural systems that reduce the footprint for arable land should be adopted in the country. In addition the government through her agencies should strategize ways of reducing the consumption of foreign (imported) food crops - for any effort to reduce this will reduce the ecological footprint of the country and promote the integration of the three components of sustainable development – economic development social development and environmental protection-as interdependent and mutually reinforcing pillars.

Considering the ecological deficit of 6.1 hectares per capita, to ensure ecological remainder or strong sustainability of agricultural resources every citizen of the country should adjust his/her lifestyle so as to reduce overall consumption by 6.1 hectares per capita. This will go a long way to preserving and conserving agricultural resources for the current use and the future generation and hence pave the way to achieving sustainable development in the country. Based on the high level of resource substitution (Weak sustainability) which can be linked to excessive importation (International trade) of food crops there is need to reduce the importation of food crops or other resources that depend heavily on the available resources in the country and encourage local food crop farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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