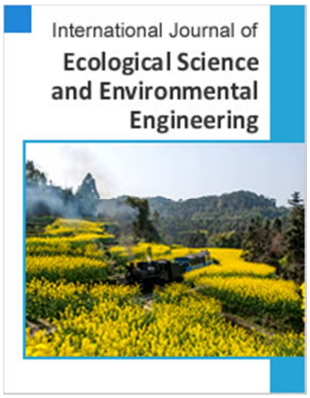
International Journal of Ecological Science and Environmental Engineering
2018; 5(1): 1-7
http://www.aascit.org/journal/ijesee
ISSN: 2375-3854

American Association for Science and Technology



Keywords
Geoponics,
Hydroponics,
Aeroponics,
Aquaponics,
Food Security,
Food Production,
SDGs

Received: October 29, 2017
Accepted: November 27, 2017
Published: January 4, 2018

Soilless Farming – A Key Player in the Realisation of "Zero Hunger" of the Sustainable Development Goals in Nigeria

Ajibade Lanre Tajudeen*, Oyeniyi Solomon Taiwo

Department of Geography and Environment Management, Faculty of Social Sciences, University of Ilorin, Ilorin, Nigeria

Email address

solomonoyeniyi1@gmail.com (O. S. Taiwo)

*Corresponding author

Citation

Ajibade Lanre Tajudeen, Oyeniyi Solomon Taiwo. Soilless Farming – A Key Player in the Realisation of "Zero Hunger" of the Sustainable Development Goals in Nigeria. *International Journal of Ecological Science and Environmental Engineering*. Vol. 5, No. 1, 2018, pp. 1-7.

Abstract

For many millennia, farming has been dependent on soil because it seen as the most available growing medium for plants. It harbour nutrients, air, and water among others for plant growth. However, soil degradation has been identified as a major global challenge facing land use for food production which has been further worsened by the effect of climate change. In addition to this, the use of soil for crop production in Nigeria is been stiffly competed with by the need for shelter, transport, urbanization and industrialization and other socio-economic needs. All these and many more challenges possess a great deal of opposition to the actualization of "zero hunger" of the SDGs and raises a questions of whether or not soil farming can be relied upon solely for food production and food security in the country. Soilless farming is a sustainable agricultural practice because the system is not in need of soil to grow crops, therefore it is free from all challenges facing soil today and subsequently, this makes it a viable alternative to soil farming in order to achieve a world free of hunger by year 2030.

1. Introduction

Over the years, due to continuous increase in human population among other reasons, there has been a drastic rise in the demand for food production which has depended almost entirely on soil as a growing medium for crops. Soils as mentioned by [18] is a complex mixture of minerals obtained from the breakdown of underlying rocks or sub-soils, organic matter obtained from the decay of plant and animal material, water, air and other gases, plus biological life in the form of worms, insects and microbes. It provides a basic medium for plant growth, supporting the production of crops and fodder and assisting a range of ecosystem activities [22]. [24], estimated that by 2050 the world population is expected to rise from its present 7 billion to 9 billion. This will require another production of about 1 billion tonnes of cereals per year [3].

However, soil degradation has been identified as a major global challenge facing land use for food production which has been further worsened by the effect of climate change. In addition to this, the use of soil for crop production in order to feed this ever growing population is been stiffly competed with by the need for shelter, transport, urbanisation and industrialization and other socio-economic needs. According to [6], land and water resources and the way they are used plays a principal role in food security and these

resources are at risk due to demographic pressure, climate change and increased competition and so to ensure food security and nutrition improvement, agricultural production will have to rise faster than population growth to about 70% globally which will depend majorly on existing Agricultural land.

The problem of soil degradation is a global challenge with Nigeria having her fair share while her population and consequently the need for food production increases. All these and many more challenges possess a great deal of opposition to the actualization of the "zero hunger" SDG and raises a questions of whether or not soil farming can be relied upon solely for food production and food security in order to consistently feed her estimated population.

2. Food Security and Food Production

Crop production plays a major role in food production and food security in the development of any nation. Nigeria has about 79 million hectares of arable land, of which 32 million hectares are cultivated [7]. Despite this, both crop and livestock production remains below potentials. Also, despite a 7% growth rate in agricultural production (2000 to 2008), the growing population is still dependent on imported staple food as indicated by increase in food import bill (Challenges of food security in Nigeria: options before Government [5].

[5] mentioned that Agriculture has remained an important aspect of any economy. Viable agricultural programmes and activities in any nation are capable of sustaining the food supply and reserves needed for the welfare of the citizens but changes of climate over a period of time affect food security significantly. Changing climatic conditions affect both the physical and the economic availability of certain preferred food items. Their impacts on income-earning opportunities can affect: the ability to buy food, the availability of certain food products, and price. Changes in the demand for seasonal agricultural labour, consequent upon changes in production practices, will in turn affect income-generating capacity. [16] highlighted further that low level of technology, policy inconsistency and corruption, poverty and hunger, conflicts, natural disaster, low agricultural financing and rural-urban migration as posing serious threat to food production in Nigeria.

3. SDGs in Brief

In the third quarter of 2015, 193 countries came together to set new goals for global development and tackle challenges facing the world today for the next 15 years and design necessary framework for its success. This is as a follow up of the achievements of the previous 15 years Millennium Development Goals (MDGs) which ended same year. The new set of goals, the Sustainable Development Goals (SDGs), aims to end poverty and hunger by 2030 with goals set for the land, the oceans and the waterways [23].

These set of 17 goals include: #1 – No poverty, #2 – Zero hunger, #3 – Good health and wellbeing, #4 – Quality education, #5 – Gender equality, #6 – Clean water sanitation, #7 – Affordable and clean energy, #8 – Decent work and economic growth, #9 – Industry, innovation and infrastructure, #10 – Reduced inequality, #11 – Sustainable cities and communities, #12 – Responsible consumption and production, #13 – Climate action, #14 – Life below water, #15 – Life on land #16 – Peace, justice and strong institutions, #17 – partnership for the goals.

Every member nation is expected to key into these goals, put in place necessary policies, initiate and fund projects and others possible means to aid its achievement within the stipulated time. Nations are thereby needed to work together and with the support of several other local and international organisations in order to achieve this desired future.

Nigeria as a country played a strategic role as far as MDGs is concerned and was able to recorded substantial achievements particularly in the area of universal primary enrolment, gender parity in education, reduction of hunger, spread of HIV/AIDs, maternal and child mortality and eradication of polio [12]. In order to ensure successful achievement of SDGs the government decided to map her priorities for implementation placing eradication of extreme poverty and hunger as her first while setting Agriculture at the forefront with the aim to double the agricultural productivity and the incomes of small-scale food producers, particularly women, indigenous peoples, family farmers, pastoralists and fishers [11].

4. Traditional Farming and the "Zero Hunger" SDG

Although agriculture can directly or indirectly contribute to the achievement of every goal on the list of SDGs, it seems to be most relevant in the achievement of goal 2 – "zero hunger" since there is no other way to solve the problem of hunger than to eat food. Farming is an indispensable sector if "zero hunger must truly be achieved. It calls for us to make our agriculture and food systems more efficient and sustainable [9].

A dedicated global goal, SDG2, based on a comprehensive approach to tackling food insecurity and malnutrition while promoting sustainable agriculture is an important step to achieving zero hunger and ushering in a new era of sustainable development [8].

"From ending poverty and hunger to responding to climate change and sustaining our natural resources, food and agriculture lies at the very heart of the 2030 Agenda for Sustainable Development" [9].

For many millennia, farming has been dependent on soil because it seen as the most available growing medium for plants. It harbour nutrients, air, water among others for plant growth. [2] and [26] asserted that the choice of what to produce and how to produce it is largely determined by the soil condition. The soil on which the crop is grown play a

major role in securing the right quality and safety of crops and their derived products [15].

This traditional method of farming using soil is referred to as geoponics. Geoponic technology has many weaknesses and flaws, most arising due to the presence of a vulnerable medium in which plants grow: soil. Soil is so vulnerable because of its non-consistency in density, nutrient concentration, and moisture level. Differences in these factors make it very difficult for one type of fertilizer to accurately and effectively increase crop yields and improve the quality of production for all of one type of crop. Fertilizer in itself is imperfect due to the effect of runoff pollution from farms into large bodies of water [28]. In addition [1], also mentioned that geoponic is faced with problems such as; the land tenure system, decreasing soil fertility, climate change, presence of disease causing organisms and nematodes, unsuitable soil reaction, unfavourable soil compaction, poor drainage, degradation due to erosion among others.

In West Africa, 48% of soils have been discovered to have low productivity and soil management issues including: soil erosion; salinization; flooding; organic matter decline; degradation of soil structure; loss of soil chemical quality; acidification; deforestation/overgrazing and poor management with nutrient loss rates shown to be highest in Ghana, Nigeria and Ivory Coast [25]. Although some level of improvement was noted but much still need to be done in order to ensure increased food production and food security as it relates to the SDG.

Land degradation has been identified as a major crisis facing geoponics today. It has been defined as the decline in any or all of the characteristics which make soil suitable for food production through the deterioration of the physical, chemical and biological properties that results in soil compaction, soil loss from wind and water erosion, acidification and salinization. An estimated amount of between $6.3 and 10.6 trillion dollars is said to be lost per year globally to soil degradation, affecting 1.9 billion hectares, 12 million hectares of land lost to food production and 24 billion tonnes of fertile soil irretrievably washed or blown away [18].

As mentioned by [14], the challenges facing the Nigerian soil include:

i. Soil Erosion: Siting Nigeria Country Profile, (1997), gully erosion has been observed to be particularly severe in Abia, Imo, Anambra, Enugu, Ondo, Edo, Ebonyi, Kogi, Adamawa, Delta, Jigawa and Gombe States. Anambra with Enugu States alone having over 50 active gully complexes, with some extending over 100 metres long, 20 meters wide and 15 meters deep.
ii. Soil Salinity: factors that contribute majorly to salinity are soil salinity, wet breeze from high tide especially around peak of rainy season and irrigation of crop with saline water. This is experienced majorly in the coastal areas of Nigeria with small patches in the semi-arid belt of northern Nigeria.
iii. Flooding: He noted that in Nigeria there are three main forms of flooding: coastal flooding, river flooding, and urban flooding. Coastal flooding occurs in the low-lying belt of mangrove and fresh water swamps along the coast. River flooding occurs in the flood plains of the larger rivers, while sudden, short-lived flash floods are associated with rivers in the inland areas where sudden heavy rains can change them into destructive torrents within a short period. Urban flooding occur in towns located on flat or low lying terrain especially where little or no provision has been made for surface drainage, or where existing drainage has been blocked with municipal waste, refuse and eroded soil sediments. According to Punch Editorial Board (2012), in 2012, flood was recorded to wash away farmlands in 20 states and Nasarawa lost over 2,000 hectares of farmland to the flood.
iv. Declining Soil Fertility: this is a decline of chemical, physical and biological soil properties which are required for good plant growth. Citing Agboola (1989) only 5.52% of the Nigerian soil is said to fall under the category of high productivity, 31.75% falls under medium productivity, 46.45% under low productivity and 16.31% under very low productivity with 0.00% under very high productivity.
v. Desert Encroachment and Drought: 11 states across the north-west and north-eastern zones of the country are being threatened by adverse desert encroachment which poses great danger to agriculture, food security, and water resources. In katsina, out of the state's 34 local governments councils, eight — Daura, Maiadua, Zango, Sandamu, Baure, Jibia, Kaita, Mashi, Katsina — mostly the bordering Niger Republic are most affected. These areas have been grappling with the challenge of desertification which travels at 0.6 kilometres every year, leading to soil erosion and disruption of the ecosystem (Daily trust, 2016). Currently, Nigeria is losing about 351,000 square kilometres of her land mass to the desert yearly, this been a pointer to the fact that land might not be available for farming soon if no drastic steps are taken or productive and sustainable alternatives provided in order to meet up with the need for food production.
vi. Another major issue is Land availability which continues to reduce as a result of increasing population, economic use of land for other purposes and the likes. Under strong demographic pressure in the coming decades, the per capita availability of land in developing countries is expected to halve (to 0.12 ha) by 2050, resulting in increasing pressures for expanding the cultivated area (Fischer et al., 2010). "Agricultural land- use category occupy the largest area of land-use class but keeps on decreasing in Kaduna from 1980 to 2005 and with the greatest agricultural loss experience between 2005 and 2012. This trend may continue if not controlled and it will drastically leads to loss of productive agricultural areas" [27].
vii. Among other challenges include: Land tenure, Soil-

borne diseases and Pest, Land and water pollution due to chemical usage and Labour requirement.

As a result of these challenges and limitations facing soil and soil farming, there is need to opt for better, safer and a more productive way of farming so as to boast food production and ensure food security in order to achieve the "zero hunger" SDG. Hence the need for soilless farming.

5. Soilless Farming – A Key Player in the Realisation of "Zero Hunger" of the SDGs

Soilless culture can be defined as "any method of growing plants without the use of soil as a rooting medium, in which the nutrients absorbed by the roots are supplied via the irrigation water". The nutrients to be supplied to the crop are dissolved in appropriate concentration in the irrigation water and such solution is referred to as "nutrient solution" (Gianquinto G. and Berlin H., 2013)

"The 2030 Agenda recognizes that we can no longer look at food, livelihoods and the management of natural resources separately. A focus on rural development and investment in agriculture - crops, livestock, forestry, fisheries and aquaculture – are powerful tools to end poverty and hunger, and bring about sustainable development. Agriculture has a major role to play in combating climate change. Soilless farming is a sustainable agricultural practice that possess a more sustainable solution to the challenges of soil faming today" (Food and Agriculture - Key to achieving the 2030 Agenda for Sustainable Development, 2015)

[19] states that as nutritious soil is fast disappearing because of climate change and intensive farming activities and there is need increased to feed more people, soilless farming may provide a more productive and sustainable alternative to soil-based farming.

Soilless farming is not in need of soil to grow crops in order to feed the constantly growing population, therefore it is free from all challenges facing soil today and subsequently, this makes it a viable alternative to soil farming in order to achieve a world free of hunger by year 2030.

5.1. Hydroponics

Hydroponics according to [20] can simply be defined, as the growing of plants in a soilless medium and fertilizer solution containing necessary nutrients for the plant growth.

[4], classified hydroponics into five namely:

1. Deep Water Culture (DWC): this technique allows plant to be grown in bucket containing nutrient solution covered with a lid and the plants, contained in net pots, suspended from the centre of the cover. This system is aerated using an air pump as the covering of the bucket limits air-water exchange.
2. Float Hydroponics (FH): in this technique, floating materials such as polystyrene or Styrofoam are placed on a trough containing nutrient solution. These floating materials are used to support each plant in net pot which are placed in holes made on the material. Most float systems are long, rectangular reservoirs built out of cement or wood and lined with a durable polyliner.
3. Nutrient Film Technique (NFT): in this technique, thin layer of nutrient solution is made to flow through an elevated channel (trough) within which the root of the plant lie. Thin layer of the nutrient solution allows the upper part of the plant root to be adequately oxygenated while the elevation of the channel is to allow nutrient solution to reach plants at the lower end. The nutrient solution may be delivered continuously in a 24-hour cycle, or intermittent (alternating watering and dry periods to increase root system oxygenation) or continuous recirculation during daylight hours and automated switching off at night.
4. Deep Flow Technique (DFT): similar to some other aforementioned techniques, the root of plants are continuously exposed to moving nutrient solution by supporting them with floating materials but the channel here usually contains solution of a depth of 50–150 mm and width of about 1m. Control of the nutrient solution is simplified by the large water volume and this buffers the temperature, making it suitable for regions where fluctuation in temperature of nutrient solution can be an issue.
5. Aeroponics: this has to do with growing plants with their roots suspended while fine mist of nutrient solution are continuously or intermittently applied.

In some parts of Bangladesh most affected by flood and waterlogging, farmers are using methods similar to hydroponic know as floating agriculture. In this method, plants are grown on the water in a bio-land or floating bed made of water hyacinth, or other plant residues [19]. This method of farming is not only practised in Bangladesh but in some other part of the world faced with similar challenge and this makes it recommendable for regions in Nigeria having such issue of flooding or waterlogging or little land but much water resources.

5.2. Aeroponics

According to [13], soil-less farming (aeroponics) is an optimized process developed for growing crops and plants in an air medium without the use of soil. Here, plants are suspended in a closed or semi-closed environment and the plant's dangling roots are sprayed with nutrient-rich water solution. Basically, plants require 17 essential nutrients for growth and development: carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), magnesium (Mg), boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), and zinc (Zn) [17]. All these nutrients are made available in aeroponics farming, because without these nutrients plants cannot complete their life cycles and their roles in plant growth cannot be replaced by any other elements.

The soilless culture grower must have a good knowledge of the plant nutrients, because the supplied nutrient solution

is important in achieving soilless farming. The soilless culture methods enable growers to control the availability of essential nutrients by adjusting or changing the nutrient solution to suit the plant growth stage and to provide them in balanced amounts [1]. These conditions allow for better plant nutrition assimilation in a more balanced way, with consequential faster development of the cultivated plants because plants do not need to search or compete for available nutrients as they do in soil.

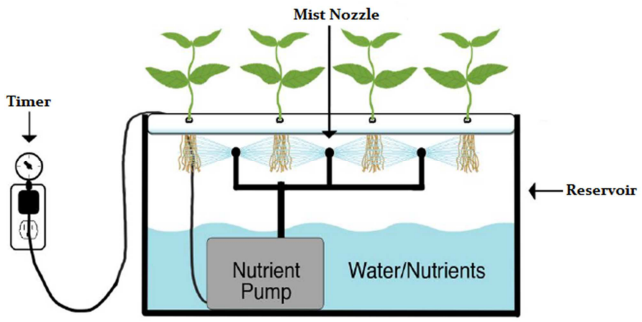


Figure 1. *Aeroponics System.*

i. A seedling is transplanted to an Aeroponic System
ii. Plant is suspended, foliage and roots free of obstructions
iii. Nutrient mix is sprayed or misted directly onto the roots through the nozzle
iv. Reservoir holds nutrient mix
v. A pump supplies nutrient mix to the roots
vi. The timer controls the nutrient pump.

5.3. Aquaponics

Basically, Aquaponics is a symbiotic combination of aquaculture and hydroponics. It essentially fills the existing gap between both and develop on their limitations to provide a more efficient use of both techniques [10] noted that while aquaculture and hydroponics are both efficient methods of producing fish and vegetables, combining the two turns their negatives into positives.

In aquaculture, nutrient rich water is regularly flushed out due to its potential harm to the aquatic life and so also is excessive nutrient which is harmful to plant life regularly flushed out in hydroponics system. In an Aquaponics system however, nutrient filled water from a fish tank is pumped into a grow bed as required to serve as a source of nutrient for the plants and the plants in turn purify the water as it is channelled back into the fish tank. The nitrogen cycle is a simple process that explains the purification of the system. *Nitrosomonas sp.* bacteria present in the grow bed converts the ammonia present in fish water being supplied as a result of decomposing fish feed and fish excreta into nitrite. *Nitrobacter sp.* futher turns the nitrite into nitrate which is taken up as food by the plants thereby purifying the water for the fishes. When the system has enough bacteria to completely process the ammonia and nitrites it is said to have "cycled" [21]. In some cases plants are made to grow directly on the fish pond by supporting them with polystyrene with their roots in the fish water and sometimes water from the fish pond is just used to irrigate plants in different media without the water returning back to the pond.

Aquaponics has some specific advantages over other soilless farming techniques which include:

1. Production of both crop and fish simultaneously.
2. Very low water consumption. About 1/10th of water is used in traditional farming.
3. No need for fertilization or nutrient solution.
4. High fish stocking density allowed.
5. No plant spacing require so crowding is allowed.
6. It can be used to grow root crops.

*Vertical farming: Vertical farming is a system of soilless farming whereby plants are grow on shelves or storey buildings stake one above the other and this can be applicable to Aeroponics, hydroponics and Aquaponics. This is most relevant in land scarce regions especially developed cities wanting to grow its own crops.

*Greenhouse farming: this is also called Controlled Environment Agriculture (CEA) whereby plants are grown in an artificial environment where factors influencing the growth of plant can the controlled. This is currently been integrated into soilless farming systems to boost production among other benefits.

6. Need for Soilless Farming

Soilless farming has been discovered to proffer solution to the problems being faced by tradition soil farming. The major advantage with such a system is the absence of weeds and other soil borne pests, no toxic pesticide residue, better use of water, better control over nutrient and oxygen, increased crop quality and yields [9].

i. Higher productivity: in line with the need for food production to rise faster than population growth to ensure food security and nutrition improvement, crops grown under soilless farming techniques have been studied and observed to better and faster as they expend energy in leave and fruit development rather than in the development of roots systems in search for nutrients in the soil as in the case of geoponics.
ii. Reduced labour requirement: the labour requirement in soilless farming is lesser as there are no soil to till, plough or ridge, no weeding to be done, no watering and requires less for pest control especially in greenhouses.
iii. Not season-bound: plants grown in soilless farming are not affected by the season as they are constantly fed with the required nutrient and water to grow.
iv. Low management cost: cost of running the systems is usually low especially for the NFT system because these are kept running almost entirely automatic and each input is expected to last for years.
v. No weed competing: since soil is not used, with all seeds carefully selected, soilless farming has no weed or weeding problem. This saves cost on herbicide and spraying.

vi. No soil-borne pest and disease: plants under soilless planting system can be attacked by pest and diseases too but not usually as much as that of soil farming as most soil and diseases are known to be soil-borne. Soilless farming has be observed to have little pest and disease issue.
vii. No big expensive machinery required: since the system doesn't involve land ploughing, ridging, tilling, clearing, windrowing therefore no big expensive machineries like tractors, bulldozers, combine harvester needed.
viii. Precision in terms of nutrient supply: excessive use of fertilizer know with geoponics is not the case in soilless farming as nutrients are either released based on plant requirement or are recycled or reused in most cases.
ix. Pollution: pollution of the surrounding air and water body close to farmlands has been discovered to be as a result of indiscriminate use of fertilisers and other chemicals which are sent to the environment by the wind or runoff.
x. Water and land conservation: less water and land is used up in soilless farming due to reduced evapotranspiration, no indiscriminate use of water for irrigation, no need for the traditional spacing standards and more is produced with lesser space.
xi. Support life in space: research shows that soilless farming has been tested and adopted for use in space jets and other planets since there are no soil for planting.
xii. Better for research purpose: this system is specifically good for research purpose since precision is usually high and can easily be controlled. With this method one can measure the exact amount of nutrient or water or light required for plant to grow or to develop certain characteristics in them.
xiii. Adaptability to greenhouse and vertical farming: in develop nations soilless farming is usually practiced in greenhouses and are sometimes grown vertically especially in land scarce countries like Singapore and China.

7. Limitation vis-à-vis the Nigerian Economy

i. Power: power been a major challenge in Nigeria for several decades with each successive government promising to provide stable and affordable electricity but without success. Soilless farming though uses far less energy than traditional farming [10], requires stable power to run certain equipment especially air pump and water pump. The epileptic nature of the Nigerian electricity supply without exception of any state and its high cost poses a great limitation to the implementation of a full scale commercial soilless farming.
ii. High initial cost of investment: according to Olympios C. M., the initial stage of introduction of soilless farming system involves high cost of inputs for construction and maintenance and also considering the degree of perfection required in control when compared to the traditional farming system but eventually the annual running cost for NFT is lower.
iii. Technical knowhow: soilless farming can be technical as the knowledge of plant physiology, chemistry, instrumentation and the likes might be require from time to time.
iv. Government policy: government is needed to put in place structures, framework and policies to aid the success and development of soilless farming.
v. Other limitations could include low awareness due to the fact that it is a somewhat young innovation just gradually gaining publicity compared to soil farming and also acceptability due to the sceptical nature of people in accepting new innovations.

8. Way Forward

In line with afore mentioned limitations, for soilless farming to be successful a lot has to be put in place as it is quite a big investment and as such cannot be gambled with. The government will need to see it as a major part of the nation's food production chain so as to include it in policy making. Grants and loans should be provided with private-public partnership to encourage youths and entrepreneurs to invest money and resourcefulness into this emerging agricultural sector. It should be viewed as a means of achieving equality, reducing unemployment and supporting people in waterlogged regions of the country so they too can feed themselves and be a part of the nation's food producer. Power problem should be speedily addressed as it not only affects agriculture but all other sectors of the economy. Also, government, private investors, companies manufacturing equipment for soilless farming and all stakeholders should not only encourage but assist research and training of all interested on the technicalities involved.

References

[1] Aatif, H., Kaiser, I., Showket, A., Prasanto, M., Negi A. K. (2014). A Review On The Science of Growing Crops Without Soil (Soilless Culture) – A Novel Alternative For Growing Crops. *International Journal of Agriculture and Crop Sciences. Vol., 7 (11), 833-842*

[2] AbdulAziz, T. (2002). "Corruption" Sustainable Food Security for All by 2020, IFPRI, pp 172-175

[3] Bruinsma J. 2009. The resource outlook to 2050: by how much do land, water use and crop yields need to increase by 2050? Expert Meeting on How to Feed the World in 2050. Rome, FAO and ESDD.

[4] Dimitrios S., Giorgio G., Yuksel T., and Nazim G. (2013). Good Agricultural Practices for greenhouse vegetable crops. Principles for Mediterranean climate areas. Soilless culture. FAO plant production and protection paper 217.

[5] EME O. I. and ONYISHI T., Uche O. A. & Uche I. B. 2014. Challenges of Food Security in Nigeria: Options before Government. Arabian Journal of Business and Management Review (OMAN Chapter) Vol. 4, No. 1

[6] FAO (2011). The state of the world's land and water resources for food and agriculture (SOLAW) - Managing systems at risk. Food and Agriculture Organization of the United Nations, Rome and Earthscan, London.

[7] Food and Agricultural Organization (2012), Food Security Statistics- Nigeria; FAOSTAT, Rome.

[8] FAO, IFAD and WFP. (2015). The State of Food Insecurity in the World 2015. Meeting the 2015 international hunger targets: taking stock of uneven progress. Rome, FAO.

[9] FAO, (2016). FOOD AND AGRICULTURE: Key to achieving the 2030 Agenda for Sustainable Development.

[10] Joel M., (2007). Backyard Aquaponics magazine - Issue 1a

[11] Jubril S. (2015). CPPA Brief on SDGs: Prioritizing Targets for Implementation: Which Way Forward For Nigeria? Towards achieving sustainable development for all.

[12] Millennium Development Goals End-point Report 2015, Nigeria.

[13] Mithunesh, P., Kiran, G., Sujata, G., Shailesh, H. (2015). Aeroponic Based Controlled Environment Based Farming System. *IOSR Journal of Computer Engineering Volume 17, Issue 6, Ver. II (Nov – Dec. 2015), PP 55-58.*

[14] Ojuola O. (2012), status and challenges of soil management in Nigeria.

[15] Oliver M. A. (1997) Soil and human health: a review. European Journal of Soil Science, 48, 573–592.

[16] Otaha, I. J, 2013. Food Insecurity in Nigeria: Way Forward. An International Multidisciplinary Journal, Ethiopia Vol. 7 (4), Serial No. 31, September, 26-35, ISSN 1994-9057 (Print) ISSN 2070—0083.

[17] Robert L. Mahler (2004). Nutrients Plants Require for Growth. College of Agriculture and Life Sciences, University of Idaho.

[18] Richard Y., Stefano O. and Lan F. (2015). Soil degradation: a major threat to humanity. Published by the Sustainable Food Trust – a global voice for sustainable food and health, UK. http://sustainablefoodtrust.org

[19] Shantanu K. S. Soilless Cultivation for Landless People: An Alternative Livelihood Practice through Indigenous Hydroponic Agriculture in Flood-prone Bangladesh. Ritsumeikan Asia Pacific University.

[20] Sheikh B. A. (2006) Hydroponics: Key to Sustain Agriculture in Water Stressed and Urban Environment. Pak. J. Agri., Agril. Engg., Vet. Sc. 22 (2).

[21] Steve C., (2007). Backyard Aquaponics Magazine - Issue 1

[22] Theresa M, (2013). The importance of soils for ensuring food security. Insight magazine - issue 1.

[23] UNDP, (2015). Sustainable Development Goals.

[24] United Nations (2009). World population prospects: the 2008 revision population database. New York, UN Population Division.

[25] Victor Chude, 2012. Global soil partnership. International Technical Workshop "Managing Living Soils". FAO Headquarters Rome, Italy.

[26] Wiebe, K. (2003) Land Quality, Agricultural Productivity, and Food Security at Local, Regional, and Global Scales Paper presented at the American Agricultural Economics Association Annual Meeting, Montreal, Canada, July 27–30, 2003 Economic Research Service, USDA.

[27] Y. Saleh, **A. M. Badr, **F. El Banna & **A. Shahata. 2014. Agricultural Land- Use Change and Disappearance of Farmlands in Kaduna Metropolis-Nigeria. www.scienceworldjournal.org. Science World Journal. Vol. 9 (No 1) ISSN 1597-6343.

[28] Zachary D. (2015). University of Pittsburgh, Swanson School of Engineering 1.