Review Article

REVIEW OF GREEN TECHNOLOGIES USE BY FARMERS: IMPLICATIONS FOR ENVIRONMENTAL SUSTAINABILITY IN NIGERIA.

Abstract

Background: *The study reviewed green technologies used by farmers. It specifically reviewed what green technology is all about in farming; green technologies used by farmers and its role on environmental sustainability and challenge to use of green technology in farming.***Materials and Methods**: *The authors reviewed books, journals, bulletin… theses, dissertations, research reports….etc.***Results**: *From the findings, it is observed that solar photovoltaic, wind energy, biofuel, biogas, biomass, organic farming, integrated pest management, mixed farming, etc. are the most common green technologies use by farmers in Nigeria. It also reveal that the adverse effect of conventional technology and modern farming practice on the natural environment were environmental degradation, global warming, climate change, reduction in biodiversity, destruction of soil health and natural habitat, economic loss to farmers, which can be addressed by green technologies use with its potentials of healing damaged natural environments and ensuring profitability as cost of production is reduced by 67% and sustainability of environment in the production process. The benefits of green technologies are quality natural environment, healthy farm produce and sustainable biodiversity while challenges to its use are cost intensive, lack of technical know-how, illiteracy of the farmers, inadequate information on the potentials and limitation of its application. Green technology is the path of rapid agricultural development and welfare improvement as it increases profitability and health of farmers and guarantees environmental sustainability. The study recommends policy measures promoting use of green technologies by farmers for environmental sustainability and profit maximization.*

INTRODUCTION

Agriculture is the most practice profession in Nigeria. It is the integral part of man for his existence as he depends on it for provision of food, shelter, meat, medicine, etc. for himself and families, and it's the key source of income to about 80% of rural dwellers [1]. In the early period when the population was smaller, resources were abundant and there was enough to eat without so much concern about processing and storage, and agricultural production was basically based on cycling and recycling of nutrient between plant biomass, organic and inorganic soil stores[2]. At that period there was enough to eat and the populace lived healthier and longer as the production was eco-friendly.

As the population grew, limitation in natural resources aroused and this pushed man to craving for industrialization in agriculture in order to produce enough food for the growing population[2]. Based on that, agricultural production developed with the use of off-farm inputs such as inorganic fertilizer, agro-chemicals for pest and weeds control which aided increase in productivity but with serious side-effect that lasted than its benefit to the environment and man, making the entire ecosystem unsustainable[3]. Some of the serious environmental problem as result of these agricultural production techniques include but not limited to reduction in biodiversity, aquatic eutrophication by nitrogenous and phosphorus substances caused by over-fertilization, global warming caused by enteric fermentation and use of fossil fuel, water shortage due to irrigation, eco toxicity, human effects, etc.[2]. Owais, Sushree & Singh (2018) also noted that the use of

chemical and the prevalent farming practices result to environmental hazards such as damage of soil health and natural habitat, soil salinization, reduce ground water level, soil erosion, decreased food quality, pollution due to fertilizer and high cost of cultivation rendering farmer poorer year after year[4]. This is in line with my position as it damages the natural environment and renders the environment unsustainable and even affect farmer up to the point of affecting his health and income.

The practice of the use of off-farm inputs were basically for the increase of food productivity to feed the growing population but over 14 million people in Nigeria are still malnourished[5], and instead of increasing farming productivity to carter for rapid growing population in the country, it is increasing the damage of the natural environment making it unfavorable and unsustainable.

Achieving food security mainly depends on efficient farming practices that will not only concerned about increase in food productivity but also concerned with not subjecting environment to ecological problems such as soil degradation, climate change, erosion while farming [6]. The growing awareness of the negative impact of the use of off-farm inputs in farming is causing a shift among consumers, policy maker and even producers to desiring efficient and environmental friendly method in agricultural practices.

Green technology is an alternative practice which assures reduction of environmental damage leading to higher farm profit and protecting natural resources [4]. It increases the productivity with no damage to the environment[3], and that's the same purpose of the use of off-farm inputs but it in turn causes damage to the environment which renders it unfavorable to mankind. Green technology practice in agriculture increases environmental sustainability because it produces high quality organic food from a high quality environment[4].

1.2 Statement of the Problem

The large share of Nigeria population dwell in the rural area and their major occupation is agriculture. This implies that they largely depend on agriculture for the provision of their basic need such as food, shelter, income, medicine, etc. Earlier before advancement in agricultural practices as result of urbanization and rapid population growth, agricultural production was basically by cycling and recycling soil nutrient and waste product into soil to increase soil fertility to aid agricultural productivity. This particular practice was eco-friendly because it helped in preservation of natural environment while trying to increase agricultural productivity.

As population grow and urbanization on rapid increase; resources depletion became high leading to scarcity, and it became necessary to utilize the relative scarce resources such as land to ensure production of enough food for the growing population which necessitated the use of all kinds of off-farm inputs to increase productivity per area of land as against earlier practice which increases productivity by increasing area of cultivated land. At this point, the uttermost concern is increase in production without concern about the environment. The use of the off- farm input actually increased productivity but not as fast as population growth yet the negative impact last longer than the benefit. Indiscriminate use of chemicals and conventional agricultural practices yielded to so many environmental hazards such as water pollution, decreased food quality, damage of soil health, soil erosion, soil salinization, reduced ground water level, and even lead to increase in cost of cultivation. The reduction in the food quality has rendered food produced with off-farm inputs unpreservable and unhealthy for human consumption.

Based on the growing awareness of the negative impact of the use of all kinds chemical and conventional agricultural practices on the environment and man; the producers and consumers are seeking for a healthy food produced on a healthy environment that is fit for consumption and preservable. Then, it becomes

necessary to identify and understand eco-friendly agricultural practices preferably known as "Green Technology" that will aid productivity and profitability of agricultural production without damage to the natural environment and mankind, rather heals already caused damage.

1.3 Objectives of the Study

The overall objective of the study is to review the current green technologies use by farmers and how it affects environment while the specific objectives are to;

i. recognize what green technology is all about.;
ii. assess green technologies used by farmers and its role on environmental sustainability, and
iii. highlight challenges in using green technology in farming.

LITERATURE REVIEW

2.1 Green Technology

Technology is basically, the application of scientific knowledge for the purpose of manipulation of the human environment to satisfy the changing desire of man. In this context, technology allows people to achieve things that are not easy or possible. There are many kinds of technology which exist, but, most of these have no consideration on the environment it's been used to manipulate or its sustainability for the benefit of the future generation. Hence, green technology is a kind of technology that considers the environment and its sustainability.

Green technology is any product, system or methods that are used to conserve natural environment and resources which reduces negative impact of human activities[7]. This technology is not limited to conserving environment but also enhances the profitability of the farmer as Owais et al. (2018), stated that green technology is an alternative of conventional technology which assures minimization of environmental damage leading to increase in farm profitability and protecting natural resources[4]. The researcher agrees with this assertion as the conventional technologies are capital intensive which reduces the profitability of farmers or capable of putting them off the farming business as result of lack finance to access them and equally damage the environment. Asian and Pacific Centre for Agricultural Engineering and Machinery (APCAEM) also defined green technology as "environmental healing technology that reduces environmental damage created by the products and technologies for peoples 'conveniences[8]. It also agrees with the assertion of Owais et al (2018) that it increases farm profitability while reducing environmental damage and conserves natural resources[4]. Therefore, the basic goal of green technology is to protect environment and repair the past damage and conserve natural resources while carrying out economic activities such as farming in the environment. These definitions serve as a baseline for green technology around the world as well as Nigeria in this review.

2.2 Green Technology for Environmental Sustainability

On the ground of trying to increase productivity to meet up with the food demands of the growing population has yielded many challenges such as climate change, environmental pollution, depletion of natural resources, etc. [9]. The researcher agrees with the assertion because before industrialization there was nothing like climate change, environmental degradation or soothe as the difficulties experienced today in some areas in Nigeria.

According to Nithya (2017), environmental sustainability " is the rate of renewable resources harvest, pollution creation, and non-renewable resources depletion that can be continued indefinitely" which implies

that environmental sustainability is concerned about the future generation as it is also concerned about present generation, but, it has not being achieved as reported by Minjian et al. (2017) that the environmental pollution, natural resources depletion, climate change, inefficient use of natural resources are among the growing global problems[9,10]. All these might have resulted from the application eco-unfriendly methods or technology and there's need for advancement into eco-friendly technology that will ensure sustainability of the natural resources and healthy environment for the end-users of the products. Technologies that meet present need without compromising the ability of the future generations to meeting their own need- green technology.

Green technology as environment–friendly technology is not only concerned about preserving the natural environment but also enhances the profitability of the farmer, is a way of ensuring environmental sustainability. It is also in line with the findings of Noor, Ivy, Ali & Rudy (2017), that green technology is much concerned about the future generation and the environmental quality of the end-users of their products[11]. According to Owais, et al. (2018) green technology is environmental sustainability because it provides high quality organic food from high quality environment and retains its natural landscape, habitat and species, ensuring quality life for the people therein[4]. This is so true because literature have proven that consumers are yearning for products that is produced using environmental friendly technology in a quality environment such as products of organic agriculture which is example of green practices. Therefore, green technology practices will lead to actualization of environmental sustainability and provision of high qualitative environment for humanity.

2.3 Green Technologies Used by Farmers in Nigeria

There is practically no challenge in developing agriculture for increasing productivity and income of the farmers without damaging or affecting the environment. This is sustainable agriculture; sustainability is necessary because all over the world including Nigeria where land has been unsatisfied and challenges such as unplanned exploration of the natural resources (land, water etc.) have been realized[8].The sharp increase in the cost of machineries, energy and agricultural inputs have reduced the profit of farmers which has severely damaged the environment [8].

Green technology used by farmers is not totally new in Nigeria. It has potential of achieving increase in farm yield and profit of the farmers by utilizing techniques that are environmentally sustainable , ecologically sound and economically reliable and thus identified the following as the leading green technologies use by farmers- green technology of solar energy, green technology of mixed farming, biogas and organic fertilizers, bio refineries, biofuel, multiple cropping and crop rotation, integrated pest management [4],while Apacem (nd) also identified solar photovoltaic, wind energy, biofuel, biogas, micro and macro hybrid power, biomas, organic farming, integrated pest management, agroforestry as the green technology used by farmers in their agricultural practices and Joseph(2014) also identified IPM and conservation tillage as green technology[8,12].

2.3.1 Agroforestry

Agroforestry is a collective name for land use and technologies where trees are deliberately used in the same land with crops and /or animals. According Food and Agriculture Organization, the trees and the crops usually have ecological and economic interactions and it is dynamic ecological based, natural resources management system that through the integration of trees on farm and in the agricultural landscape diversifies and sustains production of increased social economic and environmental benefits for land uses at all levels. It further stated that agroforestry is crucial to all farmers as it improves their food supply, income and health.

This technology is quite green as it ensures the use of natural resources which sustains environment of the farmers and ensures healthy environment. Ibeawuchi et al. (2015) also affirmed the above positions as they noted that agroforestry are used to exploit the benefits of combining trees and crops or livestock and it was introduced to Nigeria in the year 1926 by International Council for Research in Agroforestry [3]. This is really beneficial to the farmers as the produce of land will increase by the products of trees such as timber, fuel wood, robber and Ibeawuchi et al. (2015) repeated the following practical application of agroforestry[3].

a) Wind break trees: These trees are planted by farmers to protect his family and their lands from strong wind, e.g. Leucaena spp., Casuarina spp., Green giant, Gaint arbrovitac.

b) Hedgerow barriers: These are trees planted around sloping lands to control erosion and provide organic matter through their leave fall, example; Ptercarpus spp. (Oha). The leaves of the trees are also used as vegetable while the trunk as timber.

c) Live fences to control movement of animals in the farm: These are trees planted around the farm stead to secure and limit the movement of animals.

The leaves are also used as fodder to feed the animals and their faeces as nutrient for the trees.

2.3.2 IPM (Integrated Pest Management)

This is a knowledge intensive approach which is an alternative to conventional use of chemical to control pest. IPM is basically all about the growth of healthy crops with very little or zero disruption of agro-ecosystem and encourages natural pest control mechanism. According to university of California Agriculture and Natural resources, IPM is a process which you can use to solve pest problems while minimizing risks to people and the environment and it can be used to manage any pest both in urban and rural areas.

This can be simply done by taking actions that will prevent pest becoming a problem to you and your farm such as growing healthy crops, planting diseases resistant crops, designing human look alike to scare the pest and rodent away from farm rather than eliminating them with chemicals which also damage the environment. According to Gogi, Nawaz, Sufyan, Sarfraz, & Liburd,(2017), IPM applications rely on knowledge of the pest biology and pest ecology in agro ecosystem and with the knowledge you can be able to identify pest control measures that will be adopted to stop pest without affecting the environment negatively[13]. Gogi et al. (2017) reported the basic principles of IPM as follow:

a) Pest avoidance/ exclusion mechanism- This is an action taken early enough to avoid the entry of any pest into the agro ecosystem to ensure its pest free. This is mainly by employing techniques which exclude and prevent the pest such hand-picking, physical beating, noise creation, burning etc. Burning included here as techniques for eco-friendly managing pest also has negative impact on the environment and man. According to Otitoju,Yakubu,Otitoju and Uka(2019), bush burning has negative effect to the environment and health of human as it pollutes the air with production of air pollution such as carbon monoxide, hydrocarbon, hydrogen sulphide, nitrogen oxide, sulphur, etc., this shouldn't be addressed as eco-friendly technique because it also damages natural environment and affects man negatively[14] .

b) Identification of pest and its status: This is management of pest by identifying the pest; its life stages and effect. Identification of pest will help you determine their status, population and effective measures to employ. However, proper identification of pest especially at early stage is expertise that cannot easily be

learned and most farmers don't have this neither do they have financial strength to employ the services of the qualified entomologist.

c) Understanding biology and ecology of pest: Sufficient understanding of the biology and ecology of pest such as anatomy, morphology, growth, etc., will enable you choose appropriate method or repellants for the pest than applying whatever that is called pest repellent or adopting any IPM method. This is also quite difficult as an average farmer cannot afford to hire a professional who can do that.

2.3.4 Solar Energy

Solar energy is a radiant light and heat from the sun that can be harnessed using solar heating, photovoltaic. According to Apacem(nd),solar photovoltaic technology converts sunlight into energy using semiconductor which can be used in agricultural production for pumping water, lighting in rural houses and pest management[8]. For instance solar water pumping prevents lot of problems when compared to conventional fuel such as no cost for fuel, maintenance and doesn't pollute the environment [15]. Sun delivers yearly over 10,000 times energy human presently use [4]. In Nigeria, there is enough sun which means that solar water pumping system and other solar related technology will get plentiful amount of solar radiation. Owais et al. (2018) also stated that this green technology as the best alternative for improving the standard of life of rural farmers in terms of cooking and lightning.

2.3.5 Biogas

This is the transformation of agricultural wastage into fuel and fertilizer through anaerobic digestion. According Apacem(nd), this technology is green because it utilizes agricultural waste and turn into fuel and fertilizers[8]. Biogas is renewable energy source which is utilized in cooking, lightning and can also be used in maintaining temperature inside green house for appropriate plant growth while the by-product are used for organic crop production[4, 16].

The residue also increases soil fertility since it has nutrient and has good penetration capacity to the soil. It is a good replacement to inorganic fertilizer and good for crop production since its odour is less by 80 from the feedstock[4,17].

2.3.6 Mixed Farming

Mixed farming is a common practice on agriculture. The best part of mixed farming occurs where the residual of crops is used to nourish animal while their faeces are used as fertilizers to grow crops and nourish the soil. According to Deshmukh (2014), mixed farming help farmers to overlook the threat of single crop production and it are the top technology for improving eco-friendly food production. This is green technology as the use of the animal faeces as fertilizer in place of inorganic fertilizers[17].

2.3.7 Organic Farming

Organic farming is one of the most growing current agricultural practices because of its benefits to man and his health and the entire environment. It is the standard of production that doesn't require use of synthetic agricultural inputs but using natural eco-friendly methods to increase soil fertility and discourage pest infestation [3]. It is established that use of synthetic inputs such as fertilizers, pesticides causes damage to the ecosystem and renders its agricultural produce unhealthy for consumption and difficult to preserve. Owais et al. (2018) noted that demand of farm produce of organic farming has rapidly increased as the consumers' desire for quality and safety[4].

Organic food is safer and of better quality for consumption and even storage as Owais et al. (2018) also noted that its animal or plant produce based on farming system that avoids the use of chemical fertilizers, pesticide, growth regulators etc.[4]. This is the kind of agricultural produce consumers desires and above all

it promotes availability of healthy environment and protects biodiversity which is necessary for efficient and sustainable manipulation of natural environment and resources. According to Oyedele, Wole-Alo,Owolabi & Okunlola (2018) organic farming promotes biodiversity and enhances ecological harmony[18].

Therefore, organic farming is a green technology as it avoids the use of off- farm inputs which damages environment and affects man negatively and rely on the ecological based process to increase fertility of soil and enhances productivity.

2.4 The Role of Green Technologies for Environmental Sustainability

Technology is a solution facilitator but it is also part of the problem of environmental damage. Amongst the impact of this conventional technologies on the environment included the misuse and damage of our natural earth and the main two ways this damage have occurred, are through air and water pollution and depletion of natural resources. Henri-Ukoha (2020) noted that Global warming which causes environmental unsustainability is as a result of climatic change which emanated from the activities of man such as fossil fuel burning, deforestation, industrialization which affects the livelihood of the people and eco-system deeply[19]. All these is as a result of the use of conventional technologies and synthetic products in our environment especially agriculture that is practiced by about 80.0 percent of the entire populace of Nigeria.

Green technologies have been found to play vital role in solving or reducing to a barest minimum of those negative impact such as;

1. Environmental degradation

Environmental degradation is the deterioration of the environment through resource depletion including both biotic and abiotic elements that make up our surroundings such as air, water, soil, plant, animals etc., of the planet earth[20]. Over the years, the intensive use of technologies and off-farm input to advance agricultural production has been employed which leads to environmental degradation. Ibeawuchi et al. (2015) stated that environmental degradation is as a result of more use of conventional farming practices than green practices and also identified that the practice lead to environmental degradation such as “erosion of biodiversity, climatic change to pollution, desertification”[3]. Henri-ukoha (2020) also noted that intensive agriculture contributes to over 20% of green gas emission[19]. All these problems are as a result of human activities by application of conventional farming knowledge and technology to the environment. This is in line with Henri-ukoha (2020) who claimed that climatic change is as a result of human activities and it affects agriculture more than any other sector[19]. Whatever that affects agriculture in Nigeria affects the greater percentage of the country entire populace. This implies that the best way to mitigate these impacts is to go green in agriculture production.

James,Utpal, and Joseph (2014) noted that farmers using green technology will reduce soil erosion, improve water quality, enhance forest land, grazing land and restores wildlife habitation. This is to say that green technology practices reduce and solves the problem of environmental degradation[12].

2. Protection of biodiversity:

Biodiversity is the general term of the level of variation in all living things that exist in the natural environment. According to Rawat and Agarwal (2015), biodiversity “is the variety of different forms of life on earth, including the different plants, animals, microorganism, the gene they contain and the ecosystem they form”[21]. Most of the species of both plant and animals which is beneficial to man and ecosystem have been destroyed by the intensive use of conventional practices which makes them unavailable. Rawat et al. (2015), also noted that biodiversity can be conserved by through gene banks, zoos, and botanical gardens[21]. The conservation of biodiversity through that means are feasible but, it is not sufficient and

their maintenances cost is high which have rendered many conservational centers in Nigeria inoperative and it is also to note that this conversation centers are also situated around the same bad environment and they are not immune to air and water pollution. Therefore, these methods are not reliable and dependable to achieve healthy environment we all desire, but green technology which involves the use of natural environment and avoid use of conventional technology and synthetic input use that facilitates the destruction of biodiversity.

3. Self-reliance and natural conservation;

The goal of green technology is to sustainably manipulate the natural environment to contribute to agricultural production positively. The farmer using green technology need different species and plant and essential ecosystem as a source of input to replace its non-use of synthetic input (Ibeawuchi et al 2015), which will enable achievement of self-reliance and good environment[3]. Henri-ukoha,Osuji,Effiong,Eze and Anyanwu,(2019), noted degraded ecosystem as one of the factors that that hinders agricultural development which means that the use of conventional technologies and farming practice is a contributing factor to Nigeria food insecurity as it degrades natural environment [22]. Any forms of agriculture in the natural environment is the obstruction of the natural process occurring in the natural environment by man which will definitely lead to environmental damage but environmental friendly technologies have seen to operate with barest minimum damage[3,23,24].

Mader (2004), compared organic farming system which is one of the green technologies use by farmers and conventional farming with respect to their environmental performance and concluded that green technology (organic farming) showed better confidence interval for environmental performance than conventional farming and Ibeawuchi et al. (2015); Pretty (1995) also stated that it contributes to rational use of natural resources and environmental protection which it implies it enhances and preserves natural environment[25,3,26].

Table 1. Differences between Green Technologies and Conventional Technology

	Green technology	**Conventional technology**
	is concerned with the environment.	is not concerned about the environment.
	is concerned about the future generation as meets the need of the present.	oncerned about the present alone.
	depends on farm inputs alone.	depends on off-farm inputs.
	increases profit of farmers as the cost is w	increases profit of the farmers as its cost tensive.
	is environmental friendly.	impacts the environment negatively.
	protects and preserves biodiversity.	destroys biodiversity.
	it ensures clean environment and its ıstainability.	pollutes the environment and threatens its ıstainability.

2.6 Challenges to Use of Green Technologies by Farmers

Green technology is not relatively new in Nigeria as our forefathers practiced it long ago but in rudimentary form before the advent of various off-farm inputs. They used many methods such bush fallow, shifting cultivation, etc., and they were all green as they tend to enrich soil through those means so as to increase their production but the recent some of green technologies are not fully utilized as results of numerous constraints such as:

a) Inadequate information on the potentials and limitation of its application: Most farmers don't have adequate information in all the potentials and limitation of green technology because of its newness in the country. According to APECEM, green technology such as photovoltaic which converts solar energy to electrical energy and its used for water pumping, rural area electrification , lightening have proven to be effective but the major setback is inadequate information on the potentials and limitations of its application[8]. This unavailability of detailed information may hinder farmers or government commitment in it.

b) Illiteracy of the farmers: The frequent use of chemicals and other off farm inputs in agricultural production has caused a lot of damage to the environment and health of man. APECEM stated that the use of the chemicals has lead development of high resistance pests, affected soil fertility and caused high pesticide residue in food and IPM can mitigate or solve these problems but the challenge is the illiteracy of a farmer as it requires high level of knowledge[8]. IPM is knowledge-intensive approach which most farmers are not learned as such.

c) Air pollution: Organic farming is one of the green technologies which avoid the use of herbicide, inorganic fertilizer, pesticide which is detrimental to our environment and man but there is always environmental cost of transporting organic manure to the farm. The cost is polluting the limits the quality of air in the entire environment.

d) Lack of technical know-how: Most green technologies application or practice requires technology expert for its efficient and optimize use but most farmers are illiterate and not technocrats.

e) Cost intensive:Some of the Green Technologies is more expensive than the technology it intends to replace. Owais et al. (2018) highlighted that green technology application is sometimes expensive but, its cost of training and development can make it even more costly in comparison with established technologies[4].

3.0 Conclusion and Recommendation

Reviews show that conventional farming method and use of off-farm inputs have been used to advance agricultural production at the expense of natural environment and health of human. The desire of people for

quality food from quality environment favors green technology which preserve natural environment, biodiversity and maintain sustainable food and health of man which when used by farmer it ensures environmental sustainability and also increases profit of farmers. Green technology is a path of sustainability as it is conscious of the future while taking care of the present need of man and it guarantees healthy environment. Therefore these recommendations were made; Deployment of well-trained extension agent to sensitize rural farmers on the adverse effect of the use of off-farm input on the natural environment and health of man and the need to go green in their production; elimination of every form of subsidies in the supply of chemical inputs such as inorganic fertilizers, herbicide, and pesticide to discourage the use of such in our farming practices and government to establish adult education centers in the rural areas to increase the literacy level of core farmers so as to facilitate the adoption of green technologies in their farming practices.

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