Deployment of energy technologies for sustainable rural agricultural development in Nigeria

Onah, B. N¹, Okafor, I. F¹, Oyigbo, D. N² and Nnate, K. N¹.  
¹National Centre for Energy Research and Development, University of Nigeria, Nsukka  
²Department of Adult Education and Extra-Mural Studies, University of Nigeria, Nsukka

Corresponding author: beatnonah123@gmail.com

Abstract: Renewable energy technology deployment is very critical for sustainable rural agricultural development. This study analyses renewable energy technologies for sustainable rural agricultural development in Nigeria. The National Centre for Energy Research and Development, University of Nigeria, Nsukka, has developed viable renewable energy technology devices which include solar powered dryers, solar chicken brooders, solar incubators and solar PV system and biogas production system. This study analyzed the applications of these renewable energy devices and challenges to their deployment for sustainable rural agricultural development. Rural adults mostly involved agricultural practices lack knowledge of modern technologies that could lead to boosting rural agriculture. Thus, exposing them to knowledge of renewable energy technologies, achieving sustainable rural agricultural development is possible.

Keywords: Renewable Energy, Renewable Energy Technology, Sustainable, Rural Agricultural Development

1. Introduction

The roles of renewable energy technology in rural agricultural development are quite enormous. Renewable energy technologies specifically can be very effective and reliable tools for sustainable rural agricultural development in Nigeria. With renewable energy technologies, crops can be cultivated all year round via solar water pumping system to provide uninterruptible water supply for crops irrigation. With renewable energy technologies, farm produce (foods, vegetables and fruits), which could have been wasted after harvest can be dried using solar crop dryers of different designs/configurations and safely preserved for future use, making food supply surplus all year round. Also some agricultural, animal wastes/manures would be dried and kept against planting season via solar dryers of different types. Moreover, with solar incubators and chicks brooders, hatching and brooding of chicks are essentially developed as alternatives to the conventional devices, which depend on fossil fuels that have adverse environmental implications.

Agriculture is a major means of livelihood of rural areas in Nigeria. In every country of the world, it is well known that food that feed the nation is mainly from rural areas, especially in the developing countries like Nigeria. The rural people who are adults engage in diverse forms of agricultural productivity such as land farming and livestock production, but lack knowledge of renewable energy technology applications for boosting their agricultural
practices. Agricultural productivity is one of the sure ways of boosting both the economic power of rural adults and national economy in diverse ways. Agriculture is the major source of income in rural areas of developing countries like Nigeria. Agriculture remains the dominant sector in the rural areas of Nigeria where 70% of Nigerians reside. The diversity of favourable climatic conditions, the richness of soil types and abundant water sources, and the high population density provide great potentials for crop, livestock, fishery and forestry production. Prior to independence and thereafter, agriculture was the mainstay of the economy and a major source of revenue for funding development programmes of government [1]. For overall national development, there is a need to pay special attention so that the energy needs of rural areas for subsistence and productive requirements (e.g. agriculture, industries and transport) are met on a sustainable basis [2]. Moreover, agricultural activities contribute to increase in national economic wellbeing and GDP of any nation. Agriculture and industrialization has been generally accepted as the surest and most direct route to economic development of any nation like Nigeria. Their potentials, if properly harnessed, has the capacity to grow a nation income. In comparing agricultural activities with industry and their contributions to increment GDP agriculture ranked higher. While agriculture had 58% industry had 32% [3]. The agricultural sector in Nigeria is facing lots of challenges of which inadequate power supply is one. The epileptic power supply in Nigeria, no doubt should be an eye opener to administrators in Nigeria to delve into alternative power supply. The study by [4] lamented that inadequate power supply restricts socio-economic activities, hinders meaningful development, etc. The study by [4] further noted that renewable energy technology offers a promising solution to the perennial energy crisis in Nigeria.

Despite the contributions of agricultural sector to national development, the agricultural practices in Nigeria still lack sustainable energy technology for boosting its productivity especially in the rural areas. This study analyses the applications of renewable energy devices such as solar powered dryers, solar powered chicken brooders, solar water pumping system, etc. to empower the rural adults in Nigeria with adequate knowledge of these devices for sustainable agricultural practice. These devices have been developed by the National Centre for Energy Research and Development, University of Nigeria, Nsukka, but they are not yet adequately disseminated for rural agricultural development in Nigeria. The study by [5] noted that Nigeria needs sustainable energy technology systems in the agricultural sector to meet the rising demand for increased agricultural productions, due to population outburst, in order to improve standard of living and to curb rural to urban migration. This study also analyses the challenges to the applications of these renewable energy devices as regard to rural adult education for sustainable rural agricultural development in Nigeria. With adequate knowledge of renewable energy technology, rural adults engaging in agricultural practice will have the capacity to deploy renewable energy devices for boosting agricultural productions in Nigeria to guaranty food security.

2. Renewable Energy Devices for Rural Agricultural Development

The National Centre for Energy Research and Development, University of Nigeria, Nsukka, has developed a number of renewable energy devices that are yet to be deployed for sustainable rural agricultural development in Nigeria. Sustainable agricultural development will in no doubt improve agricultural practices and ensure sustainable food security in Nigeria. Some of the renewable energy technologies that could be deployed to boost rural agriculture development include: solar dryers, solar chicken brooders, etc. These devices and
their roles in sustainable rural agricultural development are presented in the subsequent sections of this work.

2.1 Solar thermal powered crop dryers
The amount of food crops, vegetables, fruits, etc. lost during harvest is enormous. Solar crop dryer is one of the renewable energy technologies that can be used to dry food crops, fruits and vegetables for future use, leading to sustainable rural agricultural development. According to Food and Agricultural Organization [6] high rates of food losses contribute to food shortages and have left millions in low-income countries suffering from malnutrition. The study by [7] gave that solar drying is one of the most effective and cost-effective renewable and sustainable technologies to conserve agricultural products in Asian and Sub-Saharan Africa countries. Also some perishable agricultural produce could be dried and kept secure for future use via solar dryers. These solar dryers come in sizes. They include community based solar dryer for grains, root crops, and family sized dryers for fish and meat preservation. Others include solar manure dryers for cow dung, poultry and pig droppings.” [8].

Solar drying has some advantages over sun drying. The sun has been used for drying as long as humans have inhabited the planet and laying a product out in the sun to remove its moisture is known as sun drying. Although sun drying is still by far the most common method of drying, it does have several inherent disadvantages. The unprotected crop can be damaged by rain, contaminated by dirt and animals and/or eaten by birds and insects. Since the temperatures attained during sun drying are usually lower than in a solar dryer, drying times are longer. This usually results in poorer final quality because of crop discoloration caused by enzymic and non-enzymic browning, and often because of the formation of moulds. In a solar dryer, however the temperature of the air surrounding the product is raised above the ambient air temperature. Depending on the type of solar dryer, the temperature of the product may also be raised by direct absorption of solar radiation. The temperatures in a solar dryer are higher than in sun drying and this reduces the drying time and usually improves the final product quality. Crop losses and spoilage from rain and animals are prevented because the crop is protected within the solar dryer [9]. Use of solar dryer for agricultural produce has advantage over conventional methods. The study by [10] identified other advantages of solar drying over sun drying as–protection from flies, pests, rain or dust. Figure 1 shows a solar crop dryers developed by NCERD, UNN.

![Figure 1: Solar Crop Dryers developed by NCERD, UNN](image-url)
2.2 Solar thermal powered chicken brooders

Many benefits are derived from poultry farm. The benefits of this technology to rural farmers include employment opportunity, source of income for expansion and family needs, poultry droppings as source of manure, etc. A unique feature of solar brooder is the utilization of solar energy as heat source in place of electricity, kerosene lamps and stoves normally used in conventional brooders.

In comparison with conventional brooders, solar energy brooders are pollution-free, environmentally friendly, have lower maintenance costs and are energy saving; showing over 97% efficiency and about 2-3% mortality rate [8]. Solar chicken brooders are viable renewable energy technologies for brooding of chicken. This system uses solar radiation as heat source in place of kerosene lamps and stoves to provide heat for freshly hatched chicks during their first four to six weeks for best survival rates [4]. With the above advantages of solar brooders over conventional brooders, there is no gainsaying that solar brooders contribute enormously to rural agricultural development when made available to them. Figure 2 shows a solar Chicken brooders developed by NCERD, UNN.

![Solar Chicken brooders developed by NCERD, UNN](image)

2.3 Solar thermal powered incubator

One of the realistic sources of income in Nigeria is chicken production. People need chicken as one of the sources of protein. In the rural areas, people make use of electricity in incubating and hatching eggs. The challenge is that the incessant electricity failure is a hindrance to adequate hatching of eggs. The work by [11] revealed that the constant failure of electricity supply in Nigeria obstructs operation of incubators and reduce its performance. In the most developing countries, the vast majority of poultry farmers in the rural communities operate their farms on small scale and/or even subsistence level. They often use a collection of bush lamps and kerosene stoves to achieve the heating requirements of the small hatcheries and brooders for day-old chicks [12] in [13]. The study by [14] believed that seeking a viable alternative energy source has always been the center of attention particularly in agricultural sector. In consonance with the above, [15] declared that solar energy application was the most attractive option for a sustainable energy supply in poultry production. Figure 3 shows a solar incubator developed by NCERD, UNN.
The problems with these systems are enormous. If we use fossil fuel, it produces toxic gases which are harmful to eggs and poultry attendants. Electricity based egg incubators are known to produce clean energy without harmful effects on the environment but they are however limited in operation due to the initial cost of procuring such equipment coupled with the high cost of electric bill, frequent power outages where grid electric exists. Thus it becomes a dream for people in rural areas to get into poultry business. That is why the proposed solar poultry incubator comes into play. It can operate even in the absence of power from grid, it works from the solar power and we need power from grid only in the extreme cases.

2.4 Solar PV system for water pumping
Solar PV system is another renewable energy technology that can lead to boosting rural agricultural development. The study by [16] revealed that photovoltaic (PV) cells that transform sunlight directly into electricity are made of semiconductors such as crystalline silicon or various thin-fuel materials. The role of solar water pumping in rural agricultural development cannot be overemphasized. With solar water pumping, channeling of water to different parts of a large farm and agro-industries is made easy. During dry season, water could also be channeled to farms, whether animal, fish or land farms from any nearby source of water. This in turn can lead to cultivation of farm produce all year round. Solar pumps can also be valuable in agro-based industries.

There many advantages of solar PV watering system over energy of pumps used for agricultural irrigation that is provided from electrical energy or fossil fuels. Since fossil fuels begin to annihilate besides its increasing of prices and hazards to environment, alternative energy seeking efforts has become inevitable also in agricultural sector [17]. Furthermore, [18] made it known that solar pumping systems are ideal for lifting water for drinking and irrigation without harming the environment and can be installed easily. Figure 4 shows a solar Water pumping system installed by NCERD, UNN.
2.5 *Solar PV system for rural electrification*

Solar Photovoltaic (PV) is a source of power to rural areas. Solar photovoltaic (PV) systems have shown their potential in rural electrification projects around the world, especially concerning Solar Home Systems. With continuing price decreases of PV systems, other applications are becoming economically attractive and growing experience is gained with the use of PV in such areas as social and communal services, agriculture and other productive activities, which can have a significant impact on rural development [19]. Furthermore, the solar photovoltaic systems play an important role in the agriculture sector for reducing fossil fuel consumption. Solar water pump can be one of the most important and applicable device in farms where there is existing power line. Photovoltaic water pumping systems are very reliable and require little maintenance. Figure 5 shows a Solar PV System installed by NCERD, UNN.
3. Challenges to the Deployment of Renewal Energy Technologies for Sustainable Rural Agricultural Development in Nigeria

The challenges to deployment of renewal energy technologies in rural agricultural include social, economic as well as political barrier. Rural people are already used to a particular method of farming. Moreover, to adapt to an innovation where people are not aware or do not understand it is another issue. The transition from conventional resources to renewable energy has encountered public resistance and opposition. This is due to a lack of awareness of the benefits of renewable energy, disruption of seascape, and acquisition of land which could have been used for agriculture, tourism, etc [20]. Inadequate awareness of renewable energy technologies and uncertainties about the financial feasibilities of renewable energy installation projects [21] are also social barriers.

Economic barrier is one the major challenges to deployment of renewable energy technologies for sustainable rural agricultural development. Some of the economic barriers were identified by [22] identified some of these barriers as high initial capital, lack of financial institutes, lack of investors, competitions from fossil fuels, and fewer subsidies compared to traditional fuel. Government provides more subsidies to conventional energy than that of renewable energy [23]. The rural adults involved in agricultural practice are low-income earner and lack financial capacity to acquire renewable energy devices for their uses.

Technological barriers are also there. These include limited availability of infrastructure, inefficient knowledge of operations and maintenance, insufficient research and development initiatives, and technical complexities like energy storage and unavailability of standards [24]. Curbing these challenges is possible when stakeholders act in positive manner.

4. Conclusion

From the study, different renewable energy technologies that could be utilized in boosting rural agricultural practices were identified. They include solar dryers, chicken brooders and incubators. Others are Solar PV for water pumping system, Solar PV System for rural electrifications. The National Centre for Energy Research and Development, University of Nigeria, Nsukka, has developed viable renewable energy technology devices which include solar powered dryers, solar chicken brooders, solar incubators and solar PV system and biogas production system. Their functions ranges from drying of farm produce for future use and curbing food shortage. Water is made available to farm land and agro-industries via solar pumps. With solar rural electrification, agro-based industries can thrive and preservation of perishable farm produce is made possible. Different challenges to the deployment of these devices include social challenges, economic challenges as well as technological barriers.

5. Recommendations

Some of the challenges to the deployment of renewable energy technologies for sustainable rural agricultural development are failure of the rural dwellers to diversity and lack of awareness. Therefore:

- Government at different levels should see it as a duty to bring to the notice of the people the availability of such devices and the need to utilize them to boost rural agricultural productivity. Training of people in the use of this technology by government and non-governmental agencies should also be a welcome idea.
- Secondly, economic barriers are challenges too. Government, non-governmental organizations and public spirited individuals can sponsor the procurement of these devices and handed to farmers to boost agricultural productivity.
- Training of adults who carry out agricultural practices in rural areas can go a long way to solving the problem of technical barriers.
- Moreover, government should encourage more research on these devices

References
[1] Onwualu, A. P. (2012). Agricultural Sector and National Development: Focus on value Chain Approach. Presented By Engr. (Prof.) A.P. Onwualu. fas, f.a.eng., fnse, fnim; Director General/CEO, Raw Material Research and Development Council (RMRDC) At the 5th Edition of the Annual Lecture of Onitsha Chamber of Commerce at Sharon House, GRA, OnitshaResearchGate, 24th May. Updated March 9, 2016. Retrieved from: www.rmrdc.gov.ng

[2] Olayinka, S. O. (2014). Towards achieving energy for sustainable development in Nigeria. Renewable Energy and Sustainable Development Reviews 34(2014), 255 – 272. Retrieved from: www.elsever.com/locate/rser

[3] Adenomon, M.O. & Oyejola, B. O. (2013): Impact of Agriculture and Industrialization on GDP In Nigeria: Evidence VAR and SVAR Models. International Journal of Analysis and Application, 1 (1), February, pp. 40 – 78.

[4] Okafor, I. F. & Unachukwu, G. O. (nd). Renewable Energy and Energy Efficiency for Sustainable Agricultural Development in Nigeria

[5] Okafor, E.N.C. & Uzuegbu, C. J. (2016). Challenges to development of renewable energy for electric power sector in Nigeria. ResearchGate. Researchgate.net

[6] Food and Agriculture Organization of the United Nations, and Technical Centre for Agricultural and Rural Cooperation (Ede, Netherlands) (2011): Rural structures in the tropics: design and development. Rome: Food and Agriculture Organization of the United Nations.

[7] Udomkun, P.; Romuli, S.; Schock; S.; Mahayothee, B.; Sartas M.; Wossen T.; Njukwe, E.; Vanlauwe B. & Muller, J. (2020). Review of Solar Dryers for Agricultural Products in Asia and Africa: An Innovation Landscape Approach. Journal of Environmental management 268(-): 110730. Researchgate.net, May. Retrieved from: http://www.elsevier.com/locate/jenvman

[8] National Centre for Energy Research and Development, (NCERD), University of Nigeria, Nsukka (2009). National Centre for Energy Research and Development, (NCERD), University of Nigeria, Nsukka, Activities at a Glance. Nsukka: Deepspring Press

[9] Fuller, R.J. (nd). Solar drying – a Technology for Sustainable Agriculture and Food Production. Solar Energy Conversion and Photoenergy Systems, Vol iii Solar Drying
– A Technology for Sustainable Agriculture and Food Production. Retrieved from: http://www.eolss.net/Eolss-sampleAllChapter.aspx

[10] Tiwari, A. (2016). A Review on Solar Drying of Agricultural Produce. Journal of Food Processing & Technology, 7(9), 1 – 12.

[11] Osanyinpelu, K.L.; Aderinlewo, A., Adetunji, O. & Ajisegiri, E. (2016). Development of Solar Powered Poultry Egg Incubator. International Journal of Innovative Research and Creative Technology, 3(6), pp 50 – 63. Retrieved from: www.ijirct.org

[12] Okonkwo, W. I. (1989). Unpublished undergraduate project, Department of Agricultural Engineering, University of Agriculture, Makurdi, Nigeria, in Abraham, N. T., Mathew, S. L. & Kumar, C.A. P. (2014). International Journal of Engineering and Advanced Technology (IJEAT), 3(3), February.

[13] Abraham, N. T., Mathew, S. L., Kumar, C.A. P. (2014). Design and Implementation of Solar PV Poultry Incubator. International Journal of Engineering and Advanced Technology (IJEAT), 3(3), February 2014.

[14] Kuye, S.I., Adekunle, N.O., Adetunji, O.R. & Olaleye, D.O. (2008). Design and Construction of Solar Incubator. Proceedings of the Third Conference on Science and National Development, pp 87 – 96. Retrieved

[15] Okonkwo, W. I. (2008). Passive Solar Heating for Poultry Chick Brooding in Nigeria. Presented at International Workshop on Renewable Energy for Sustainable Development in Africa, Trieste,

[16] Fischer, J.R., Finnel, J.A. & Lavole, B.D. (2006) Renewable energy in agriculture: Back to the future. Choices, 21(1): p. 2006-1.

[17] Dursun, M. and Ozden (2012). Application of solar powered automatic water pumping in Turkey. International Journal of Computer and Electrical Engineering, 4(2): p. 161

[18] Ali, S., Dash, N. & Pradhan A. R. (2012). Role of renewable energy on agriculture. International Journal of Engineering Sciences and & Emerging Technologies, 4(1): p. 51-57.

[19] Capeman, B.V., Guidi, D. & Best, G. (2000). Solar Photovoltaic for Sustainable Agriculture and Rural Development. Rome: FAO: Environmental and Natural Resources Service Sustainable Development Department.

[20] Goldsmiths, K. R. (2015). Barriers and solutions to the developments of renewable energy technologies in Caribbean (April), Google Scholar.

[21] Nasirov, S., Silva, C., Agostini, C.A (2015). Investors’ perspectives on barriers to the deployment of renewable energy sources in Chile. Energies. 2015; 8 (5): 3794 – 3814.
[22] Raza, W., Saula, H., Islam, S. U., Ayub, M., Saleem, M. & Raza, N. (2015). Renewable energy resources: Current status and barriers in their adaptation for Pakistan. J. Bioprocess. Chem. Eng. 2015; 3(3): 1-9.

[23] Dulal, H.B., Shah, K. U. Sapkota, C, Uma, G. & Kandel, B. R. (2013). Renewable energy diffusion in Asia: Can it happen without government support? Energy Policy. 2013; 59(April): 301-311 – (Google Scholar).

[24] Zhao, Z., Chang, R. & Chen, Y. (2016). What hinders the further development of wind power in China? A social-technical barrier study. Energy Policy 88 (January): 465-476