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OVERVIEW OF TILLAGE PROCESSES INVOLVED IN NIGERIA RICE PRODUCTION USING SAWAH ECO-TECHNOLOGY SYSTEM

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ABSTRACT

Tillage is considered as a unique process that is needed for the optimum performance of rice production in Nigeria using Sawah eco-technology system. Sawah eco-technology involves man-made improved rice fields with demarcated bunded, puddled and levelled rice fields with water inlets and water outlets which if possible can be connected to various irrigation facilities such as canals, ponds, dykes and springs. This system coupled with the use of agro-chemical input and high yielding varieties improves rice farming. It is the basic infrastructure without which other components for achieving rice green revolution becomes meaningless. The traditional system used for rice production in Nigeria which is bedeviled with low productivity and poor tillage practice can no longer meet the demand of the teeming population who loves eating rice. The main tillage processes involved in Sawah eco-technology in this study include bunding, ploughing, harrowing, puddling and levelling. The specialized tillage operation involved in this system include furrow opening and poldering. Despite the contribution of Sawah eco-technology to rice farming in Nigeria, one of the salient factors retarding the ease of disseminating and adopting the technology in Nigeria and other sub-Saharan African countries is the poverty level among our rice farmers. For Nigeria to retain her position as the leading producer of rice in Africa, the Sawah eco-technology system needs to be promoted in Nigeria as it entails optimum application of machinery for the management of the soil nutrient and water leading to a remarkable yield increment as a result of its adoption in different localities in Nigeria. NCAM played a foundational role in Kebbi State rice revolution, the previous administration played a pivotal role by the launching of Anchor Borrowers Progrmme. This paper strongly recommend among others that other state governments in Nigeria should borrow a leaf from Kebbi State government who worked in collaboration with the Federal Government team led by NCAM in providing an enabling environment for the spread and adoption of the technology by the State farmers.

Keywords: tillage, sawah, eco-technology, rice, production, processes

1. INTRODUCTION

Rice is the only cereal that is grown across most regions in the world (Isiaka et al., 2008). Rice is one of the three most staple food among maize and cassava in Sub-Sahara Africa (Naoyoshi, 2011) where its consumption keeps increasing due to population growth, urbanization and change in consumer habits. Research into sustainable rice production has thus evolved to satisfy its increasing consumption**.**

Nigeria is the leading consumer and largest producer of rice in Africa, however, it is one of the largest rice importers in the world. Many years back, Imolehin and Wada (2000) noted that rice in terms of area of land under food crop production in the country, rice ranks sixth after sorghum, millet, cowpea, cassava and yam. According to Ojehomon et al. (2009), farmers term rice both a food and a cash crop which contributes to smallholders revenues in the main producing areas of Nigeria. Out of a total land area of 70 million hectares available for land cultivation in Nigeria, rice is grown on approximately 3.7 million hectares representing 10.6% of the 35 million hectares of land under cultivation. Seventy seven percent (77%) of the farmed area of rice is rain-fed out of which 47% is lowland while 30% is upland.

The term sawah according to Wakatsuki et al. (2009) is a man-made, improved rice-growing environment with demarcated, bunded, leveled and puddle fields, for water control. Sawah is soil based eco-technology. In a simpler form the term Sawah refers to leveled, bunded and puddled rice field with water inlet and outlet to control water and manage soil fertility, which may be connecting irrigation and drainage facilities including Sawah to Sawah irrigation and drainage. Thus to effectively apply these scientific technologies, farmers have to develop typical sawah or similar alternatives which can conserve soil properties and control water.

Sawah eco-technology involves man-made improved rice fields with demarcated bunded, puddled and levelled rice fields with water inlets and water outlets which if possible can be connected to various irrigation facilities such as canals, ponds, dykes and springs (Oladele and Wakatsuki, 2011) alongside agro-chemical input and high yielding varieties (Wakatsuki et al., 2011). Thus, the three sawah inputs namely, demarcated bunded, puddled and levelled rice fields coupled with agro-chemical input and high yielding varieties has improved yield output of government institutions such as NCAM, FADAMA, ADP, APPEALS and CADP where we have an output ranging from 4 to 8 ton/ha compared to the local farmers field output which ranged from 1 to 3 tons/ha. Sawah eco-technology was seen as an adoptable and sustainable platform for intensive rice production.

The three essential components of sawah are (i) the demarcation of field by bunding which is based on topography, hydrology and soil. This may be achieved by attaching a mouldboard to the power tiller or tractor for the creation of demarcations and bunds; (ii) puddling is an operation that is achieved through attaching a puddler to a power tiller or tractor for preparing the soil for easy acceptance of rice seedling when transplanted; and (iii) controlled water management by creating room for the inflow and outflow of water.

The previous administration has done so much on rice production in Nigeria through the launching of the Anchors Borrowers Programme where the Sawah eco-technology system used for rice production was first demonstrated in Kebbi State. This paper tends to discuss on the tillage processes involved in Nigeria rice production using Sawah eco-technology system.

2. TILLAGE PROCESSES INVOLVED UNDER SAWAH PRODUCTION

Sustainable personal or co-operative irrigated fields for rice production usually encourage small scale, sustainable machinery which in most times involves the single axle tractor or the power tiller. Most farm implement can be coupled to the power tiller for tillage operations in lowland and upland fields. However, lowland field is much preferred due to soil fertility and water availability. The power tiller is driven using the cage wheel to avoid mechanical hindrance in the soil.

Land preparation starts with the complete removal of all vegetation which may be buried completely to avoid re-growth through pulverization of the soil to destroy soil lump for proper levelling off the field. Some of the activities that take place during sawah rice field preparation include bunding, sloughing, harrowing, puddling and levelling,

2.1 Bunding

This is the demarcation of fields into basins with the assistance of field topography by taking advantage of gradient variations to group closely related portions. Standard bunds should be of 50 cm width by 50 cm height using a moldboard severally in vertical motion to achieve good bunds. However, standard bunds are created for major sawah demarcation while small bunds are created for sub-sawah demarcations. Furthermore, the creation of bunds creates canals and

drainages in the sawah field. It is also constructed to submerge the field for easy levelling. Fig. 1 shows the picture of bunding operation carried out during rice farming at Lake Chad basin.

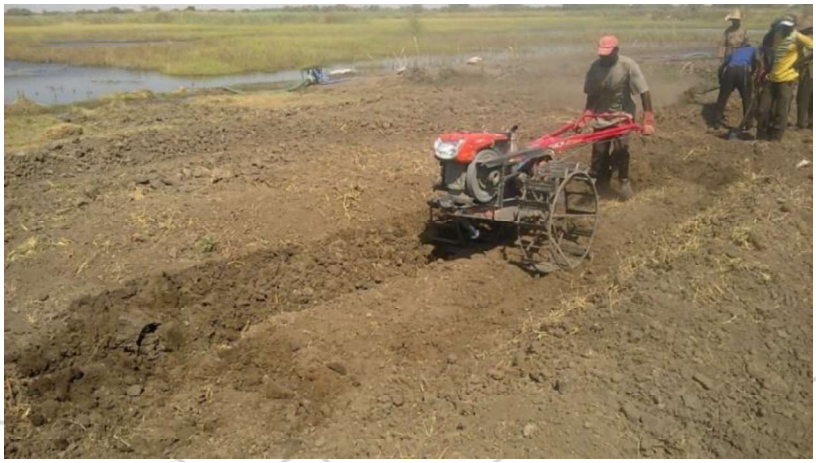

Fig. 1. Picture of bunding operation during rice farming at Lake Chad basin

2.2 Ploughing

The objectives of this activity are to bury the previous vegetation, loosen, overturn and aerate the soil, and bring leached nutrients back to the surface. Ploughing should be done 2 to 4 weeks before sowing or planting so as to give time for vegetation to rot and the acids to be neutralized. Land preparation is tedious and so it is frequently mechanized. Ploughing operation are encouraged in virgin land operations to further soften the soil for further tillage operation. Ploughing should be done at about 10 cm to 20 cm depth of top soil without water. Fig. 2 shows the picture of ploughing operation carried out during rice farming at Lake Chad basin.

Fig. 2. Picture of ploughing operation during rice farming at Lake Chad basin

2.3 Harrowing

Harrowing is the process of breaking up clods and smoothening of the soil that is suitable for planting seeds. It can be done in dry or wet conditions after rain or irrigation. Harrowing should be done with hoes, ox-driven harrows in water or tractor-disk harrows. It should be done until all debris are completely buried. Fig. 3 shows the picture of harrowing operation carried out during rice farming at Lake Chad basin.

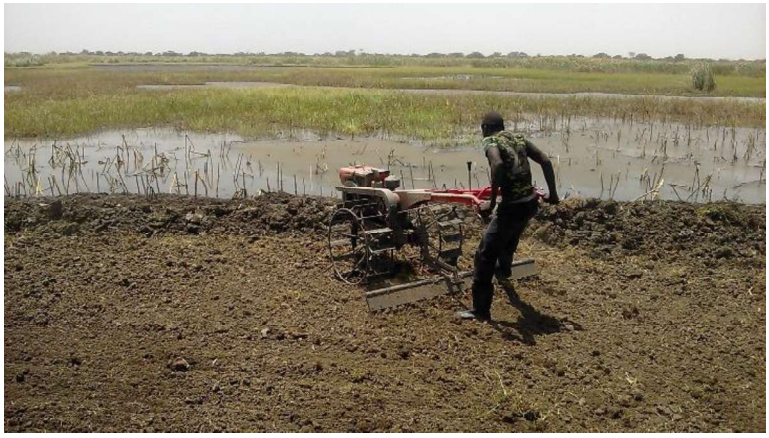

Fig. 3. Picture of harrowing operation during rice farming at Lake Chad basin

2.4 Puddling

Puddling is the process of further making the soil softer after harrowing. It serves to soften the soil for transplanting only under flooded conditions, creates a semi-hard pan for reducing percolation and help make levelling easier. Puddled fields should not be allowed to stand for long before sowing or transplanting. Puddling could be done when the field is flooded, by foot, with the use of cattle, hoes, cage wheels and rotavators or by repeated wet harrowing. Puddling should be done a day to planting or sowing. Puddling operation involves attaching puddlers to the power tiller to further till the soil when submerged in water to create a slurry mixture of soil and water that is best suited for transplanting rice seedlings. The puddling operation prepares the field for proper soil and rice attachment. Puddling to an extent helps in levelling the basin. Fig. 4 shows the picture of puddling operation carried out during rice farming at Lake Chad basin.

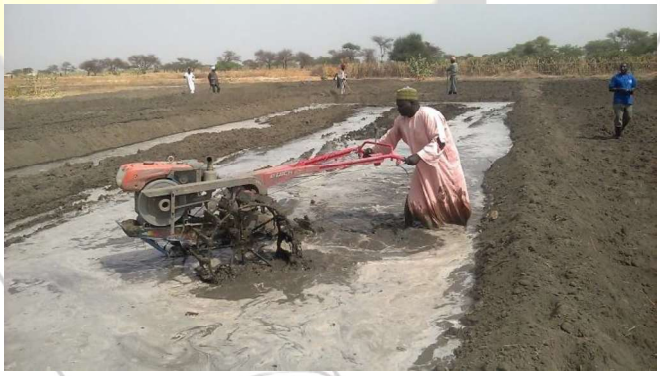

Fig. 4. Picture of puddling operation during rice farming at Lake Chad basin

2.5 Levelling

Levelling is the process of making a field surface relatively uniform and flat. The objective of levelling in land preparation is to produce a flat field where water management and nutrient distribution can be made easier. It involves the movement of soil from high (exposed) spots to low spots. This result in a smooth, level area before sowing or planting. This further promotes the equal submergence and reduces weed infestation in the basin. Fig. 5 shows the picture of levelling operation carried out during rice farming at Lake Chad basin.

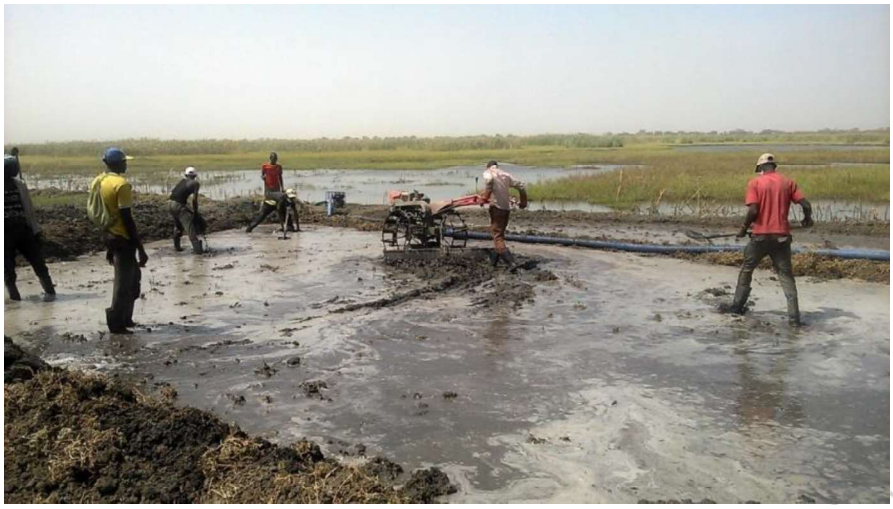

Fig. 5. Picture of levelling operation during rice farming at Lake Chad basin

2.6 Specialized Tillage Operation practiced in Sawah Eco-technology System

2.6.1 Furrow opening

Furrow opening is an operation that involve creating a channel for water to flow out of a waterlogged field and conversely also to lead water into a field for the purpose of irrigation. This is usually achieved through the use of (i) a specialized outward sweeping double disc or mouldboard implement designed for the purpose of furrow opening or (2) improvising a mouldboard ridger mounted on a power tiller or a tractor. Fig. 6 shows the picture of furrow opening operation carried out during rice farming in Amayi Igbere of Abia State.

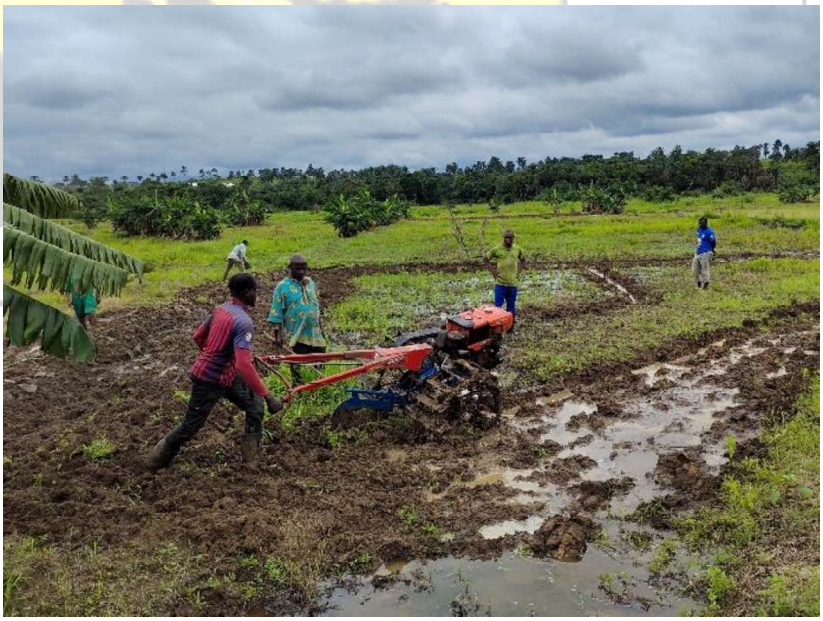

Fig. 6. Picture of furrow opening operation during rice farming in Amayi Igbere of Abia State

2.6.2 Poldering

A fertile tract of flat, low-lying land reclaimed from a body of water by the use of water supply and continuous puddling of adjacent leeves to achieve soil movement inward and water movement outward. This operation takes advantage of thixotropy, a time dependent shear thinning property of the soil becoming less viscous when subjected to an applied stress resulting to temporarily fluid when continuously puddled (shaken and stirred). Fig. 7 shows the picture of the stages involved during poldering operation carried out during rice farming at Lake Chad basin.

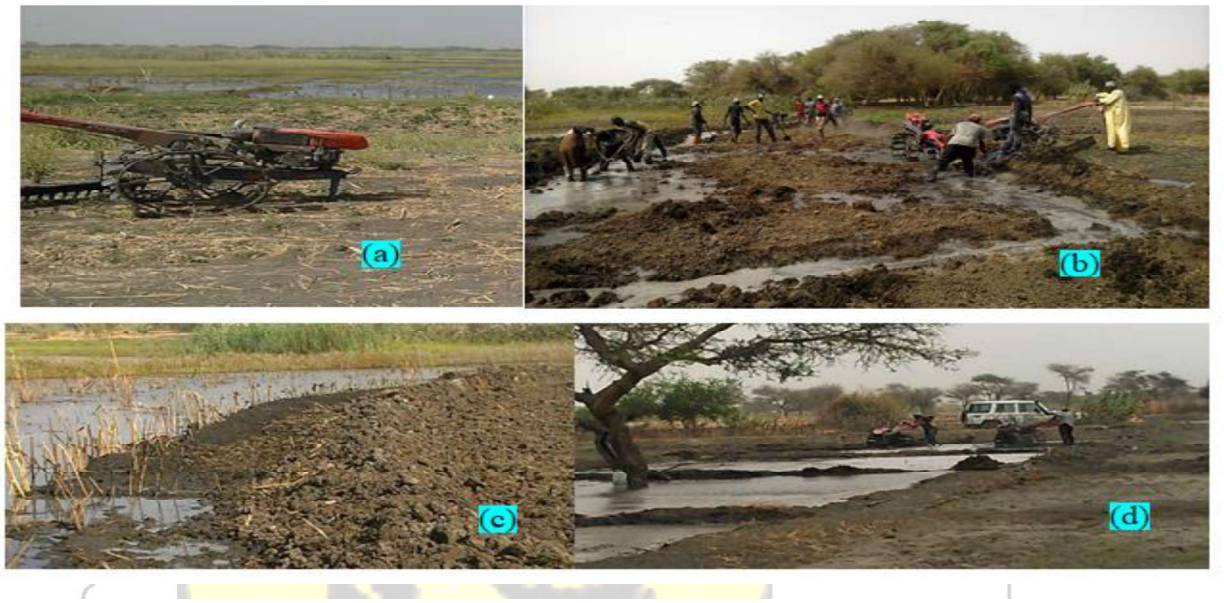

Fig. 7 a.) pre-intervention; b.) during poldering; c.) soil and water interface; and d.) levelled basins ready for rice seedling transplant

3. ADVANTAGES OF SAWAH ECO-TECHNOLOGY OVER TRADITIONAL SYSTEM OF RICE PRODUCTION IN NIGERIA

Sawah eco-technology encourages the multi-functionality of sawah systems in a watershed. Lowland sawah can produce at least 4 tons/ha of rice paddy with the application of chemical fertilizer as compared to the traditional upland rice with maximum yield which ranges from 1 to 3 tons/ha. Sustainable productivity of sawah based rice farming is therefore more than 10 times higher than that of upland slash and burn rice. The advantages of multi-functionality in sawah rice systems, according to Wakatsuki et al. (2011) include:

1. Intensive, diverse and sustainable nature of productivity through weed control by water and enhancement of nutrient supply; ecosysytem nitrogen fixation; increased phosphate availability which is a concerted effort of N-fixation; pH neutralizing eco-system to increase micronutrient availability; watershed geological fertilization: water nutrients and top soils from upland; and encouraging fish and rice, geese and sawah mutual relations.
2. Combating global warming and other environmental problems through carbon sequestration, that is, control of oxygen supply and methane emission under submerged condition, nitrous oxide emission under aerobic rice; control of flooding, soil erosion and electricity generation; watershed agroforestry by SATOYAMA approach to generate forest at upland; and denitrification of nitrate polluted water.

3. Creation of cultural landscape and social collaborations through terraced sawah system has beautiful landscape, fair water distribution systems for collaboration and fair society.

4. SUCCESS STORY OF SAWAH TECHNOLOGY IN NIGERIA

Sawah Eco- technology has been extended to more than 18 States of Nigeria with over seven hundred (700) local farmers trained to adopt the technology and over eighty (80) ha of lowland utilized for rice production. Presented in Table 2 are some of the achievements made while training farmers in different locations in Nigeria on the use of Sawah eco-technology for effective rice production. It can be deduced from Table 2 that the level of training received by these rice farmers irrespective of their locations had positive impact on rice yield.

Table 2. SAWAH Activities from 2015 to 2021

S/No.	State	Description	Location	No. of farmers trained	AYBT (t/ha)	Year	AYAT (t/ha)
1	Niger	ESTRASERIF	Rani	20	3.5	2015	5
2	Niger	ESTRASERIF	Ubandoma	25	3.5	2015	5
3	Kogi	ESTRASERIF	Koriko, Sarkin Noma.	20	2.5	2015	4
3.	Nasarawa	OJCB	Maraba,Tundun Kauri	8	3	2016	4.5
4	Nasarawa	OJCB	Shabu Azuba,	25	2.2	2016	3
5.	Niger	ESTRASERIF	Gbajigi	24	3	2017	4
6	Akwa-Ibom	PPP	Ini	21	-	2017	5
7	Akwa-Ibom	State Government	Nung Obong	31	2	2017	4
8.	FCT	Fadama	Yaba	18	1.8	2017	4
9.	Kano	Sasakawa	Bunkure, Kura	25	3.5	2017	4.2
10	Kebbi	ESTRASERIF	Kamba	20	3	2017	5
11	Kano	ESTRASERIF	Bagwai	20	3.5	2017	6
12.	Benue	ESTRASERIF	Tse-Abata	20	3.2	2017	6.5
13	Kwara	Landmark University	Omu-Aran	10	2.1	2018	4
14	Katsina	ESTRASERIF	Ajiwa	20	3	2017	4.6
15.	Ebonyi	ESTRASERIF	Uburu	15	3.5	2017	7
16.	Nasarawa	ESTRASERIF	Asakio	28	2.7	2017	3.5
17	Kwara	Landmark University	Omu-Aran	12	2.5	2018	4
18	Niger	ESTRASERIF	Gbajigi	27	3	2017	4.3
19.	Benue	ESTRASERIF	Apir	20	2.7	2018	6.5
20.	Akwa-Ibom	ESTRASERIF	Ikot Esen	20	3	2018	7
21	Anambra	ESTRASERIF	Ogboji	20	3.5	2018	6
22.	Osun	ESTRASERIF	Iwo	20	2.5	2018	5.5
23	Osun	ESTRASERIF	Osogbo, Gbonmi	25	3	2018	5.5
24	Taraba	ESTRASERIF	Mutum Biyu	25	3.5	2018	6.5
25	Kwara	ESTRASERIF	Lafiagi	20	3	2019	5.5
26	Kwara	ESTRASERIF	Shonga	35	3	2019	6
27.	Imo	ESTRASERIF	Mbaise	25	2.5	2019	5
28	Oyo	ESTRASERIF	Igbo Adan	20	3	2019	6
29.	Oyo	ESTRASERIF	Palapala	6	2.7	2019	5
30	Sokoto	ESTRASERIF	Goronyo	25	3	2019	5.5
31.	Ekiti	ESTRASERIF	Aishegba	25	2.5	2020	5
32.	Abia	ESTRASERIF	Ibeku	21	2.2	2020	4.5
33.	Niger	ESTRASERIF	Sheshibekun	23	3.5	2020	6
34.	Ogun	ESTRASERIF	Ifasa, Sawonjo, Igbogila	20	3	2020	5.5
35.	Ondo	ESTRASERIF	Awujale	25	3.2	2021	4.9
36	Ondo	ESTRASERIF	Okuta Elerin	25	3.3	2021	5.3

37	Ondo	ESTRASERIF	Akure North Secretariat	25	3.0	2021	5.0
38	Enugu	ESTRASERIF	Nnewe	25	2.7	2021	4.5
39	Benue	ESTRASERIF	Makurdi	25	3.2	2021	5.6

Keynote: AYBT = Average Yield before Training; AYAT = Average Yield after Training; OJCB = On-the-job capacity building; ESTRASERIF = Expansion strategy for Sawah Eco-Technology and Rice Farming; PPP = Public Private Partnership project

5. CHALLENGES OF SAWAH ECO-TECHNOLOGY FOR RICE PRODUCTION IN NIGERIA

The dissemination of the Sawah Eco technology in Nigeria has encountered the following challenges.

1. Rice farmers shy away from adopting rice transplanting method because it requires thorough tillage practice to the extent of levelling which these farmers try to avoid during farming operation.
2. Manual labour requirement for transplanting is a bottle neck to rapid full adoption of the technology.
3. Land tenure system if it is not well secured before sawah eco-technology is introduced into locality conflicts and eviction abounds.
4. The use of power tiller to carry out bunding operation require repeated passes to make appreciable bund. These repeated passes bring along the use of more energy in carrying out the task which leads to increase in soil compaction.
5. Poldering which is a specialized tillage operation is only applicable to an ecology of receding lakes, senile rivers, bank of dams and deltas which are not widespread.
6. Furrow opening which is also part of the specialized tillage operations carried out in Sawah eco-technlogy system require expertise in depth control to avoid damage to the soil through erosion.
7. The poverty level in Sub Saharan Africa (SSA) is among the factor that retards the ease of disseminating and adopting Sawah. The unexpected idea of some rural dwellers asking for compensation before allowing new technology to be demonstrated discourages technology transfer to the local farmers.
8. Farm practices amongst different cultures of a particular locality affect the ease of adoption. An example is the rate at which a local community that is familiar with bund making during rice field preparation is easier in adopting Sawah than others that don't bund their field for rice farming.
9. Some socio economic factors that affect the extension of Sawah eco-technology for farmer's adoption include:
    i. Age: The youth are more inclined to adopt the technology than the aged farmer.
    ii. Level of education: The higher the level of education of farmer the easier it is to adopt the technology.
    iii. Group dynamics: The extension of Sawah eco-technology is easier done through cooperatives and associations.
    iv. Farm size: An appreciable size of land attracts dissemination of technology than smaller fields.
    v. Land tenure and Land Ownership: This is one big challenge often encountered in areas where there is limited land supply appropriate for low land cultivation. Entry of Sawah Ecotechnology project to a community often lead to a tremendous increase in the value of such land and its neighbouring properties. The high prospect of gains makes the landlords to hike the value of the property wherever there is no prior agreements

vi. Location of Sawah plot: Close distance of plot to farmer encourages farmer input to the technology at every point in time during dissemination than plots that are far from farmer.
vii. Cost of use and Maintenance of Power Tiller: Proper skill in the use of power tiller increases the durability of the machine as well as appropriate maintenance culture (Ademiluyi et al., 2008). Whereas lack of skill will lead to quick damage and high cost of adoption.
viii. Language Barrier: In Nigeria, the multi lingual nature makes it difficult for a researcher or an expert from another part of the country to transfer technology because there is no universal way to describe Sawah (Wakatuki et al., 2008).

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This paper takes a good look at the tillage processes involved in Nigeria rice production using Sawah eco-technology and from all indications there is need to scale-up Sawah eco-technology for ease of adoption by enthusiastic Nigerian rice farmers through application of versatile new model power tillers, mini transplanters, sustainable solar water pumps and mini modular processing plants that is attractive to teeming youth of Nigeria.

6.2 Recommendations

Sawah eco-technology is gradually generating interest in Nigeria over the traditional system of producing rice. In an attempt to encourage rice farmers to adopt the system, the following approach are proffered as recommendations to intensify the promotion and widespread adoption of this proven technology that have moved Nigeria to its present position in Africa in rice production. The recommendations include:

i. Other state governments in Nigeria should borrow a leaf from Kebbi State government who worked in collaboration with the Federal Government team led by NCAM in providing an enabling environment for the spread and adoption of the technology by the State farmers.
ii. The present rice production rate in the country is increasing, however, effort should be intensified on the productivity rate which this technology is advocating and promoting.
iii. The technology is equivalent to the introduction of engineering into rice production which entails structural development, system design, field layout, bund and canal construction, development of weirs and dykes for optimum water management which improves tillering of rice seedlings suppressing weed growth within the rice field or basin invariably increasing rice production and bring about optimum water management.
iv. This good tillage practice can be adopted for other lowland crop production.
v. This system if well managed will increase productivity and reduce cost of production.
vi. The technology attracts youth to agricultural vocation and also encourage and permit mechanization practices towards achieving rice green revolution in Nigeria.
vii. There should be incentives by government and other donors to encourage farmers that adopts this technology. In addition, the technology is the way forward for agricultural revolution since it has the capability for sustenance and increased productivity.
viii. The technology is eco-friendly and should be encouraged to all lowland crop production.

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