Potential Impact of the 'Sawah' System on Rice Production in Ghana.

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Abstract

The 'sawah' system of rice production ensures increase and sustainable rice production, thus increasing income and reducing poverty. To estimate the impact of 'sawah' on rice production in Ghana four scenarios were considered: (i) Business-as-usually: Under this scenario no effective policy put in place and normal practices of rice production maintained. Yield per unit area will remain at 2.4 $MTHa^{-1}$, (ii) There is some amount of commitment. MOFA's target of 3.5 $MTHa^{-1}$by 2015 is achieved, (iii) Serious commitment by all stakeholders with 50% of area under rice production developed into 'sawah' in 2015 and paddy yield averaged at 5.0 $MTHa^{-1}$ under 'sawah' and (iv) Serious commitment by all stakeholders with 75% of area under rice production developed into 'sawah' by 2017 and paddy yield averaged 5.0 $MTHa^{-1}$under 'sawah'. Estimated rice production under 'sawah' in 2015 (scenario 3) will be 54% more than what would have been produced under normal practices (scenario 1). In 2017 if 75% of the land under rice cultivation is developed into 'sawah' then production will be twice what would have been produced under scenario 1. With increasing local rice production the quantity of imported rice will decrease resulting in reduction in pressure on the country's foreign exchange. Promoting the 'sawah' system of rice production will enhance the output and income of the small holder farmers, processors and traders, thus promoting national economic growth and thus enhancing and ensuring food security.

Key words: Inland valleys, paddy yield, projections, scenarios,

Introduction

In Ghana about 13.3 million hectares is potentially arable land(MoFA, 2010), and the density of population per cultivable area is moderate. Nearly 60% of the arable land is presently not cultivated. Although much of this surplus cultivable land may be under temporary bush fallow in the crop rotation/bush fallow system, there still is substantial land which remains fallow every year. The potential area for small scale irrigated 'Sawah' in valleys is estimated at 700,000 hectares (JICA/CSIR-CRI, 2000; Wakatsuki, 1994). There is also the potential for increasing production by increasing productivity. Yields of most crops can be increased significantly through application of improved technologies such as timely and proper application of fertilizers, adequate weeding, use of improved seeds, proper cultural practices, and use of the 'Sawah' system of rice production in the inland valleys.

Critical attention should be given to food production since agriculture is very essential to the macro-economic performance and to the Governments economic recovery and poverty reduction program. Introduction of the 'Sawah' technology (bunded, puddled and levelled rice field with irrigation and drainage facilities) has resulted in significant rice yield. Buri, et al. (2008) observed a significant increase in rice yield (averaged 1.0t ha^{-1} initially and 4.0 t ha^{-1}after a year and presently above 5.0 t ha^{-1}) when 'sawah' was introduced to farmers in part of Ashanti region. Issaka et al (2009) also observed high rice yield (> 6.0 t ha^{-1}) under 'sawah' system over the traditional system. The "sawah' system of rice production satisfies both areas of sound environment and high rice yields. It also enhances nutrient build-up, especially carbon and exchangeable cations. This paper discusses the potential impact of 'sawah' system on rice production in Ghana.

Materials and Methods

Secondary data were obtained from literature. These include; Estimation of area suitable for *Sawah* development in Ghana (JICA/CSIR-CRI, 2000; Wakatsuki, 1994) and Information on area under rice production and amount produced from 2002 to 2009 (MOFA, 2010). Rice yield per unit area under Sawah system (Buri, et al. 2008, Issaka et al 2009). National average yield of rice was compared to yields under the Sawah system in the development of various scenarios.

Results and Discussion

Rice production and productivity:

National rice production from 2002 to 2009 is presented in Table 1. During this period rice yield per unit area ranged between 1.0–1.5 MT ha^{-1}. This very low rice yield suggests the unavailability of good technologies. Under such a situation production can only be improve by increasing the land area under rice production leading to further environmental degradation due to extensive cultivation. Presently rice yield per unit area has increased to 2.4 $MTha^{-1}$ (MOFA, 2010). This value is still very low if the country is to produce enough rice for consumption and reduce importation. Under the Ministry of Food and Agriculture strategic plan, productivity is targeted at 3.5 $MTha^{-1}$in 2015 (MoFA, 2010) which still falls below expectations considering the rate of rice consumption in the country.

Table 1. Rice production in Ghana from 2002 to 2009

Year	Area Cultivated	Paddy Produced '000 MT	Yield $MTha^{-1}$
2002	123	168	1.4
2003	118	143	1.2
2004	119	145	1.2
2005	120	142	1.2
2006	125	150	1.2
2007	109	111	1.0
2008	133	181	1.4
2009	162	235	1.5

Adapted from MOFA, 2010.

Traditional rice production: In Ghana inland valleys occur throughout the country and have a huge potential for rice production (JICA/CSIR-CRI, 2000). Many inland valleys are annually used largely for rice production and to some extend vegetables. Rice is normally grown using traditional methods.

Lack of structures to manage water, use of a mixture of rice varieties and little or no application of fertilizers. The traditional system of rice production is becoming more unreliable under the current climatic conditions. Crop failure can be as high as 80-100 % when a long drought sets in. To arrest this situation ecological sound management practices need to be adopted

'Sawah' system of rice production: 'Sawah' is defined as bunded, puddled and levelled rice field with inlets for both irrigation and drainage. "Sawah" has an intrinsic resistance to erosion and self enriching in some major nutrients. Many studies on the use of 'Sawah' for rice production in Ghana have been done. This range from description of various 'Sawah' systems (JICA/CSIR-CRI, 2000), rice agronomy (Buri et al, 2004, Issaka, et al. 2009), nutrient status of inland valleys (Buri et al. 2009, Senayah et al, 2008, Issaka et al 1997) and general development of inland valleys into 'Sawah' fields. Currently rice yield under the 'sawah' system of rice production ranged from 4.0 - 7.5 $MTha^{-1}$. If this condition is up-scaled nationwide rice production will increased significantly.

Scenarios and Projections

To increase rice production significantly to the point of self sufficiency requires a systematic and scientific approach. Huge investments using the appropriate technologies are necessary to achieve the desired results. We create scenarios and project rice production under these conditions. Assuming the area under rice cultivation (162,000 ha) in 2009 is maintained in 2015, the production levels will differ depending on the commitment by the Ghana Government towards rice production as follows:

Scenario One. Business-as-usual: Under this scenario no effective policy is in place and the normal practices maintained. Yield per unit area will remain at < 2.4 $MTha^{-1}$

Equation 1. Production = A x Qn where A is area under cultivation in hectares and Qn is yield per ha under normal practice.

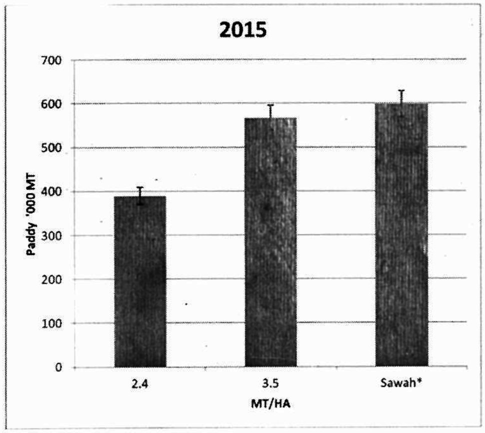
Scenario Two. There is some amount of commitment and MOFA's target of 3.5 $MTha^{-1}$ by 2015 is achieved.

Equation 2. Production = A x Qt where A is area under cultivation in hectares and Qt is yield per ha (MOFA target)

Scenario Three. Serious commitment by all stakeholders with 50% of area under rice production developed into 'sawah' in 2015 and paddy yield averaged at 5.0 $MTha^{-1}$ under 'sawah' while 50% of the area will give 2.4 $MTha^{-1}$.

Equation 3. Production = (A/2) x Qn + (A/2) x Qs where A is area under cultivation in hectares and Qs is yield per ha under 'sawah'

Using these scenarios, rice production in 2015 will be below 400,000 MT under scenario one while production will increase significantly under scenario two and three (Fig 1). Paddy produced under scenario three will be at least 200,000 MT more than under scenario one. However rice produced under scenarios two and three will be similar.



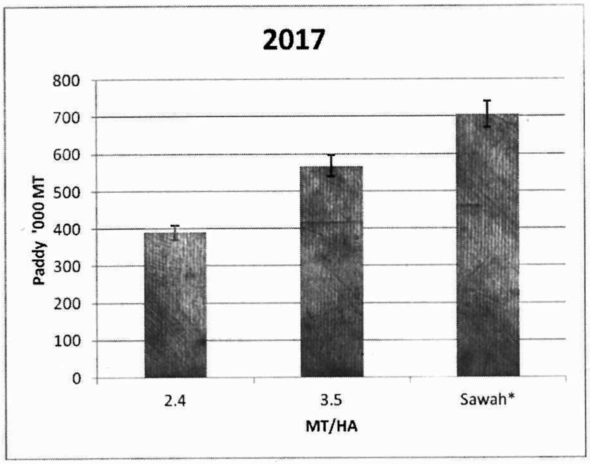
**50% of area under sawah (average yield: 5.0 MTHa^{-1})*

Figure1. Projected rice production in 2015 under different scenarios

Scenarios one and two still applicable in 2017, more valleys will be progressively developed into 'sawah'.

Scenario Four. Serious commitment by all stakeholders with 75% of area punder rice production developed into 'sawah' and paddy yield averaged 5.0 MTha^{-1} under 'sawah'.

Equation 4. Production = (A/4) x Qn + (3/4A) x Qs where A is area under cultivation in hectares and Qs is yield per Ha under 'sawah'



75% of area under sawah (average yield: 5.0 MTHa^{-1})

Figure 2. Projected rice production in 2017 under different scenarios

Conclusion

Progressive development of valleys into 'sawah' will ensure significant increases in rice production. By 2017 rice produced under scenario three will be almost twice that produced under scenario one and significantly more than that produced under scenario two. Within the rice value chain small holder males dominate in the production sector while small scale processors and traders are mostly females. Promoting the 'sawah' system of rice production will enhance the output and income of the small holder farmers, processors and traders, thus promoting national economic growth. Additionally the 'sawah' system satisfies both areas of sound environment and high rice yields.

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Experiences of 'Sawah' Development Activities in Ondo and Delta States of Nigeria.

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Abstract

The consumption of rice had risen astronomically in Nigeria and SSA over the last 2 decades. Production of rice to meet demand of the growing population is a major challenge for all stakeholders. The solution to this challenge lies in the realization of rice green revolution through the adoption of "Sawah" Eco-technology. Rice production through site specific adaptation, environmental eco-technology and lowland reclamation is very necessary. "*Sawah*" is an eco-technology concept which improves rice ecology. The term "Sawah" refers to levelled rice field surrounded by bunds with inlets and outlets connecting irrigation and drainage canals. The basic concepts of "*Sawah*" eco-technology are site selection, "*Sawah*" systems design, field development, use of High Yielding Varieties (HYV) of rice, agronomic management involving water management, soil fertility management, weed control and pest management. This paper discusses four important skills and technologies for 'sawah' dissemination as experienced in Ondo and Delta States of Nigeria viz: (1) site selection and site specific 'Sawah' system design,(2) skills for cost effective 'sawah' systems development and management (3) farmers organization for successful on-the-job training, development and management of 'sawah' system, (4) 'sawah'- based rice faming to realize at least the sustainable paddy yield of > 4 tha^{-1} paddy and 20 ton paddy production within three years using one power tiller for 5ha *Sawah* operations.

Keywords: dissemination, eco-technology, experiences, farmers, "Sawah"

Introduction

The consumption of rice had risen astronomically in Nigeria and SSA over the last two decades. Production of rice to meet the demand of the growing population is a major concern for all stakeholders in the rice value chain. The answer led in realizing the target for green revolution in the rice value chain through the adoption of 'Sawah' Eco-technology for rice production on site specific adaptation, environmental eco-technology and lowland reclamation. The realization of Nigerian Rice Green Revolution is not only based on irrigation for water supply, fertilizer for nutrient supply and high yielding varieties but also on managing irrigation for effective water supply. It has been postulated that the prerequisite for a speedy achievement of rice green revolution in Nigeria and Sub-Saharan Africa is through the adoption of the "Sawah" Eco-technology, (Waktsuki, et al 2009).

Ondo State, is located in the South-western Zone of Nigeria and lies between longitudes 4"30" and 6" East of the Greenwich Meridian, 5" 45" and 8" 15" North of the Equator. Ondo State is composed of lowlands and rugged hills with granitic outcrops in several places. The geo-morphological units of the creek and river rine areas include sand ridges, lagoons, swamp flats, creeks and the anatomising distributaries of the western Niger Delta. Numerous rivers flowing southwards to the Atlantic Ocean drain the state.

The major rivers flow through sedimentary rocks in deeply incised valleys aligned in a north-south direction, into the coastal lagoons. The climate of Ondo State is of the Lowland Tropical Rain Forest type, with distinct wet and dry seasons. The mean annual total rainfall exceeds 2000 millimetres. The natural vegetation is high forest. Over most of the state, the natural vegetation has been very much degraded as a result of human activities, the major being the rotation of bush fallow system.

Soil: The soils, derived from Basement complex rocks are mostly well drained, with medium textures. The soils, classified as Ondo Association, are of high agricultural value for both tree and arable crops. The swamp flats are characterised by swampy organic and flooded organic soils.

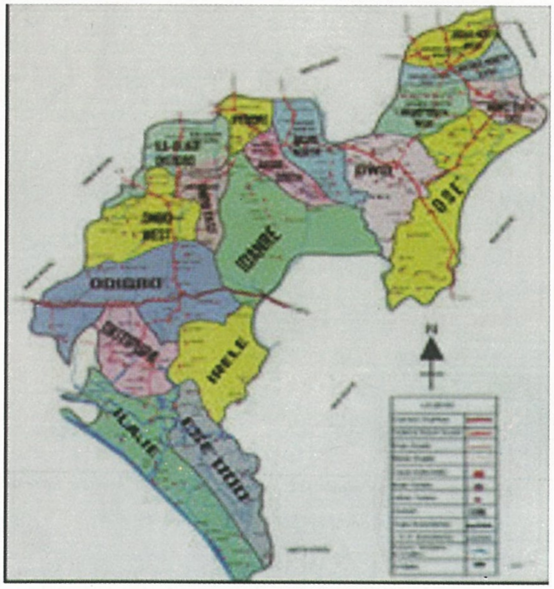

Fig. 1: Map of Ondo State of Nigeria

DELTA STATE

Delta state on the other hand covers a landmass of about 18,050 Km2 of which more than 60% is arable land. The State lies approximately between Longitude 5°00 and 6°.45' East and Latitude 5°00 and 6°.30' North. Delta State is generally low-lying without remarkable hills with a wide coastal belt inter-lace with rivulets and streams, which form part of the Niger-Delta. It lies between the flood plain and Benin lowlands. The swamps are more restricted to broad drainage channels created when this area was an active delta. The average monthly rainfall is about 266.5mm in the coastal areas and 190.5mm in the extreme north. Rainfall is heaviest in July. The vegetation varies from the mangrove swamp along the coast, to the evergreen forest in the middle, and the savannah in the north east.

Soil: There are three types of soil in Delta State. These consist of alluvial soil on the marine deposits along the coast; alluvial and hydromorphic soils on marine and lacustrine deposits found in the area closest to the Niger and Benin rivers; and the ferral soils on loose sandy sediments in the dry land areas of the north and northeast. The ferral soils are usually yellowish in colour.

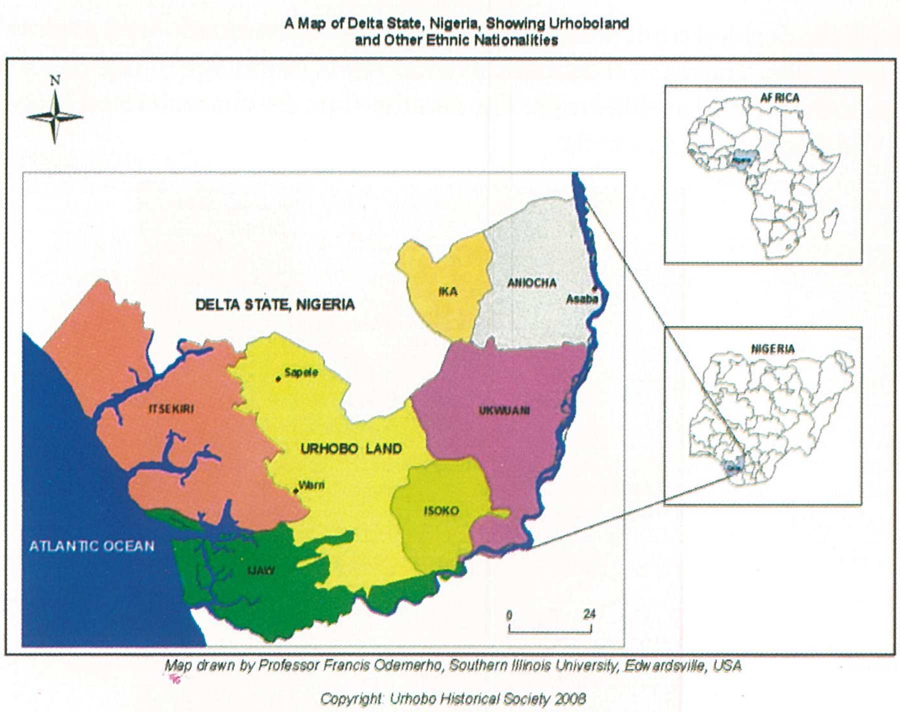

Fig. 2: Map of Delta State of Nigeria

"Sawah" Technology in the States

Ondo and Delta states of Nigeria are among the rice producing states in the country favoured by their ecological and relief pattern. Ondo has about 40,000 hectares of land while Delta has about 20,000 hectares of agricultural land suitable for rice production, (Longtau, 2003). The major rice systems in the two states are shallow fadama and valley bottoms (swamps) due to the soil formation and relief pattern of the states. Valley bottoms, or 'deep *fadama*', provide the ideal environment for rice production. However, due to lack of flood control technology and appropriate varieties, this system remains largely untapped, (Madu-West, 2002).

These prevailing conditions and the multi-functionality of the "Sawah" system makes the two states the target of the Kinki University 'Sawah' Project and NCAM-Kinki University/Fadama III 'Sawah' Technology project.

Materials and Methods

'Sawah' was introduced to Ondo state in 2008 through the joint efforts of State Agricultural Development Program (ADP) under the auspices of the state commissioner for Agriculture and the sawah project led by Prof. T. Wakatsuki of the Kinki University, Japan. It commenced with demonstration sites covering two hectares at Ahule in the neighbourhood of the state capital.

The 'Sawah' activities in Delta state is as a result of the collaboration between NCAM-Kinki University and Fadama III project of Nigeria. About 2.5 hectares of land was developed in the introductory stage as one of the selected pilot stations was established in ogbologboma/Asaba the South-South geo-political zone of Nigeria.

Results and Discussion

Experiences in Sawah Eco-Technology dissemination in the States

(a) On-the-Job Training of Extension Officers of ADP and Fadama III

The 'Sawah' activity in the states has led to the training of more than three Officers of Fadama III project in Delta state and five ADP extension officers in Ondo state. The trainings were conducted both on the site and in other locations across Nigeria through collaboration with the International Co-operation Centre for Agricultural Education of Nagoya University, Japan, National Cereal Research Institute, Badeggi, Nigeria and National Centre for Agricultural Mechanization, (NCAM), Ilorin, Niger.a as well as Kinki University, Nara, Japan. The trainings covered different skills of 'Sawah' development techniques which include:

Site Selection: 2-4days per potential site

The priority sites were rice cultivation areas for easy dissemination of the Sawah Technology: The best season for the site selection is December/October during the rainfall season, but in the case of Ondo state just before harvesting in November and after harvesting between January/ end of February. This was possible after hearing from rice farmers about the local hydrological conditions of the area which is very important as it helps to identify extreme draught and flood conditions of the area. Characteristics of selected sites should include the following:

a. Secure continuous water flow: Aule in Ondo State had > 5 month base water discharge : > 20lt/sec, i.e. > 1500-2000m^3/day, potential irrigated sawah area >10-20ha.
b. The Flood depth is < 50cm and continuation of the flood is stronger within few days after continuous rainfall. This normally happens in September and with such cases we normally involve big scale engineering works in preparation against the coming flood attack to control water.
c. Flat and very gentle slope :< 2%, slope is < 0-1%, leveling operation is easy.
d. Strong will of rice farmers to master Sawah technology skill and Sawah development by farmers self support effort.
e. Good road access for demonstration
f. Land tenure to secure rent between 5-10 years.
g. Good soil texture (not gravelly)

Sawah-based rice farming in the first year of New Sawah Development at Aule in Ondo State

'Sawah' water control: 35 days-work per ha.
'Sawah' system maintenance: 30 work-day per ha.
Transplanting: 15 work-days per ha.
Fertilizer: 2 work-days per ha.
Weeding: 6 work-days per ha.
Bird scaring: 35 work -days per ha.
Harvesting: 10 work-days per ha.
Threshing: 8 work-days per ha.
'Sawah'-based rice faming is to realize at least the sustainable paddy yield > 4t ha^{-1}

and 20 ton paddy production within three years using one power tiller for 5ha 'Sawah' Development operations.

On-the-Job Training of Leading Rice Farmers

During the training as outlined earlier, farmer groups were identified and new ones formed to introduce and disseminate 'Sawah' eco-technology to them. Leading rice farmers were identified and trained in line with the peculiar characteristics of the groups.

Impact of Activities on Farmers and Society

The impacts of 'Sawah' activities in the states are: (i) Increased youth participation in farming and provision of employment, (ii) De-nitrification of nitrate polluted water, (iii) Watershed agro-forestry (SATOYAMA) adotion which encourages conservation of the environment, forest generation, enrichment of the lowland through various geological processes, (iv) 'Sawah' has contributed to control of flooding and soil erosion in the states (v) 'Sawah' has created cultural landscape and social collaboration among different tribes in both states, (vi) 'Sawah' has become valuable in the current rehabilitation process in the Niger Delta of Nigeria, and (vii) 'Sawah' systems serve as field laboratorys for research and technology generation and the factory for dissemination of the technology developed.

Challenges

The major challenge facing the dissemination of the 'Sawah' eco-technology in the states is the mechanization of field activities. It has been brought to our notice that mechanizing field operations can easily result in 80% utilizations of the lowlands. Thus, suitable means of adaptation of the power tiller for bund making, canal construction digging, transplanting, harvesting and transportation are required. The following are some of the major constraints experienced during introductory aspects of lowland mechanization for rice production in both Ondo and Delta states:

(i) Scarcity of trained and experienced operators of single axle tractors. Success of several operators depends on expertise level of Power Tiller operator.

(ii) Poor ecology. The lowlands are often with low weight bearing capacity resulting in sinking of heavy single axle tractors in excess of 10hp.

(iii) Inappropriate wheel design: Paddle wheels are better suited for the puddling operation in 'Sawah' lowland basins. Pneumatic tyres or skid wheels are not appropriate and tend to increase the incidence of sinking.

(iv) Limitation in application of Power Tiller to several vital operations of new 'Sawah' development. Bund making takes a significant proportion of power requirement in new sawah development, and there is challenge in finding appropriate adaption of the single axle tractor for this operation. A team of 'Sawah' researchers of the National Centre for Agricultural Mechanization, Ilorin is trying to develop a bund builder implement to be attached to the single axle tractor for this important operation.

(v) Leveling necessitate heavy, medium or light movement of soil mass as determined by topography and layout design of 'Sawah' basins. Efforts at machine adaptation for effective leveling are still being limited by:

a. *Fragmentation or small basin sizes:* the need to preserve the top layer soil where high gradient necessitate more than moderate soil movement. So far, the only practicable option is manual intervention in temporary removal of top soil and replacement after sub-layers has been moved.

b. *Machine sinking* following repetitive passes on 'Sawah' basins in the attempt to achieve leveling is a common feature. To reduce or avoid this, it is important to match the weight of machinery to bearing capacity of the soil, avoid too many post puddling passes and maintain adequate basin water level during leveling.

c. *Maneuverability:* - Since bunds are sources of obstruction to machinery movement in a 'Sawah' basin care must be taken to avoid getting the chassis caught in the heap. Experience has shown that diagonal orientation is preferred in crossing the bunds.

(vi) Puddling: - Puddling operation can be hampered by presence of stumps and rock particles in the basin which can damage the cultivator. Attempting a puddling operation without adequately flooding the basin to > 5cm water depth often result in poor performance of the power tiller and eventual sinking whereas heavy soils like clayey hold down the wheels and cultivator of the power tiller.

(vii) Transplanting:- Poor alignment of plant rows due to non-strict compliance with the guidance of the planting ropes create difficulty in mechanized weeding when needed.

(viii) Weeding:- The push-pull rotary weeder is most suitable for control of obnoxious weeds in a flooded sawah basin but this weeder is yet to be popular in our rice growing communities. Presently, hand picking remains the most widely applied option for weed control in a flooded sawah basin.

(ix) Harvesting and Processing: - Non availability of mechanized harvester suitable for the various traditional rice growing terrains has been a constraint to rapid expansion of production with increasing adoption of technologies like 'Sawah'. It has become necessary to mechanize harvesting and processing even at low levels. With the advent of small scale harvesters like "RICH" presently undergoing modification to adapt it to realities of the fields and processing plants capable of presenting rice free of stones and other impurities, there is high hope that locally produced rice can be presented to the market competitively enough to sustain and stimulate further cost effective local production.

Meeting SERIF'S Target

Continuous study and research into mechanization challenges at several and various stages of 'Sawah' development will help to bring about the much needed realization of rapid rice yield increase and probable realization of the green revolution. To meet the target for 'Sawah' Eco-technology and Rice Farming (SERIF) in Ghana, Nigeria and Sub-Sahara Africa with particular reference to Ondo and Delta States of Nigeria, there is need for more research activities on mechanization, address challenges and find solutions to constraints. Also more people (farmers and Extension agents) have to be empowered through capacity building (training) programs and workshops.

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Impact of Mechanization on Lowland Use and Rice Production in Nigeria

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Abstract

The Nigerian food situation is vulnerable to the changing global trends as the country is a net importer of major food items. The market demand and prices of rice worldwide will likely remain high as other crops, (e.g. maize and cassava) are diverted for bio-fuel production. These global changing trends therefore challenge Nigeria to quickly address this vulnerability by refocusing and retuning the entire agricultural system in the country. There is great potential for Nigeria to achieve large-scale production of rice but this has to be complemented with capacity for high quality post-harvest technologies for processing, storage and marketing to serve both domestic and foreign markets. This study examined the impact of using power tiller as a means of increasing lowland use and mechanizing lowland rice production in Nigeria. The study was carried out in Bida area, Niger state, where the 'sawah' rice farming eco-technological concept was disseminated by Watershed Initiative in Nigeria (WIN) and in Ajase Ipo and Elerinjare of Kwara State. Some of the parameters assessed during the study included average speed of operation, average wheel slip/travel reduction, average draught of implement, and fuel consumption. The cost of operation and yield over five years of usage at Niger State and two years in Kwara State were determined and it was therefore concluded that the power tiller is the most appropriate field machinery for tillage operations such as ploughing, puddling and levelling on lowlands for rice production in Nigeria.

Key words: lowland use, mechanization, rice production, power tiller.

Introduction

Major changes have taken place recently in farming practices in Nigeria. These have been encouraged by the development of irrigation facilities, the adoption of modern high yielding varieties and the proper use of chemicals. Land preparation has also shifted from traditional to mechanized methods. The main reasons are timeliness of operation, better quality of land preparation and weed control, less drudgery and lower tillage costs. Agricultural mechanization is the application of mechanical technology and increased power to agriculture, largely as a means to enhance the productivity of human labor and often to achieve results well beyond the capacity of human labour at minimal cost. This includes the use of tractors of various types as well as animal-powered and human-powered implements and tools, internal combustion engines, electric motors, solar power and other forms of energy.

Mechanization also includes irrigation systems, food processing and related technologies and equipment. Levels and types of improved mechanical technologies need to be appropriate, compatible with local, agronomic, socio-economic, environmental and industrial conditions. Rice has become an important strategic and daily staple food crop in Nigeria. The potential land area for rice production in Nigeria is between 4.6 - 4.9 million ha. Out of this, only about 1.7 million ha (35%) of the available land area is presently cropped to rice (WARDA, 1988).

The main production ecologies for rice in Nigeria are rain-fed lowlands; rain- fed upland, irrigated lowland, deep water / floating and mangrove. Of these, rain-fed lowland rice has the largest share of the rice area (50%) and rice production as shown in Table 1. New high-yielding lowland varieties of the NERICAS are undergoing agronomic evaluation in Nigeria and several other countries.

Small-scale farmers with farm holdings of less than 1 ha cultivate most of the rice produced in Nigeria. However, rice productivity and production at the farm level are constrained by several factors. These constraints include insufficient appropriate technologies, biotic factors, poor supply of inputs, ineffective farmer organizations and groups, low yield and poor milling quality of local rice varieties, poor marketing arrangements, inconsistent agricultural input and rice trade policies, poor extension systems and environmental constraints. These environmental constraints include poor drainage and iron toxicity in undeveloped lowland swamps, poor maintenance of developed lowland swamps, drought, deficiencies of N and P, insufficient rainfall and poor soil management practices. The size of the average family holding in many developing countries is of the order 2 to 5 hectares, with 3 hectares as an appropriate average figure. Such a holding would therefore require a power input of 1.2 kW(Crosceley, 1978). It is therefore the opinion of many that due to the economic level of majority of farmers in developing countries like Nigeria, in transforming from the presently predominant hand- tool technology to a full blown large scale engine power technology, there has to be an appropriate intermediate technology. In the past this has been viewed as the animal draft technology. However, the introduction of two-wheel tractors (power-tillers) in many countries is proving to be a better and more appropriate intermediate technology. In the past five to six years, there has been an influx of two- wheel tractors into Nigeria and the demand has particularly been increasing in rain-fed lowland areas where its use for the cultivation of lowland rice is increasingly becoming popular.

The objectives of this study are to (i) determine the profitability of using power tiller in rice production, (ii) determine the impact of power tiller on increasing lowland use capacity and (iii) determine the impact of using the power tiller as a means of mechanizing rice production.

Methodology

Description of the machine used: The power-tiller or walking tractor, as it is sometimes called is a single-axle (two-wheel) tractor. This particular one is of Indian make and the model is VST-SHAKTI 130 DI with 10 kW (13 hp) rated power, diesel engine of 2400 rpm rated crankshaft speed. The engine is single cylinder horizontal 4 strokes, water cooled and hand-cranking type. The driving wheels are of two types: the pneumatic type for normal traction and the steel or cage wheel for wet puddling.

Field layout, location and operations: The operation of the machine was carried out in wet puddling on two different rice field located at Shaba-Maliki and Ejeti village near Bida on a clayey loamy and sandy soil respectively. Bida is 137 m above sea level and lies on longitude 6° 01'E and latitude 9° 06'N in Niger State of Nigeria. Ajase Ipo of Kwara State is at an altitude of 370 m above sea level and lies on longitude 2^0 30'E and latitude 7^0 45'N both under the Guinea savannah ecology of Nigeria. The 600 mm tine cultivator was attached to the power tiller and it was used for puddling of the field before transplanting of rice was done. Fashola *et al., (2007)* has a detailed description of the 'sawah' system on farmers' fields. Some of the parameters assessed during the field test included average speed of operation, average wheel slip/travel reduction, average draught of implement and fuel consumption. The soil properties monitored included soil moisture content, bulk density, porosity, penetrometer resistance/cone index and shear strength. The core technique was used in obtaining samples for bulk density measurement, soil penetrometer and shear vane readings were determine *in situ*. Soil samples were obtained at various depths of 7 cm intervals. Soil laboratory analysis was done using standard procedures (Hunt, 1977).

Cost determination: Cost calculations for mechanized farm operations are almost similar everywhere. Usually there are basic assumptions and few other adjustments are made to suit the particular needs and locality. For example, while in some countries taxes are paid on agricultural machines and implements, in Nigeria they are tax-free.

Costing of mechanized operation can be done either on an hourly basis or a hectare basis. The former is only meaningful when accurate records of the time (machine hours) are available. In Nigeria, 34.7% of the operator's time was spent in doing unproductive work of which 31.2% represents avoidable delays (Aboaba, 1965). It would be unfair and inaccurate to add this idling time to the overall time for carrying out an operation. The farmer is more interested in knowing how much it will cost him to farm a unit area so as to compare it with the yield per unit area.

Generally, machinery costs fits into two broad categories:
Fix costs: The factors involved in the calculation of operating costs of farm machinery can be grouped under two main components - "fixed and variable" costs. Fixed cost includes cost that must always be taken into account whether the machinery is in operation or not. They are related to machine ownership and represent a form of financial discipline, to make sure that the business does in-fact pay-off capital investment within a reasonable period. They are depreciation (on tractor and on implement), interest on investment, taxes, insurance and shelter. After reviewing several methods of cost claculations, it was found that for the Nigerian condition, the straight line method was most appropriate. The equation used was: Depreciation = Initial cost of machine/expected total hours of use.

Variable costs: Variable cost is the remaining operating cost that depends on particular operations and is directly proportional to the machinery usage. This includes labour (operator and mechanic), spares, fuel and lubricants.
(i) Labour: The usual daily rate for skilled workers like operators and mechanics increases from N500 in 2002 to N700 in 2006 per day while it was N 1,000 to N 1,200 per day in 2009 to 2010, but it is very uncommon to employ mechanics on a daily wage basis; instead they are paid whenever their services are needed in a case of sudden breakdown.
(ii) Fuel: The variables that have direct influence on the fuel consumption for any operation are speed of operation and soil properties (texture and moisture) and skill

of operator. Fuel cost perper ha can be given as

$$F = \frac{fxp}{c} \quad .... (1)$$

Where F = fuel cost/hectare (ha), f = fuel consumption rate (l/h), p = cost of fuel (l), c = rate performance of machine or machine capacity (ha/l).

The operating cost of power tiller was determined based on its annual use for a period of five years. The cost per year was calculated by the relation:

$$C = \frac{(FC)P}{100} + \frac{H(R\&M)}{10^4} + L + O + F \quad ....(2)$$

Where C = annual cost, FC = annual fixed cost, % (interest + taxes + depreciation); this value is often rounded off at 16%, P = purchase price, H = hours used per year, R&M= repair and maintenance cost, % per 100 hr of use, L= labour cost per year, O = oil cost (often 10% of fuel) per year and F = fuel cost per year.

Table 1: Share of rain-fed/irrigated lowland rice areas in Nigeria

Production system	Major states covered	Share of rice area (%)	Average yield ($t\ ha^{-1}$)	Share of production (%)
Rain-fed lowland	Akwa Ibom, Bayelsa, Edo Benue, Cross River, Ekiti, Ebonyi, Delta, Ogun, Ondo, Kaduna, Lagos Niger and Rivers states.	50	2.2	53
Irrigated	Anambra, Benue, Borno. Cross River, Ebonyi, Enugu, Kano, Kebbi, Kogi, Niger and Sokoto states.	16	3.5	27

Source: WARDA (1988)

Results and Discussions

The summary of the field tests, effects of the tillage tool on some soil physical properties and the operating cost of power tiller are presented in Tables 2-5 The test of significance difference between the measured parameters across sites as presented in Table 3 were not significant for most of the parameters except for Slippage, which was significantly higher in Ajase Ipo with a mean value of about 11.10% when compared to the mean values of Shaba Maliki and Ejeti (10.53% each). For the non significant parameters, however, it was observed that the effect of tillage operations is relatively the same for the three sites. This simply implies that fuel consumption, for instance, did not differ significantly across sites. This was true for all non-significant parameters and conforms to derivation of basic design of small tractors (Crosceley, 1978).

Table 2: Descriptive statistics of field operation result

Parameters	Site	N	Mean	S.D	S.E
Slippage	Ejeti	3	10.53	0.000	0.000
	Shaba Maliki	3	10.53	0.000	0.000
	Ajase Ipo	3	11.10	0.000	0.000
	Total	9	10.72	0.285	0.095
Effective field cap.	Ejeti	3	0.047	0.008	0.005
	Shaba Maliki	3	0.089	0.046	0.027
	Ajase Ipo	3	0.055	0.012	0.007
	Total	9	0.064	0.031	0.010
Theoretical field cap.	Ejeti	3	0.050	0.010	0.005
	Shaba Maliki	3	0.096	0.049	0.028
	Ajase Ipo	3	0.071	0.009	0.005
	Total	9	0.072	0.032	0.011
Field efficiency	Ejeti	3	93.37	1.165	0.672
	Shaba Maliki	3	91.96	1.526	0.881
	Ajase Ipo	3	91.26	0.807	0.466
	Total	9	92.20	1.397	0.466
Fuel cons.(l ha^{-1})	Ejeti	3	11.19	1.977	1.141
	Shaba Maliki	3	12.91	.812	0.469
	Ajase Ipo	3	10.55	6.277	3.624
	Total	9	11.55	3.480	1.160
Fuel cons. (l hr^{-1})	Ejeti	3	0.54	0.189	0.109
	Shaba Maliki	3	1.12	0.505	0.292
	Ajase Ipo	3	0.54	0.189	0.109
	Total	9	0.73	0.409	0.136
Area of land (ha)	Ejeti	3	0.03	0.005	0.003
	Shaba Maliki	3	0.03	0.007	0.004
	Ajase Ipo	3	0.04	0.005	0.003
	Total	9	0.03	0.006	0.002
Average time of operation	Ejeti	3	21.70	3.765	2.174
	Shaba Maliki	3	13.15	5.541	3.199
	Ajase Ipo	3	18.70	4.532	2.616
	Total	9	17.85	5.520	1.840

SD represents standard deveiation; SE represents standard error

Table 3.0: Test of Main Factor Effect (ANOVA)

		Sum of Squares	Df	Mean Square	F	Sig.
Slippage	Between Groups	0.650	2	0.325	65535.	0.001*.
	Within Groups	0.000	6			
	Total	0.650	8			
Effective field cap.	Between Groups	0.003	2	0.001	1.888	.231 ns
	Within Groups	0.005	6	0.001		
	Total	0.008	8			
Theoretical field cap.	Between Groups	0.003	2	0.002	1.862	.235 ns
	Within Groups	0.005	6	0.001		
	Total	0.008	8			
Field efficiency	Between Groups	6.935	2	3.467	2.398	.172 ns
	Within Groups	8.676	6	1.446		
	Total	15.610	8			
Fuel cons.(l/ha)	Between Groups	8.945	2	4.472	0.305	.748 ns
	Within Groups	87.945	6	14.657		
	Total	96.889	8			
Fuel cons.(l/hr)	Between Groups	0.684	2	.342	3.137	.117 ns
	Within Groups	0.654	6	.109		
	Total	1.339	8			
Area of land (ha)	Between Groups	0.000	2	.000	1.232	.356 ns
	Within Groups	0.000	6	.000		
	Total	0.000	8			
Average time of operation	Between Groups	112.905	2	56.452	2.589	.155 ns
	Within Groups	130.830	6	21.805		
	Total	243.735	8			

*significant at 1% level, ns = not significant

Table 4 presents a summary of the soil physical properties considered during the experiment. It was observed that moisture content recorded higher mean values after operation than before operation, while cone index was as much as eighty times larger before operation than after operation. Moisture content and porosity decreased as soil depth increased from 0-7cm to 14 -21cm. Bulk density and cone index increased as soil depth increased from 0-7cm to 14 -21cm. This indicates a positive condition for the flow of water and air through the soil profile and minimum resistance to root growth and proliferation. Puddling with the power tiller has improved soil moisture content, reduced shear strength and penetration resistance as earlier observed by Fashola et al, (2007b).

Table 4: Effect of tillage tool on some soil physical properties

Parameter	Activities	N	Mean	S.D	S. E
Moisture content	Before operation	3	23.64	9.467	5.466
	After operation	3	29.51	10.070	5.814
	Total	6	26.58	9.313	3.802
Bulk density	Before operation	3	1.57	0.279	0.161
	After operation	3	1.52	0.155	0.090
	Total	6	1.54	0.204	0.083
Cone index	Before operation	3	51.68	36.458	21.049
	After operation	3	6.20	7.946	4.588
	Total	6	28.94	34.313	14.008
Shear strength	Before operation	3	0.032	0.024	0.014
	After operation	3	0.005	0.005	0.003
	Total	6	0.019	0.022	0.009
Porosity	Before operation	3	40.77	10.540	6.085
	After operation	3	42.67	5.859	3.382
	Total	6	41.72	7.697	3.142

SD represents standard deveiation; SE represents standard error

The operating cost of power tiller (Table 5) was determined based on the annual usage and farm size. It was evident that the operating cost per annum increased yearly till 2005 based on 4 hours per day usage. For the first five years of operation in Niger State, the highest area of coverage was recorded in 2005. The same year recorded highest cost of repairs and maintenance and paddy yield of 5.2 t ha^{-1}. The first three years recorded same volume for repair and maintenance cost until the break down that occurred in 2005. The price of diesel varied between ₦45 per litre to ₦90 per litre between 2002 and 2006. This also contributed to increase cost of production yearly. Nontheless comparing income based on hiring services, there was short fall in 2002. This might be due to the inexperienced nature of the operator in handling the machine. He could not make maximum use of the machine to cover much area. For example in 2002, 80 hrs of operation covered 5 hectare while twice that area was covered in 2003 in 120 hrs, saving 40 hrs. After 2003 there was a gradual increase in revenue generation as the hiring rate increased slightly with other factors of production. Since the machine was not hired to farmers, but rather given to them freely so that they can be familiar with it and considering the yield at Ajase Ipo within the first two years of power tiller introduction it is hoped that there will be a tremendous increase in subsequent years with proper field management.

Table 5: Annual use of power tiller

Year	Total annual use (hr)	Total annual coverage (ha)	R&M cost per annum (000 ₦)	Fuel cost per annum (₦)	Total operational per annum (000 ₦)	Hiring cost per annum (000 ₦)	Yield (t/ha)
2002 +	80	5	10	2, 722	27.55	15	5.0
2003 +	120	10	10	6, 050	32.85	40	5.1
2004 +	160	16	10	11, 616	51.34	80	5.0
2005 +	220	25	35	25, 606	132. 47	175	5.2
2006 +	120	22	32	23, 958	81.18	154	5.1
2009 *	18	1	5	4,806	14.81	-	2.4
2010 *	31	2	10	8, 608	18.61	-	4.3

+ Usage in Niger S

Conclusions

Having determined the impact of using power tiller for '*sawah*' for a period of five years at Ejeti and Shaba-Maliki and for two years at Ajase Ipo, it is evident that power tiller is the appropriate machinery for mechanization of lowland rice production. It is obvious that the power tiller is able to carry out both primary and secondary tillage operations and is most suitable for operations under wet conditions and for small holdings. Given the right set of implements and attachments, the power tiller is capable of performing most field operations under intensive cultivation of '*sawah*' rice. The light weight of the power tiller is a favourable factor for working in wet land conditions of '*sawah*' fields as it does not sink and creates least disturbance to soil structure. It is also relatively cheaper. In view of the above attributes, it is recommended that the power tiller has an advantage over heavier machinery (tractors)that farmers cannot afford to invest their money in it. Power tillers are therefore appropriate alternatives for most farmers in developing countries like Nigeria. With mass adoption of power tiller use, local artisans can learn to manufacture simple components of the machine, giving rise to employment opportunities for many people.

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Challenges and Prospects of Youth Involvement in 'Sawah' Rice Farming in Nigeria

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Abstract

Nigeria has reached a very critical point in agriculture because many of our farmers who grow the bulk of locally produced food are very old. If not addressed, food security in Nigeria and most parts of Africa would reach a crisis point. The challenge is getting young people to be involved in agriculture. Meeting this challenge, with particular reference to 'Sawah' Eco-technology and Rice Farming (SERIF,) has encountered some experiences and constraints in the past and if not quickly addressed may retard efforts of the nation and region in providing solutions to food insecurity, environmental problems and poverty. This paper examines some of the experiences, challenges, constraints as well as the prospects of youth involvement in 'Sawah' rice farming and provides recommends on the way forward.

Key words: challenges, eco-technology, prospects, rice, farming, 'sawah', youth.

Introduction

Nigeria with a population of over 140 million people (NPC, 2006) has an abundant human and natural resources for agricultural production. UNICEF (2008) reported that about 76% of Nigeria population lives in the rural areas and about 90% of the rural dwellers are engaged in agricultural production. However, irrespective of this array of advantages, the goal of self-sufficiency in food production in Nigeria remains elusive. According to Nwachukwu (2008) "one of the problems for non-realization of our goal for food sufficiency is the condition of the Nigerian farmer and the farming environment". The Nigerian farmer is ageing with an average of 50 years. The problem with this is that the younger generation is not interested in farming. The age and low level of education of the average Nigerian farmer correlates with his/her aversion of risks associated with the adoption of new innovations and hence the very low productive capacity. In the opinion of many, getting the youth to take up farming seems a possible panacea to the problem. According to Jibowo and Sotomi (1996), it is expected that with higher level of education, innovation, minimal risk aversion, greater physical strength and less conservativeness, Nigerian youth active and effective participation in agriculture would ensure adequate food production for the country.

Available evidence suggests an ageing farming population in Nigeria, with an average age of 47 years (NBS 2008, Oboh et al., 2009). In 2009, the national unemployment rate was 19.7% with the youth accounting for more than 75% (NBS, 2010). Increased involvement of the youth in agricultural activities would help to, not only solve the problem of ageing farmer population but would also reduce youth unemployment.

The World Bank reports that global food prices rose 83% over the last three years and the Food and Agriculture Organization cites 45% increase in their world food price index during the past nine months (Eric and Loren, 2008). Bio fuels have also forced global food prices up by 75% more than previously estimated. Grains have been diverted away from food to fuel. For example, over a third of U.S corn is now used to produce ethanol and about half of vegetable oil produced in Europe goes into the production of bio diesel (Aditya, 2008). The implication of this recent trend is that, developing countries like Nigeria whose economy solely relies on importation of grains (particularly rice), for the feeding of their teeming populations have to go back to the drawing board to formulate more pragmatic policies capable of turning the food production pendulum back to their side.

The youth at present, constitute about 60% of Nigeria's population and have over the years made significant contributions to National Development (Vision 2010 report, 2005). Unfortunately, the present environment makes it even more difficult to explore their full potential in agricultural production. In order to stimulate the interest of our youth in agricultural production; government has to put in place certain measures that will eliminate the associated constraints in the sector. Despite the fast growing opportunities in this sector, it is alarming and quite incredible to see many rural youths opting out of farming in search of non-existed white-collar jobs in the cities, leading to unprecedented level of rural-urban migration. This is obviously a serious threat to the aspiration of government to achieve food security by 2015. For sustainable agricultural development in Nigeria, there is an urgent need for a more rapid transformation from subsistence farming to a more commercialized one, involving the application of modern technology (Adisa, 2005) such as the 'Sawah' eco-technology for rice production.

Challenges of Youth Involvement in 'Sawah' Rice Farming

Young people do not want to go and farm like some of our parents and grandparents did using outmoded tools and machinery. The youth need strong incentives to come into agriculture. Therefore, young scientists, technologists and other professionals have to be involved in agricultural production, processing and marketing through effective and stimulating packages. Scientific inventions/interventions that would ensure massive production, preservation and storage which would translate into profitability are needed. This will attract the youth into agriculture and help reduce unemployment and the brain drain.

Constraints to Youth Involvement in SERIF

These constraints have been identified primarily through surveys (Adekunle et al. 2009). From the literature review, there are economic, social and environmental factors reducing rural youth involvement in agricultural production in Nigeria (Table 1). Economic factors include inadequate credit facilities, low farming profit margins, a lack of agricultural insurance, initial capital and production inputs. Social factors include public perception about farming and parental influence to move out of agriculture. Environmental issues include inadequate land, continuous poor harvests, and soil degradation. These findings are largely in agreement with the results obtained from other interviews conducted with selected youth leaders. The results further reveal that economic-based constraints seem to be the most important factors.

Another constraint is on policy. Policies are implemented by one government and then abandoned when a new government comes or even reversed completely. This is very costly and painful to our farmers, youth and businesses. So, policies reversal, poor or non-implementation of policies is a risk factor to agriculture. The solution to this is for governments to allow a bottom up approach in deciding policies. Constitutionally supported policies which are policies coming from the grassroots, communities, business people, farmers are supported by the people and they tend to make the desired impact.

Table 1: Constraints to Rural Youth's Involvement in Agriculture

Constraints	Mean	Ranking
Inadequate credit facility	2.88	1
Poor returns to in vestment	2.67	2
No agricultural insurance	2.67	2
Poor basic farming knowledge	2.57	3
Insufficient access to tractors & other farm inputs	2.48	4
No ready market	2.35	5
It is energy -sapping	2.33	6
People perception	2.28	7
Insufficient initial capital	2.15	8
Farmers are not respected	2.10	9
Non - lucrativeness of agriculture	2.03	10
Continuous poor harvest	1.94	11
Poor storage facilities	1.93	11
Insufficient of land	0.97	12
Soil degradation	0.66	14

Source: Derived from Adekunle et al., 2009

Prospects of Youth Involvement in SERIF

Nigeria's government has attempted to stimulate youth's interest in agriculture (production and processing) since the late 1980s. In 1986, the federal government established the National Directorate of Employment (NDE) to provide vocational training for the youth. In 1987, the Better Life Programme was created to empower women, especially female youth in rural areas through skills acquisition and healthcare training. In addition, the People's Bank and the Community Banks were established in 1989 and 1990 respectively, to provide credit facilities to low income earners embarking on agriculture and other micro enterprises, with speciality for the youth. In 1992, the Fadama program was initiated to enhance food self-sufficiency, reduce poverty, and create opportunities for employment for the youth in rural areas. In 2004, the Ondo State government initiated a program called "Youth in Agriculture" and in 2008 the Akwa Ibom State government initiated an integrated farming scheme for newly graduated agricultural students. It set up a micro-credit scheme for youth engaged in agriculture. Other state governments also initiated graduate and school-leaver's agricultural loan schemes in an attempt to encouraged the youth to go into agriculture, empower those already engaged in agricultural activities and reduce youth unemployment. Despite these incentives and the expanding markets for primary and secondary agricultural commodities, the involvement of the youth in agricultural activities has steadily declined in recent years (Adekunle et al. 2009).

Conclusion

Despite the predominance of rain-fed agriculture in Nigeria, the 'Sawah' system for use in the inland valleys will enhance continuous cropping and better use and distribution of the production activities. 'Sawah' is multi-functional and can greatly contribute to realizing the green revolution as well as the restoration of our fragile ecological environment. Itemized below are the benefits of 'Sawah' technology to Nigerian Agriculture: (i) technology has the capacity to increase youth participation in farming, (ii) Lowland 'Sawah' farming utilizes geological and irrigation fertilization resulting from mineralization of nutrients and translocation due to movement of top soil from upland, (iii) 'Sawah' will help combat global warming and other environmental problems, (iv) Carbon sequestration through control of oxygen supply. Methane emission under submerged condition, nitrous oxide emission under aerobic rice will be reduced, (v) De-nitrification of nitrate polluted water will be reduced, (vi) Watershed agro-forestry, SATOYAMA describes active 'Sawah' in the lowland and forestry in the upland; this encourages conservation of the environment, forest generation, enrichment of the lowland through various geological processes, (vii) 'Sawah' contribute to control of flooding and soil erosion and also has potential to generate hydro-electricity, (viii) In communal settings 'Sawah' promote fare water distribution systems for collaboration and fare society, (ix) 'Sawah' can significantly contribute to the current rehabilitation activities in the Niger Delta of Nigeria. The youth of Nigerian therefore have a lot to gain if they can participate in the 'Sawah' Eco-technology system which has the potential to transform the agricultural sector through boosting rice production and alleviating poverty.

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