The Study on "Development of Improved Infrastructure and Technologies for Rice Production in Africa (DIITRPA)"

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Abstract

Japan International Research Center for Agricultural Sciences (JIRCAS) began the study on Developing Improved Infrastructure and Technology for Rice Production in Africa (DIITRPA) in 2008 financially aided by the Ministry of Agriculture, Forestry and Fisheries in Japan. DIITRPA was designed to explore ways to increase rice production in accordance with diverse forms of rice ecosystems in Africa, especially to improve farmland and facilities and develop farmers' cultivation skills in rain-fed lowland areas, by improving methods for rice field construction and cultivation management, introducing appropriate cultivars, and providing seeds as well as equipment and materials. At the same time, on-the-job-training for extension workers and irrigation engineers was to be also carried out, and a technical manual for dissemination of the results of this study will be made by consolidating the results. This study shares the same goal with CARD (Coalition for African Rice Development) in increasing rice production in Africa. A basic study of rice production in rain-fed lowlands was conducted in 2008 in the eastern and western regions of sub-Saharan Africa through site visits in each region. Based on that basic study, it was decided to execute a verification study in rain-fed lowland areas in Ghana from 2009 and in Ethiopia from 2010 utilizing the results in Ghana. The verification study is being done with farmers at selected model sites on the following topics: establish construction methods of farmland and simple irrigation facilities suitable for variable topographies and water resources, improved cultivation techniques, organize farmer groups to manage facilities, machinery and materials and draft an instruction manual for leaders of farmers to utilize based on field experience and local conditions. During the validity study in Ghana, JIRCAS encountered several difficult conditions of both topography and precipitation, but a successful result has been achieved during three and a half years' of activities and after receiving valuable collaboration from counterpart institutes in Ghana.

Introduction

In 2008, the Japan International Research Center for Agricultural Sciences (JIRCAS) started a study on Development of Improved Infrastructure and Technologies for Rice Production in Africa (DIITRPA). JIRCAS was financially aided by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan. The study which has gone through several stages is currently focusing on drafting a technical manual in which many findings that JIRCAS has acquired through the three-and-a–half years validation study in Ghana will be highlighted and documented. JIRCAS has recently been in the stage of adapting experiences gained to other countries in Africa. This paper explains ideas of dissemination based on the activities implemented so far by JIRCAS.

Why JIRCAS started the study

Demographic study shows that rapid population growth in Africa is observed, so food shortage in Africa has been one of the world-wide serious problems anticipated in the near future. On the other hand, since food production in Africa is still not sufficient to meet demand, imports of food from Asia and North America are currently observed. Rice consumption in Africa started increasing during the 1970s. This increasing demand for rice, made governments of Western Africa and assisted by FAO, to establish the West Africa Rice Development Agency (WARDA, currently "Africa Rice Center") WARDA has produced new rice varieties in Africa (NERICA) since its establishment, and Japan has supported disseminating NERICA varieties, but NERICA hasn't been popular yet in African countries because of the poor experience of rice cultivation, etc. In May 2008, the Japanese government, together with the Alliance for Green Revolution in Africa (AGRA), developed the concept of the Coalition for African Rice Development (CARD) that targeted to double rice production in ten years, and started various studies to fulfill the goal simultaneously.

Key points to developing rice cultivation

Rice needs three key components of natural environment such as (1) appropriate temperature, (2) enough accumulated-sunshine-duration and (3) precipitation to achieve high yield. Agronomic efforts have been done to create good species of rice, effectively grown under particular circumstances of temperature and sunshine-duration at the particular area where rice is planted. On the other hand, irrigation engineers have worked hard to prepare better condition of irrigation and drainage where enough water resources for rice cultivation isn't sufficient. Dams, head-works (weirs) and canals are effective infrastructure to propel rice production for large-scale farmland, such as more than ten thousand ha. Besides constructing such huge facilities, practicing micro irrigation method, equipping pipe-lines, using sprinklers and growing cover crops are also implemented in developed countries. JIRCAS, however, adopted another method of implementing rice paddy field development using grass-roots activities.

Materials and Methods

A basic study of rice production in rain-fed lowlands was conducted in 2008 in the eastern and western regions of sub-Saharan Africa through site visits in each region. Based on that basic study, it was decided that a verification study be executed in rain-fed lowland areas in Ghana from 2009. The verification study was done with farmers at selected model sites on the following topics: (i) establish construction methods of farmland and simple irrigation facilities suitable for variable topographies and water resources, (ii) select suitable varieties and improved cultivation techniques, (iii) organize farmer groups to manage facilities, machinery and materials. At the same time, on-the-job-training was provided to extension workers as well as farmers. A technical manual was finally drafted for disseminating the result of the study based on local conditions.

Results and Discussion

(1) Lessons learned in Ghana

In West Africa, particularly Ghana and Nigeria, a special way of rice cultivation called "Sawah" system was being transferred to farmers. This activity was led by Prof. Dr. Wakatsuki, of Kinki University in Japan and recorded results have been very remarkable. Using these experiences, JIRCAS decided to facilitate the transfer and practice of "Sawah" system. According to Buri et al. (2009), technical definition of "Sawah", or "Suiden" (in Japanese), is a bunded and well-leveled rice field with an inlet for irrigation and an outlet for drainage. JIRCAS tried to trace the same method of (a) bunding paddy field, (b) leveling and puddling using power tiller (PT) and (c) delivering irrigation water to the farming plots. "Sawah" system has no tendency of decreasing yield even if fields are continuously cropped for many years. For example, Japanese experience shows that, cultivating rice on the same piece of land for over 2000 years has posed no serious problem as a result of its continued use.

(2) Technical aspects to do validation study

Validation study sites of JIRCAS were chosen to collect data. However, the data was not collected during the activities of developing-farmers'fields but was rather collected with JIRCAS's input, by field extension staff. Such data was to be included the technical manual. So, under site selection, the following creteria was considered: (i) accessibility to the project site, (ii) whether famers have experience of rice production or not, (iii) whether water resources are enough or not, (iv) whether soil condition is wet or dry, (v) whether dry season crops are planted or not, (vi) whether palm trees are existing at the selected site or not (vii) whether farmers organization exist or not and (viii) whether the land user is as same as land owner or not.

Criteria	Points	Example	Why it is important?
(1) Access	1-5	4	For dissemination
(2) Experience of rice production	1-2	2	Yes = 2; No = 1
(3) Water resources	1-2	1	
(4) Soil condition	1-2	2	Dry = 1; Wet = 2
(5) Dry season crop	1-2	2	
(6) Palm tree	1-2	2	For leveling
(7) Farmers Organization	1-2	2	
(8) Land user	1-3	2	
Total	8-20	17	

Source: A discussing material by Dr. Fukuo (2009.11.04)

(3) Canal design

During the validation study in Ghana, JIRCAS encountered several challenges regarding conditions of both topography and precipitation. JIRCAS recommended and financially supported the constructions of canals to convey irrigation water to the fields. These canals varied depending on the nature and type of valley. Some of the designs used to better water management in Kumasi, is shown in Figure 2. Some of these types include (i) dyke/weir type, (ii) dual canal type and (iii) a combination. All of these techniques are effective on paddy fields of bunded and levelled conditions which are similar to traditionally-practiced paddy fields in Japan.

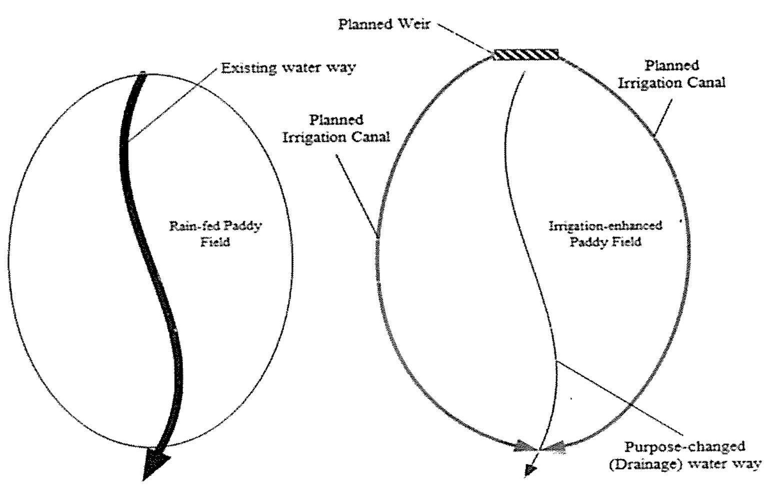

Fig-2: A typical betterment, left to right, for rain-fed paddy field.

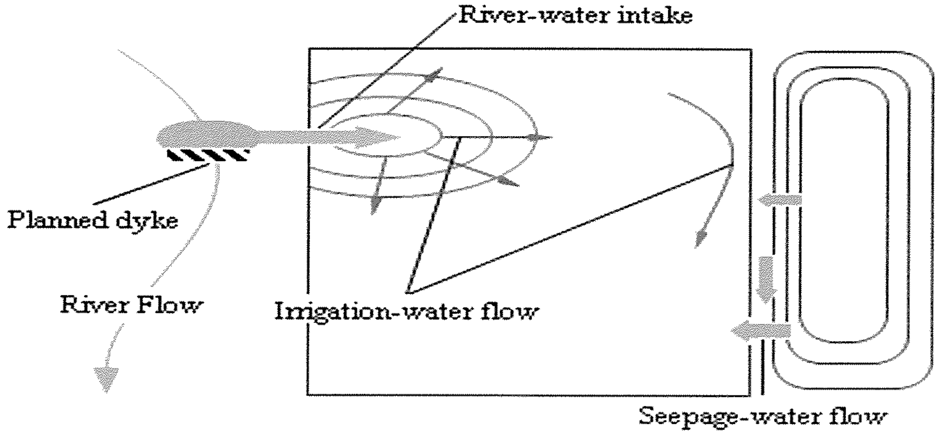

Fig- 3: A proposed betterment for upper portion of Nsutem-B site.

(4) On the job training

In 2008, JIRCAS was supported by the Soil Research Institute (SRI) and Crops Research Institute (CRI) both of the Council for Scientitifc and Industrial Research (CSIR) to choose project sites since they knew the places and had kept good relation with farmers. Recognizing and understanding the role of extension officers (EOs) JIRCAS asked the Ministry of Food and Agriculture (MOFA) in Ghana and through its District offices, they assisted in information dissemination. In FY 2009, experts from SRI and CRI, who have knowledge of the land conditions of the project sites conducted on-the-job trainings (OJTs) for EOs, who are staff of MOFA. In 2010, JIRCAS expanded the coverage to 8 sites including 20 farming plots and conducted the same activities on rice production as was done the previous year by the experts. Extesion officials, who were trained the previous year, were made to conduct OJT for farmers in several farming communities covering the operational areas of those Extension Officers. The excerise was basically successful, even though several challenges were encountered.

Social Aspects to do validation study

(i) Extention Officers (EOs)

Rice farmers are faced with a lot of challenges under the traditional system since rice responds very much to climate differences that are not predictable. Much experience can guide farmers to prepare and overcome critical situations by finding solutions to challenges. Perfect timing of fertilizer application and/or pesticide is not easy for farmers to easily understand. Information about pests and deceases could be conveyed by experienced officials to farmers. So the role of EOs is of high importance. Effective extension delivery is one of the fastest ways of achieving the goal of increasing rice yields.

(ii). Farmers organization

Rice production in its history needs collaborative work particularly during transplanting and harvesting since it will avoid birds attack and promote the production of better quality rice. According to Piper (1993), "As ways of controlling water were developed, societies changed further, investing ever more in the land for terracing, transplanting rice, and eradicating pests, and the great kingdoms of South-East Asia have usually been based on irrigated rice production." In fact, rice farmers have sometimes formed self-defense forces to confront bulling clans who took all products when harvested, and some of the forces became worriers and worrier's groups and governed districts or even states in old historical Japan. However, in Africa, practical farmer's group formation shouldn't be over expected, but individual farmers should be helped to carry out their agricultural practice, such as transplanting or using power tillers.

(iii). Land tenancy agreements

Rice cultivation needs a lot of farming space and time. It takes several years to completely and effectively develop land. In addition, the use of the power tiller and its effectiveness requires several years before farmers can earn enough money to be able to pay for its cost and maintenance. Hence, land tenancy agreements should be designed to cover a minimum of five years period or ideally ten years.

(iv). Power tiller renting agreement

The power tiller is relatively expensive for individual farmers to purchase. So it is usually better to be owned by group or organization. It is not easy for farmers who are not well resourced to operate and maintain the power tiller to be used over a longer period of time. JIRCAS employed a measure of power tiller agreement by renting one to a farmer group. JIRCAS suggested to extension officiers to let the group form power tiller maintenance committee with nominated president/chairman who represent the group and be responsible for the proper management/usage of the power tiller during the duration of rented period. The tenancy, however, differed from place to place.

(2). Lessons learned in Ethiopia

(i). Conditions

In Ethiopia, there wasn't any experience in using power tiller in the lives of farmers involved in the JIRCAS project. Although rice cultivation was introduced into Ethiopia some several decades ago, land preparation is still being done by the use of oxen. Even though controlling oxen is very difficult, and the plow made of iron is a kind of house treasure for them, several factors should be carefully considered when introducing modern machinery into such a society.

(ii). Post-harvesting technique

Post-harvesting technique in Ethiopia is far behind and lucks modern techniques. The Farmers use oxen to thresh rice as it is done for tuff (Ergrostis tuff), which is one of the staple serials in Ethiopia. It is said that the stepping on tuff is effective because it is difficult to dehusked. While rice has a different nature, farmers tend to use same techniques of threshing beause this technique is popular amongst them.

(iii). Lack of Extension Officers (EOs).

The agricultural extension system in Ethiopia is not well organized as offcers are not well trained particularly in the field of rice cultivation. The most serious problem is that extension officers are frequently changed, i.e. posted to new places or districts at the end of each year. It was therefore very difficult for JIRCAS staff to equip EOs with good quality rice production techniques since they change frequently.

(3). Future prospect of disseminating of "Sawah" system, or Asian-type paddy field, in Africa.

JIRCAS would like to apply the techniques mentioned above at several sites in Ethiopia, and finalize a technical manual. Since the first visit to Ethiopia by JIRCAS staff in 2009, several validation study sites in the Amhara Region of Ethiopia have been selected where water resources are enough to implement the study. In Ethiopia, "Sawah" system is not popular, so JIRCAS used the term Asian-type paddy field instead, which can easily be recognized by local staff and farmers.

(4). Draft Manual

Currently, a draft manual is being prepared. JIRCAS recognizes the importance of compiling the manual in local languages when it is finally delivered to EOs as well as farmer's group. As such the draft manual would be revised after government officers, EOs and researchers have read through it and made any suggestions or comments. JIRCAS compiled the first draft in 2009, and delivered to EOs and farmers inside JIRCAS experimental plot and received several comments from them. On 28th October 2011, MOFA held a technical committee to check the contents of the technical manual and carry out further inspection of its contents as well as its scope.

(5). *Recommendations for disseminating "Sawah" system to other countries (in the future)*

(i). Rainfall (Precipitation)

Adequate water is necessary to start the "Sawah" system. According to Fujimoto (2005), 800mm - 1,300mm of annual precipitation is the threshold of choosing policy of cultivating rice or wheat in People's Republic of China. So rainfall is one of the basic indicators to decide whether rice is the appropriate crop for a particular area or not. Under high-grade management of rice, such as cropping two or three times a year, or highly mechanized rice cultivation, precipitation should be carefully checked so as to plan what kind of rice production system one would like to apply in the field.

(ii). Temperature

Temperature is not a killer-factor that influences rice cultivation within a particular area. Japanese experience of long history of rice cultivation shows that the production area for rice cultivation aimed north and has finally reached the most northern island of Hokkaido where average monthly temperature ranges from 4.6°C (January) to 21.7°C (August). These lessons/experience show how temperature can be overcomed with human technology for rice cultivation. Mountainous area like Ethiopia should carefully consider the lowest temperatures during the rice cultivation season, and special consideration/treatments should be applied, such as introducing low-temperature tolerant species, or counter-measure management, such as keeping deep water in the paddy field during the nights.

(iii). Land shape (slope)

Concerning the slope of the land, little slope-area is recommended for Sawah system, since gravity irrigation is easier to be applied than in flood-plain areas where irrigation water runs from highest part of the command area to the lowest part. Flood-plain areas are usually installed with big-project facilities to convey much water both for irrigation and drainage, but the cost of such projects is too large for individual farmers to own. "Sawah" system are not meant to be applied to vasts land where professional designing is required before any good results can be obtained.

(iv). Accessibility

Project sites should be located at freely accessible areas, so that farmers who are close-by can observe and see for themselves, developed sawah fields. It is for this reason that JIRCAS considered accessibility as one of the criteria for selecting validation study sites. Good access road is important for transporting produce as well as for moving machinery (power tillers, tools, etc) to project sites.

(v). Conditions of EOs

In Africa, if the government of a country has not got a strong and well organized extension system to help farmers improve their agricultural practices, nor extension officiers to be dispatched to rural areas, this need to be pointed out to such government and its importance emphasized, before you actually enter into project sites. You cannot do any advanced technical activities in the rural area without good EO who understand local languages.

(vi). Stage of mechanization in the area

Mechanization is not easy to be achieved within several years, since the power tiller needs continuous operation and maintenance (O&M) when introduced to a particular site. Spare parts are needed and sometimes a blacksmith is needed to fix the machines. According to experience from South-East Asia, dissemination of motor-bikes is one of the key indicators for introducing power tiller for the first time. When machinery become popular, a lot of tools to fix machines and factories to provide spare parts would be required in order to maintain machines in good condition.

(vii). South-south collaboration

Importance of field-visit by farmers is often cited by many experts of various research fields. A maxim of 'Seeing is believing' is well observed in the dissemination of "Sawah" system too. JIRCAS invited three Ethiopian experts to Ghana in February 2011 to participate in the Steering Committee meeting and a field visit to the project sites in Kumasi was successful. All participants were satisfied with seeing the "Sawah" fieds with their own eyes and had discussion with farmers and EOs at the project sites.

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Agro-forestry and 'Sawah': A Sustainable Land Use System for Socio-economic and Environmental Benefits in Ghana.

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Abstract

Farmers in Ghana practice shifting cultivation where when the land becomes unfertile, the farm is abandoned in search of more fertile land for cropping. Cocoa farms are established on uplands whilst the lowlands are used for 'sawah' development. The synergy of silicon in cocoa and rice may suggest that integrating cocoa agro-forestry into the 'sawah' system has very high potential socio-economic and environmental benefits. This paper comes out from two publications. The farm activity schedules for cocoa and rice cultivations do not coincide but overlap within the farming season. Farmers who may be producing both farm commodities will be occupied throughout the year and will be rewarded with commensurate incomes and food all the year round. The major hindrance to this agricultural system is land ownership and use rights. There is the need for secure individualized title, correlated registration of titles and introduction of new attitudes toward land. Tenancy can provide the means by which landowners and the landless may join their respective resources in a productive and complementary manner. However, structural framework in which farmers (tenants and landowners) can work together will be the panacea for sustainable socio-economic and environmental benefits.

Introduction

In Ghana, farmers continuously cultivate the land for a maximum of five years and abandon this piece of land due to loss of soil fertility. Subsequently, new fertile land (i.e. forestland) is sought for farming in the same way. Cocoa farms, however, can occupy the same land management unit for more than 50 years (Owusu-Sekyere *et al* 2004). 'Sawah' rice on the other hand is capital and labour intensive especially during the preparation of the 'sawah' field for rice based cropping system for the first time or season. After development the 'sawah' field can be cultivated for as long as may be required. The major activities after this are repair and maintenance of the 'sawah' field in the subsequent cropping seasons and can be done for years. Cocoa farms are established on uplands whilst the lowlands are used for 'sawah' development. Hence, the uplands and the lowlands constitute the 'sawah' ecosystem. The major hindrance to this agricultural system is land ownership and use rights.

It is very uncommon for a farmer to crop both uplands and lowlands due to different ownership, use rights and different crop preferences. However, if a single farmer could crop both the upland and the lowland to cocoa and 'sawah' rice, respectively, biodiversity would be restored, effective and efficient land use management system will be developed, income will be intensified and diversified and land conflicts will be avoided. But if different farmers should crop the upland and lowland to cocoa and 'sawah' rice, respectively, the above economic and environmental benefits may be difficult to achieve. Therefore, all efforts should be made to ensure socio-economic and environmental harmonies between land users.

Methodology

This paper was developed from "Extending Cocoa Agro-forestry into 'Sawah' Ecosystem in Ghanaian Inland Valleys" published by Owusu-Sekyere et al., (2010) and "Land Tenure Negotiations for Sustainable 'Sawah' Cropping Systems in Ahafo-Ano South District of Ashanti Region, Ghana" submitted for publication by Owusu-Sekyere et al., (2011). These studies were carried out in three 'sawah' rice and cocoa growing communities (Adugyama, Amakom and Biemso No. 1) in the Ahafo-Ano South District in Ghana.

Results and Discussion

Generally, in Ghana, land preparation for farming begins in the dry season (November to March) and sowing or planting begins in early March to July in the rainy season every year. Maintenance of the farms does not follow any specific time frame but weeding is done two or three times in a year. Cocoa farming is considered one of the most lucrative farming activities in Ghana. Cocoa plantations are established together with food crops. Cocoa trees start bearing fruits after 3-5 years. Though the new cocoa hybrids fruit all the year round, the peak period of harvesting is done from November to March corresponding to the dry season of the general cropping season each year (Owusu-Sekyere et al., 2010).

From the farmers` activity calendar (Table 1), land preparation, planting and harvesting food crops and the cocoa plantation are concurrent. Lowland rice is grown between the months of July to September every year. The overlap of land preparation for rice and other cropping systems (food crops and cocoa) extends for one month (April). Rice planting is delayed for about two months and harvesting is done three months after planting for a month. Thus, during the peak months for the other food crops and cocoa seedlings planting and harvesting, rice cultivation and harvesting is delayed for two months (Table 1). Weeding, pest and diseases control and other activities are done as and when they become necessary and do not have particular time frames

Table 1: Farmers` monthly activity calendar for the year for the establishments of farms

Farm type	Farmers yearly activity calendar (month)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mixed food crops	Land preparation	Land preparation	Land preparation	Sowing/planting	Sowing/planting	Harvesting/processing/marketing, etc	Harvesting/processing/marketing, etc	Harvesting/processing/marketing, etc	Harvesting/processing/marketing, etc	Harvesting/processing/marketing, etc	Harvesting/processing/marketing, etc	Harvesting/processing/marketing, etc
Cocoa plantation	Land preparation	Land preparation	Land preparation	Sowing/planting	Sowing/planting	Sowing/planting	Sowing/planting	No activity (leisure)	No activity (leisure)	No activity (leisure)	Harvesting/processing/marketing, etc	Harvesting/processing/marketing, etc
Rice ("Sawah")	Land preparation	Land preparation	Land preparation	Land preparation	No activity (leisure)	No activity (leisure)	Sowing/planting	Sowing/planting	Sowing/planting	Harvesting/processing/marketing, etc	Harvesting/processing/marketing, etc	Harvesting/processing/marketing, etc

Land preparation

Sowing/planting

Harvesting/processing/marketing, etc

No activity (leisure)

Rice is cultivated in inland valleys and on uplands. The yield of upland rice is low (less than 1.6 t ha^{-1}) as compared to about 2.5 t ha^{-1} for lowland traditional rice and more than 4.5 t ha^{-1} under the 'sawah' rice technology in Ghana (Issaka *et al* 2007). The term 'sawah' refers to a levelled, bunded and puddled rice field with water inlet and outlet to control irrigation and manage soil fertility. The 'sawah' rice farming system is now catching up with farmers throughout Ghana. The 'sawah' field is invariably in the lowlands i.e. valley bottoms or flooded areas. But the uplands play major roles in maintaining the rice fields for sustainable production. Hence, the uplands form part of the 'sawah' ecosystem. The wetlands or inland valleys belong exclusively to the paramount chief who has the oversight responsibility over farmlands of towns and villages under his traditional authority whilst the uplands belong to tribes, clans, families and individuals (both indigenes and migrants). There have been great uncertainties about securing the best tenure options for suitable valley bottoms for rice cultivation that can guarantee farmers continuous and sustained rice production.

Cocoa grown in the uplands has been shown to release silicon during leaf decay and has the potential to be transported down the slope to fertilize the lowland where rice is cultivated (Owusu-Sekyere et al., 2010). Silicon is an important nutrient for the optimal growth and sustainable production of rice (Epstein 1999, Epstein & Bloom 2005, and Ma *et al* 2006) (Fig.1). This synergy of silicon in cocoa and rice may suggest that integrating cocoa agro-forestry into the 'sawah' system has very high potential benefits. It ensures effective and efficient resource utilization above and below ground leading to environmental stability both in the upland and the lowland. It also provides an opportunity for some form of activity linked with income generation all the year round without sacrificing degradation of the two farms, no period of unemployment and few leisure times on the calendar (Table 1 and Fig.1) of the farmer as earlier reported by Owusu-Sekyere et al., (2010).

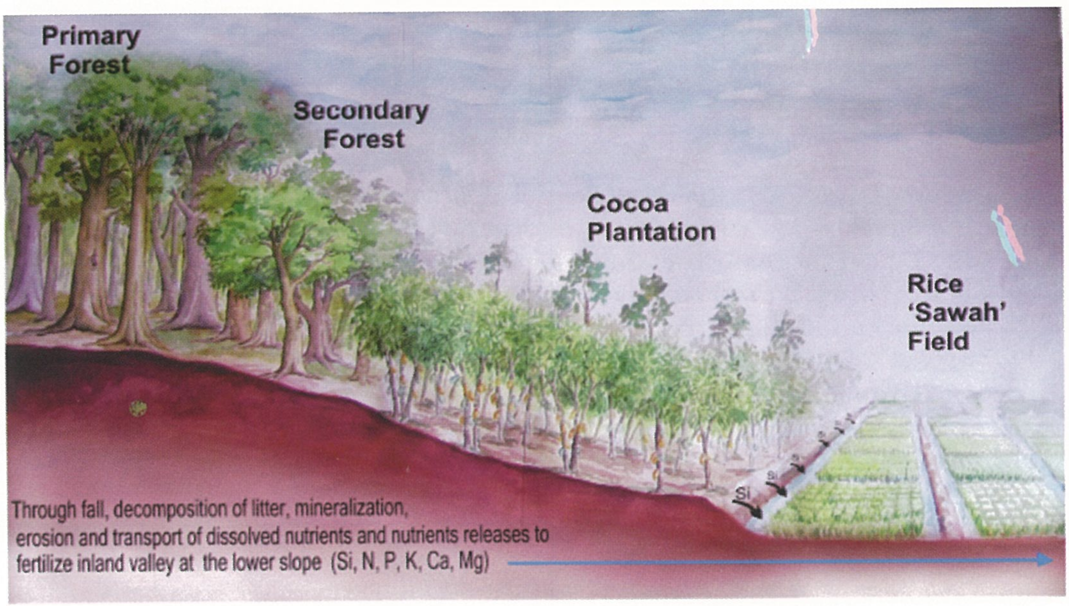

Figure 1. Extending cocoa agro-forestry into 'sawah' ecosystem in Ghana

Farmlands are obtained through inheritance given by family head and as gifts. Tenants accessed land by renting for a year, fixed tenancy for two (2) years and tenancies beyond 2 years are very few. However, few individuals own farmlands. From survey of land ownership of wetlands of 'Sawah' farmers, as much as 63% hire or rent land, 11% were for free, individual ownership was about 12% and about 14% cultivated on family lands. Land tenure problems can be solved by integrating formal law and social agreements to enhance economic efficiency.

Conclusion

It is concluded that farmlands (both uplands and lowlands) could be cultivated with cash (cocoa) and food (rice) crops. But the Tenure insecurity tends to be less important for short-term inputs than for capital long term investment. Any attempt to promote 'sawah' should ensure creation of secure individualized title, correlated registration of titles and introduction of new attitudes toward land. Tenancy can provide the means by which landowners and the landless may join their respective resources in a productive and complementary manner. However, structural framework in which farmers (tenants and landowners) can work together to improve their financial, social positions and to maintain environmental quality should be the ultimate.

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Socio-Economic, Dynamics of Farmers Associations and Adoption of 'Sawah' Rice Production Technology in Nigeria and Ghana.

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Abstract

The adoption of new agricultural techniques of which 'sawah' rice production is an example, is a key route out of poverty for many in the developing world. This paper analyzed whether and how a farmer's decision to adopt a new technology depends upon the adoption decision of other farmers in their social group, which, unlike most of the existing literature, the paper is able to identify precisely. The use of various technologies depends on socioeconomic variables and the existence of different dimensions of social dynamics. Social dynamics is especially important in determining whether households have access to, and therefore use, different technologies. Although different studies have looked at social dynamics in terms of membership in groups, there is the need to differentiate different kinds of social dynamics as they influence technology adoption differently. Social dynamics measured as bonding, bridging, and linking influence technology adoption. Overall the evidence suggests that network effects are important for individual decisions, and that, in the particular context of agricultural innovations, farmers share information and learn from each other. Individual adoption decisions depend upon the choices of others in the same social networks. Since farmers anticipate that they will share information with others, farmers are expected to be more likely to adopt when they know many other adopters. Dynamic considerations, however, suggest that farmers who know many adopters might strategically delay adoption to free-ride on the information gathered by others. The specific application of the socio-economic and dynamics of farmers association to adoption was explained through a cross sectional data collected from adopters and non adopter of 'sawah' rice technology in Ghana and Nigeria. The paper concludes that the externalities which play important role in technology-adoption decisions are network, market power and learning externalities. The study recommends investments, especially by development organizations, in strengthening these different forms of social dynamics by supporting local kinship or community groups that generate social dynamics, promote farmer access and links with external organizations that can act as sources of information and technologies for farmers, as well as links with other farmer associations and groupings from whom they can learn.

Keywords: socio-economic, dynamics, social groups, networks, externalities adoption, 'sawah', rice.

Introduction

The importance of farmers' adoption of new agricultural technologies has long been of interest to agricultural extensionists and economists. Several parameters have been identified as influencing the adoption behavior of farmers from qualitative and quantitative models for the exploration of the subject. Social scientists investigating farmers' adoption behavior have accumulated considerable evidence showing that demographic variables, technology characteristics, information sources, knowledge, awareness, attitude, and group influence affect adoption behavior. Adoption of innovations refers to the decision to apply an innovation and to continue to use it. A wide range of economic, social, physical, and technical aspect of farming influences adoption of agricultural production technology. Earlier evidences[2] led to the categorization of adoption behavior into innovators, early adopters, early majority, late majority and laggards. This is based on validated studies that the adoption behavior of any agricultural technology would follow a normal distribution curve in a given social system. The increasing importance of rice towards world food security has been stressed through the green revolution in Asia and the increasing consumption of rice among the world's poor. Aker et al (2010) stated that although rice is grown efficiently by small scale farmers, a successful rice economy needs sophisticated engagements from government to develop the economies of scale and scope that permit a low-cost rice system- and engagement that has largely been missing in West Africa.

'Sawah' rice production technology

The concept and the term 'sawah' refers to man-made improved rice fields with demarcated, bunded, puddled and levelled rice fields with water inlet and water outlet, which, if possible, can be connected to various irrigation facilities, such as canals, ponds, weirs and springs. Gajigo and Dennning (2010) noted that the presence of irrigation technology is a significant factor in explaining the variation in rice production in West Africa. The 'Sawah' system was introduced through on-farm adaptive research in the two research sites of Gara and Gadza inland valleys, located in Bida, Nigeria in 1988 (Hirose & Wakatsuki, 2002). 'Sawah' based rice production development started with three individual farmers in three villages with 0.1ha in total area in 2001. The establishment of a demonstration field (1.0 ha) at Ejeti village in 2002 galvanized the project. In 2002 the number of farmers increased in the 'Sawah' Package program and by 2003 the farmers increased to fourteen and to eighteen in 2004 from four villages. In 2005, the farmers of the 'Sawah' Package' had increased to 83 from five villages covering more than 20ha area (Fashola et al, 2006). This spread and adoption of 'sawah' which grow in leaps and bounds spreading over additional five states between 2005 and 2010 with over an estimated

10,000 adopters affirms its wide acceptance due to its improvement over the traditional system of rice farming in terms of yield, sustainable land use and the on farm demonstration method whose result in terms of field fact as witnessed by the farmers has been very convincing. Gajigo and Dennning (2010) reported that after controlling rice area harvested and per capital income, both total rice production and yield are significantly correlated with the proportion of the area irrigated.

Social dynamics and adoption

The adoption of new agricultural techniques is a key route out of poverty for many in the developing world. Yet, agricultural innovations have often been adopted slowly and some aspects of the adoption process are still poorly understood. Recent studies have shown that, both in developing and developed countries, social networks and peer effects are an important determinant of individual behaviour in a variety of settings. An integral part of sustained poverty reduction efforts is the use of improved high yielding variety seeds and sustainable use of natural resources (Kabubo Mariara et al, 2007). At the farmer level, although there are many factors that influence adoption and use of these technologies, studies have shown that rural communities that are characterized by strong social dynamics have faster rates of technology diffusion and improved environmental management (Claridge T. 2007). According to Woolcock and Sweetser (2007), social dynamics influence the use of technologies differently. For example, technologies that are knowledge intensive may require different forms of social dynamics than those that are labour or input intensive. Studies on the links between social dynamics and agricultural technologies have, however, not differentiated the different forms of social dynamics and how these influence the adoption and utilization of different technologies. Social dynamics or capital is the establishment of norms that permit people to work in groups. Hence social capital is the consequence of intensely rooted cultural habits (Fukuyama F., 2004), and as a result, it is defined differently in different cultural settings. The vast literature on social capital further refines its definition to distinguish between bonding, bridging, and linking social capital.

Social learning and information spillages have been described as important driving forces in models of endogenous growth. Conley and Udry (2000) reported that farmers within a group learn from each other how to grow new crop varieties. In relation to this, externalities have been identified to be important in technology-adoption decisions. The dynamic choices with externalities include the sources such as (i) Network Externalities. -Adopters care about how many other individuals adopt because there is some public-good element to the technology, (ii) Market Power Externalities. -Adopters with market power will care about adoption by others if adopting early implies some advantage in market power; and (iii) Learning Externalities.-Farmers may care about others' adoption decisions if early adopters teach late adopters something.

Bonding social capital is generally defined as closed networks of close friends and relatives or horizontal relationships among equals within a localized community (Claridge T., 2007). It is the social cohesion that takes place between individuals of similar ethnic backgrounds or social status and it is reinforced by working together. Szreter and Woolcock (2004) defined bonding social capital as the trusting and cooperative relations between members who are similar in a socio-demographic sense. Some examples of this type of social capital include formal and informal clubs, groups, or associations established by farming communities in many villages across SSA. These groups may be formed through religious affiliations, local traditional structures, or other localized structures. Bonding social capital is thus characterized by trust and norms that exist within the social structure. Bridging social capital, on the other hand, is widely agreed to be vertical relationships or networks that cross social groupings. These are established between people or organizations that are removed from each other and are in different communities (Claridge T., 2007).

Bridging social capital links networks requiring collaboration and coordination with other external groups to achieve set goals. For example, it can be the link between two local groups from different villages. Leonard and Onyx (2003) use five indicators of social capital (networks, reciprocity, trust, shared norms, and social agency) to define bonding and bridging social capital. Bonding social capital was described as being characterized by dense, multiplex networks, long-term reciprocity, thick trust, shared norms, and less instrumentality, whereas bridging social capital is characterized by large, loose networks, relatively strict reciprocity, and a thinner or different type of trust and more instrumentality. Linking social capital is the engagement of local groups or networks with institutions or agencies in higher influential positions[9]. Through linking social capital, groups of poor people are able to access support, resources, and information from organizations and networks. Woolcock and Narayan (2000) see bonding social capital as operating as a defence mechanism against poverty, whereas bridging social capital is what is required for real economic growth to take place. The three types of social capital, therefore, complement each other, in that the strong bonds existing in bonding social capital are diversified by the existence of bridging social capital, whose bonds are weaker but more cross cutting, hence enabling increased diversity in an otherwise closed community. Linking social capital allows for the accumulation of resources, information, and wealth, which is needed by networks to achieve set objectives. Hence, all three types of social capital can coexist in a community to different extents, but more frequently one maybe more prominent.

The objective of this paper is to examine the influence of social dynamics on the adoption of 'sawah' rice production technology in Nigeria and Ghana.

Methodology

The study was carried out in Nigeria and Ghana. It covered 12 fields in Nigeria with 80 farmers, while in Ghana 11 fields in 5 villages with 70 farmers were covered. The field locations in Ghana are in the Ahafo Ano South district. The climate is tropical with two distinct rainy seasons in the south (May-June) and (August-September). In the north, the rainy season is just one (June-September). The choice was necessitated by the fact that all 'sawah' development projects have concentrated on the Ahafo Ano South districts. In Nigeria, most of the fields covered are in Bida area of Niger state, while a village (Pampaida) was covered in Kaduna state and Akure in Ondo state. Villages covered in Bida area include Shabamaliki, Ejeti, Ekapagi, Nasarafu, Etsuzegi and Gadza. Villages covered in Ghana were Adugyama, Biemso No. 1, Biemso No. 2, Fediyeya and Attakrom. Data was collected in June 2010 from all the villages where 'sawah' rice production technology had been introduced and adopters of 'sawah' technology were interviewed. A structured questionnaire with a reliability coefficient of 0.85 was used to elicit information on socio-economic characteristics and social dynamics. Descriptive statistics was used to describe the data while Probit model was used to analyze the adoption with particular reference to the effects on the spread of the technology.

A probit model is appropriate when the dependent variable to be evaluated is dichotomous (Ameniya, T. 1981 and Anim F. D. K and Mandleni, B. 2010). The relationship between the probability of a variable Pi and its determinants q is given as:

$$Pi = \beta qi + \mu i \text{ .... } (1)$$

Where Pi=1 for Xi>Z; i=1, 2 ......, n; qi is a vector of explanatory variables and β is the vector of parameters.

In the probit model the discrete dependent variable Y is a rough categorization of a continuous, but unobserved variable Y^*. If Y^* could be directly observed then standard regression methods would be used (such as assuming that Y^* is a linear function of some independent variables, for example:

$$Y^* = \beta_1 X_{1i} + \ldots\ldots\ \beta_j X_{ji} + ui \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

In this study, Y^* is the adoption of 'sawah' technology which is used as a proxy for Y^*. The actual model specification is: adoption of 'sawah' technology = $\beta_0 + \beta_1$age + β_2 educational level + β_3 membership of farmers' groups + β_4 Membership of formal and informal clubs + β_5 Membership of traditional structures + β_6 Membership of localised structures + β_7 Shared norms among farmer groups + β_8 Extent of trust among farmers + β_9 Transport for easy network + β_{10} Network with financial institutions for credit + β_{11}farming experience + β_{12} Land tenure system + β_{13} Household size + u

The dependent variable Pi is a dichotomous variable which is 1 when a farmer adopts 'sawah' technology and 0 if otherwise. The explanatory variables are: X_1 = age in years, X_2 =dummy variable for educational level (formal education = 1, No formal education = 0); X_3 = dummy variable for membership of farmers groups (Yes = 1, No = 0); X_4= dummy variable for membership of formal and informal clubs (Yes = 1, No = 0); X_5 = dummy variable for membership of traditional structures (Yes = 1, No = 0); X_6 = dummy variable for dummy variable for membership of formal localized structures (Yes = 1, No = 0); X_7= dummy variable for shared norms among farmers groups (Yes = 1, No = 0); X_8 = dummy variable for extent of trust among farmers (Yes = 1, No = 0); X_9 = dummy variable for transport for easy network (Yes = 1, No = 0); X_{10} = dummy variable for network with financial institutions (Yes = 1, No = 0); X_{11} = farming experience in years; X_{12} = dummy variable for land tenure system (inherited = 1, otherwise = 0); X_{13} = household size in terms of number of persons.

Results and Discussion

Table 1 shows the socio-economic characteristics of farmers adopting 'sawah' technology in Nigeria and Ghana. The Table shows that in Nigeria, majority of the farmers are about 43 years of age having quranic form of education, belonging to at least one farmers group and have been farming for about 13 years. The land tenure system is predominantly through inheritance while the mean score for household size among farmers was 4.6. In Ghana, the mean age is about 45 years with most farmers having attended primary school, and belonging to farmers groups. There is an average of 17 years in terms of farming experience and land tenure system was based on secured renting.

Table 1: Socio-economic characteristics of respondents

	Description	
Household & social dynamic characteristics	Nigeria	Ghana
Age	Mean = 42.86	Mean = 45.70
Educational level	Predominantly Quranic	Predominantly primary school
Membership of Farmer group	Predominantly members	Predominantly members
Membership of formal and informal clubs	Predominantly Yes	Predominantly Yes
Membership of traditional structures	Predominantly Yes	Predominantly Yes
Membership of localised structures	Predominantly Yes	Predominantly Yes
Shared norms among farmer groups	Predominantly Yes	Predominantly Yes
Extent of trust among farmers	Predominantly low	Predominantly high
Transport for easy network	Predominantly low	Predominantly high
Network with financial institutions for credit	Predominantly No	Predominantly Yes
Farming experience	Mean = 13 years	Mean = 17 years
Land tenure system	Predominantly Inheritance	Predominantly secured rent
Household size	Mean = 4.6	Mean = 7.2

The results from the probit model in Table 2 show that the coefficients for 12 variables were significant each in Nigeria and Ghana. For Nigeria and Ghana respectively, these are age ($t = 4.12$, $p < 0.05$; $t = 7.20$, $p < 0.05$) educational level ($t = 2.77$, $p < 0.05$; $t = 2.32$, $p < 0.05$) ; membership of farmers groups($t = 1.93$, $p < 0.05$; $t = 2.57$, $p < 0.05$); membership of formal and informal clubs ($t = 2.29$, $p < 0.05$; $t = 9.63$, $p < 0.05$); membership of traditional structures ($t = 2.50$, $p < 0.05$; $t = 2.85$, $p < 0.05$); membership of formal localized structures ($t = 2.45$, $p < 0.05$; $t = 5.00$, $p < 0.05$); extent of trust among farmers ($t = 3.35$, $p < 0.05$; $t = -2.45$, $p < 0.05$); transport for easy network ($t = -1.73$, $p < 0.05$; $t = 4.24$, $p < 0.05$); farming experience ($t = 2.49$, $p < 0.05$; $t = 4.04$, $p < 0.05$), land tenure system ($t = -3.35$, $p < 0.05$; $t = -2.45$, $p < 0.05$); and household size ($t = 2.31$, $p < 0.05$; $t = 2.52$, $p < 0.05$). The sign for each coefficient is consistent with the expectation; as the probability of adoption of 'sawah' technology increases, age, educational level; membership of farmers groups; membership of formal and informal clubs; membership of traditional structures; membership of formal localized structures; extent of trust among farmers; transport for easy network; farming experience, land tenure system and household size increases. Anim and Mandleni (2010) found that all three types of social dynamics, bonding, bridging and linking affect technology adoption to some extent but bridging which includes trust shared norms and ownership of assets was the most predominant among farmers in Limpopo province in South Africa. Njuki et al (2008) found that bonding, bridging, and linking social capital all influence the adoption and use of different soil management options differently, a trend that might be similar for other agricultural technologies as well.

Table 2: Parameter estimates from Probit regression model

	Nigeria	Ghana
Variables	Coeff./S.E.	Coeff./S.E
Age	4.12	7.20
Educational level	2.77	2.32
Membership of farmer group	1.93	2.57
Membership of formal and informal clubs	2.29	- 9.63
Membership of traditional structures	2.50	2.85
Membership of localised structures	2.45	5.00
Shared norms among farmer groups	1.34	- 0.08
Extent of trust among farmers	3.35	2.45
Transport for easy network	1.73	4.24
Network with financial institutions for credit	- 0.80	- 0.02
Farming experience	2.49	4.04
Land tenure system	- 3.35	- 2.45
Household size	2.31	2.52
Intercept	- 2.15	- 18.00
Pearson Goodness-of-Fit Chi Square	110.02	301.22
Df	78	68
P	0.00	0.000

Conclusion

The study has shown that social dynamics affect technology adoption under 'sawah' rice production. In both countries the adoption of 'sawah' rice technology was influenced by social dynamic variables such as membership of farmers groups; membership of formal and informal clubs; membership of traditional structures; membership of formal localized structures; extent of trust among farmers and transport for easy network. The disaggregation of the social dynamics variable has shown critical areas for the extension agents, 'sawah' staff and development agencies to concentrate in terms of the effect of social capital on adoption for the overall scaling out of the technology. The study recommends investments, especially by development organizations, in strengthening these different forms of social dynamics by supporting local kinship or community groups that generate social dynamics, promoting farmer access and links with external organizations that can act as sources of information and technologies for farmers, as well as links with other farmer associations and groupings from whom they can learn.

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