Determinants of Adoption of Crop Production Practices: Evidence from some FADAMA Agriculture Development communities in South-Western Nigeria

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Abstract: Most of the studies that have been conducted on the impacts of the Nigeria's "FADAMA" (cultivation and farming of crops in irrigation conditions) agriculture have been silent on the aspects of exposure to and adoption of the accompanying FADAMA production practices (FPPs). However, studying the effects of these important factors is widely seen as panacea to the problems confronting the uptake of the associated FADAMA technologies. This paper uses the 'average treatment effect (ATE)' framework and data collected from 1177 households in South-western Nigeria to estimate the actual and potential adoption rates of FPPs and the determinants of their exposure and adoption. About 94% of the sampled households were exposed to at least one of the FPPs during the 2018/2019 survey period. The actual and potential adoption rates of at least one FPP were about 33% and 36% respectively in the same period. The main determinants of exposure and adoption were extension contact, household size, land holding, gender, input and credit access, owning ICT (Information and Communication Technology) assets and location dummies for Abeokuta north, Obafemi Owode, Odeda, Akinyele and Ido Local Government Areas (LGAs). Improving farmers' awareness and adoption of productivity enhancing crop production practices is important. This can be achieved by enhancing credit access to facilitate inputs and ICT assets' acquisition.

Keywords: Exposure; Adoption; Average Treatment Effect; FADAMA; South-western Nigeria
JEL CLASSIFICATION: Q12; Q15; Q16; Q24 ; Q25

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1. Introduction

In Nigeria, the World Bank promoted Agricultural Development Projects (ADPs) which is an initiative of its agricultural development policy. This was intended to build up the assets of small-scale rural farmers which were first launched as viable projects in 1972 (only two years after the end of the civil war when Nigeria was facing its first food and fibre shock) [1]. It effectively commenced in 1975 in Northern Nigeria in the enclave (experiment) areas of Funtua in Funtua Local Government Area of Katsina State, Guzau in Guzau Local Government Area of Zamfara State and Gombe in Gombe Local Government Area of Gombe State. Since 1975, the World Bank [2] has committed well over $1.2 billion for Agricultural Development Projects (ADPs) to increase farm production and welfare among smallholders' farmers in Nigeria.

The government's adoption of the ADP concept put the smallholder sector at the center of the agricultural development strategy and marked a clear shift away from capital intensive investment projects for selected areas of high agricultural potential, this is in accordance to World Bank Independent Evaluation Group, [2]. The main and first feature of the ADP was its reliance on the small-scale farmers as the central focus for increased food production. The projects were to be funded under a three-way treaty involving World Bank, Federal and State governments by 66%, 20% and 14% respectively and in addition to payments of salaries of local staff. In furtherance to the Bank's objectives, the International Fund for Agricultural Development (IFAD) also established a programme to help in improving cassava farming among rural farmers [3]. What we have today as the multi-state ADP is the product of the joint effort of the World Bank and IFAD which culminated in the establishment of ADPs in Nigeria. Since then, the agricultural sector in Nigeria has relied heavily on World Bank assistance for its growth and survival, [4]. Recently, World Bank policy on Agriculture in Nigeria has been narrowed to focus on certain measurable deliverables targeted at increasing the assets of smallholder rural farmers in Nigeria in other to attain self-sufficiency in food production. After series of review however, the World Bank realized that production based only on rain fed agriculture may not be sustainable, especially with increasing population pressure and the number of people that will be fed. The National FADAMA Facility (NFF) was thus established under the World Bank assisted NFDP loan No. 3541 UNI to assist FADAMA development in the states that met the pre-determined eligibility criteria [5-6].

A lot of investment has been made on the generation, adaptation and dissemination of improved technologies by many of the Nigeria's agricultural and food intervention programmes. These intervention programmes have been implemented through the national agricultural research and agricultural development programme systems. However, the nation's agriculture is still far from realizing its full potentials. This situation, undoubtedly, points to the fact that something musts be done. At times, researchers are disposed to blame farmers for not taking extension advice and for not adapting. The farmers are also blamed for non-precision in the application of improved technologies. Also, they often talk about the fact that farmers are either producing too little or too much instead of responding to the law of supply and demand or that they do not respond to some other economic principles. Another critical issue is the persistent low agricultural productivity in Nigeria. Achieving the desired level of agricultural productivity

has proved elusive in the past years despite the introduction of innovative technologies in Nigeria agriculture [7]. It has been realized that effective crop production and productivity can only be enhanced through exposure to and the adoption of efficient production practices, such as Crop management practices-CMP, Soil fertility management practices-SFMP and Soil water management practice-SWMP. Further, it was noted that farmers and participants in the FADAMA agricultural production can only achieve efficient production and enhanced productivity by being introduced to adequate and commensurate extension practices, [4].

The provision of agricultural extension services has been justified in the literature [8-9] on both equity and efficiency grounds. In the presence of market failures, for example, externalities, limited access to credit or non-competitive market structures, producers will not face the correct incentives to produce certain varieties of crops. In Nigeria, several intervention programmes aimed at boosting smallholders' productivity have not been seen to create the necessary extension environment that will render the required services effective in enhancing the farmers' production activities. In view of this, the coming on board of the FADAMA project has incorporated what stakeholders term "advisory services" which makes participation in the programme all inclusive. The advisory services, in addition to creating awareness on the required inputs, also maintains induced activities which include the use of improved varieties by the FADAMA farmers and use of recommended extension techniques and practices. Improving productivity and quality requires a functioning system of technology generation and transfer and a means to implement these technologies. Extension services can provide the proper institutional system to deliver these trainings to farmers.

While a number of studies have been conducted on the impacts of the FADAMA projects (e.g. [10-16]), it has been noticed that most of them were critical about the poverty, economic and social impacts on the participating stakeholders. However, these studies have been silent on the aspects of exposure to and adoption of FADAMA extension (production) practices. These aspects concern the farmers' socioeconomic, farm and production characteristics as they are related to the various crop production practices, particularly the aspect of extension practices which are either generated or promoted through the implementation of the FADAMA projects. Efforts to study the determinants of exposure to and adoption of these extension practices are widely seen as panacea to the problems confronting the uptake of cultural practices which will lead to better output and productivity of the participants and other farmers in the FADAMA and non-FADAMA farming communities.

This study aims to analyze the adoption of crop production (FADAMA extension) practices and the determinants of farmers' awareness (exposure) to and adoption of these practices. The empirical questions that we would like to address are what are: the major (identified) extension practices, the crops produced using them and their sources of awareness. The other pertinent research questions have to do with: the characteristics of farmers by adoption status, exposure to/knowledge of the improved extension practices and their determinants and the adoption rates of extension practices and the determinants of adoption.

This paper is organized a follows: Section 2 presents a brief on FADAMA agriculture in Nigeria while the materials and methods (consisting of theoretical approach for assessing adoption, empirical model, study area, sampling and data) are presented in section 3. The results and discussion are presented in section 4, while section 5 concludes.

2. FADAMA agriculture in Nigeria: Evolution, significance and some outcomes

The World Bank [17] in a report described poverty in Nigeria as "widespread and severe." Low per capita income, high unemployment, low industrial utilization capacity and high birth rates are some of the challenges the country is facing despite its vast resources, [12]. Low productivity in agriculture is another cause of the widespread poverty in Nigeria. The aforementioned report was a follow-up to the preliminary assessment which was carried on some funded projects of which the FADAMA agriculture was among. Rain-fed smallholder agriculture is the dominant occupation in Nigerian rural areas, and this has been found to be characterized by low productivity [18]. However, Nigeria has a potential comparative advantage for both wet and dry season agricultural production activities because the country is endowed with underground and surface water reserves, rich pastures and favourable agro ecological conditions. More importantly, the country is blessed with low-lying plains with alluvial deposit called FADAMA [16]. The pursuit to fully maximize the potentials of FADAMA resources in Nigeria informed the design of the National FADAMA Development project (NFDP). It is mainly funded by the World Bank, with counterpart funding from the federal and benefiting state governments [12].

The National FADAMA Development Project (NFDP) has been incorporated by the government to address the challenge of poverty in Nigeria. The project was started in 1990 and is now in its third phase. It is a $450 million project and is being implemented in 36 states and Nigeria's Federal Capital Territory, [14].

The word "FADAMA" is a Hausa name for irrigable land usually low-lying and flood plains are as underlined by shallow aquifers and found along Nigeria's river system. FADAMA is the Hausa name for irrigable, low-lying plains underlain by "shallow" aquifers found along major river systems. The FADAMA concept is an old tradition in Hausa, where flooded land is used for growing a variety of crops and small-scale irrigation. This land is suitable for irrigation, fishing and providing feed and water for livestock.

Up till now, Nigeria has had 3 phases of the FADAMA projects. Phase I and Phase II of the FADAMA project helped to raise the incomes of rural farmers by 63 percent. The present phase III (National FADAMA Development Project III) is winding down. The objective of the NFDP III is to increase the incomes of the farmers, reduce rural poverty, increase food security and contribute to the development of the Millennium Development Goals. FADAMA II project came on board as a follow-up to the implementation of FADAMA I. It essentially sought to address identified shortcomings in the design and implementation of the FADAMA I. It was designed as a comprehensive six (6) year action programme to sustainably increase beneficiaries'

income [19]. FADAMA I with full blown field activities between 1993 and 1999 focused mainly on crop production (upstream agricultural sector) and largely ignored support of post-harvest activities such as processing, storage and marketing (downstream agricultural sector) as posited by [20]. Its design excluded rural infrastructural support and other resource users such as livestock producers, fisher-folk, pastoralists, and hunters, among others. The unilateral focus on crop producers in FADAMA I engendered increased conflicts among the users of FADAMA resource. Even though it led to increased production outputs, the neglect of post-harvest technology support created bottlenecks that translated to poor market linkage, reduced agricultural commodity prices and increased storage losses. Above all, FADAMA I employed a top-down development approach or strategy which treated beneficiaries as passive recipients of already designed programmes with no regard for their inputs.

These identified shortfalls of FADAMA I brought up the need to go back to the drawing board and redesign the project which led to FADAMA II. The full blown field implementation of FADAMA II started in 2005 with the goal of addressing the shortcomings of FADAMA I by embarking on a paradigm shift from a top-down and supply-driven public sector development approach to the community-driven development (bottom-up) approach. FADAMA II further included other FADAMA resource users that were previously excluded and also supported activities and services other than production [21]. As posited by [44], FADAMA II employed the bottom-up community driven and participatory development approaches and included other FADAMA resource users like fish-folks, hunters, vegetable farmers etc. with the primary aim of empowering the local communities in order to improve government's capacity to reach out to poor people in FADAMA areas. This was achieved by designing and implementing production plans through the respective FADAMA User Groups (FUGs) in the different FADAMA Community Associations (FCAs).

[22] also submitted that FADAMA II was designed to overcome common hurdles that militate against the full realization of agricultural development programmes. These include poor development of rural infrastructure, storage, processing and marketing facilities, low investment in irrigation technology, and poor organization of farmer groups as well as lack of adequate techniques for greater productivity. All of these likewise came to fore as lessons learnt during implementation of the First National FADAMA Development Project (NFDP).Hence, FADAMA II came with initiatives and strategies that:

(i) Participation in the project should not be limited to FADAMA crop farmers, but extended to all users of FADAMA resource which include pastoralist, fisher folks, hunters, service providers as well as vulnerable and marginalized groups.

(ii) Project activities investment should not be limited to crop farming, but extended to cover other agricultural sub-sectors and even rural non-farm enterprises.

(iii) Implementation approach should be community driven (CDD), which employs a bottom-up approach whereby communities and other lower government entities are empowered through participatory and socially inclusive strategies such as Local Development Plans (LDPs).

(iv) Multi-stakeholders institutions are established at various levels. These include the State FADAMA Development Committees (SFDC) at state level, Local FADAMA Development Committees (LDFC) at the Local Government level and FADAMA Management Association at community level to evolve and enhance both efficient and effective project implementation.

Twelve states (Adamawa, Bauchi Gombe, Imo, Kaduna, Kebbi, Lagos, Niger, Ogun, Oyo and Taraba, including the Federal capital Territory) benefited under the FADAMA II projects. The CDD approach adopted by FADAMA II project permitted beneficiaries to choose the kind of activities they desire to pursue, however activities that could lead to degradation of natural resources or large-scale change of land use were discouraged.

The current FADAMA Development Project (FADAMA III: FADAMA III-AF) provides a funding of $200 million and the focus is on rice cultivation. However, a couple of other staple foods are included as well. These are cassava and sorghum. The intention is to increase production of these staple foods in the regions producing them. Some of the states involved include Kogi, Kano, Lagos, Niger, Enugu and Anambra. The objective of The NFDP III is to increase the incomes of the farmers, reduce rural poverty, increase food security and contribute to the development of the Millennium Development Goals. Six minimum components (https://www.grossarchive.com/upload/1422369600.htm) of The NFDP III are:

1. Local governance and communication; 2. Small-scale community owned infrastructure; 3. Advisory service and input support development; 4. Support to the Agricultural Development Programs; 5. Asset acquisition for individual FADAMA Users Groups and 6. Project management, monitoring and evaluation.

The NFDP is driven by the community. Local community members oversee the design and implementation of the project. This leads to empowerment, skill and capacity building, and has led to improving livelihoods and income generation. The local communities have created more than 2000 development plans. Constructions of wells, storage facilities and other initiatives have developed the farm infrastructure, and the farmers have acquired 8,000 pieces of equipment. This project has supported large and diverse residence of transient wildlife, including herbivores, carnivores and migratory birds. In the Ondo state, 50,000 households have benefited from the project. Veterinary clinics, roads, small bridges and 174 kilometers of rural roads have been constructed. The NFDP III is expected to reach about 317,000 direct beneficiary households and 1.4 million indirect beneficiary households.

Table 1: Summary of FADAMA series of projects

	Duration	IDA Loan	Project approach	Geographical coverage
FADAMA-I	1992-1999	$67.5 million	Top-down, building on Agriculture Development Program and emphasis on Infrastructure investment.	Seven core states (Bauchi, Gombe, Jigawa, Kano,Kebbi, Sokoto, and Zamfara)
FADAMA-II	2003-2009	$69.9 million	Bottom-up, Community Driven Development (CDD) building on FADAMA-I with the incorporation of local development plans for a more inclusive model.	11 states (Adamawa, Bauchi, Gombe, Imo, Kaduna, Kebbi, Lagos, Niger, Ogun, OyoandTaraba) and the Federal Capital Territory (FCT), with the African Development Bank covering six additional states (Borno, Katsina, Kogi, Kwara, Pleateau, and Jigawa), bringing the total to 18.
FADAMA-III	2008-2013	$250 million	Bottom-up, CDD, building on FADAMA-II with the incorporation of FADAMA User Equity Fund for a more sustainable model.	36 states and the Federal Capital Territory (FCT).
FADAMA-AF1	2013-2019	$200 million	Bottom-up, CDD, and Value chain approach with focus on cassava, rice, sorghum, and horticulture with export potential.	Six chosen states (Anambra, Enugu, Kano, Kogi, Lagos, and Niger).
FADAMA-AF2	2016-2019	$50 million	Bottom-up, CDD approach for restoration of the livelihoods of conflict affected households.	Six North East states affected by conflict in Nigeria (Borno, Yobe, Adamawa, Taraba, Bauchi and Gombe).

Source: World Bank, 2016.

Note: the visible field implementation dates may slightly differ from the approved dates as shown on the Table.

3. Materials and Methods

3.1 Theoretical Approach for assessing Adoption

In this paper, we carried out an analysis guided by a framework of theoretical approach for the study of technology adoption. We followed "the adoption rate" estimation procedure based on modern theories of micro-economic assessment of the impacts of policy interventions as variously described by [23-28]. We however *adapt* the theoretical procedure following from

the above and employed by [29] as follows: The FADAMA production extension *practices* is familiar to some *participating* farmers in South western Nigeria (particularly in the FADAMA States and LGAs), but not to the entire population of farmers even in the FADAMA farming communities. Therefore the potential outcomes and Average Treatment Effect (ATE) estimation framework of [30] was used to assess the rate and determinants of adoption of the FADAMA production practices. This procedure has earlier been used by [31] and [32] and adopted by [29]. (2012). Recently, it was used by [33] in their paper on "Adoption assessment of improved maize seed by farmers in Benin Republic". The methods in these approaches make it possible to correct for both non-awareness bias and the selection bias due to incomplete diffusion of improved technology (in our case, FADAMA production-extension-practices) in the population and the selection bias of the beneficiary population. Although a couple of extension practices have been introduced to the farmers by the FADAMA project, only a small fraction of the farming population has been exposed to the practices. The framework is therefore relevant in this analysis. Furthermore, exposure to the practices by farmers was not random. Therefore, applying the treatment framework allows us to control for both non-exposure and selection biases and helps in estimating true population and adoption rates and determinants of adoption. The ATE methodology allows the identification and consistent estimation of the population potential adoption rate, which is the adoption rate when all the individuals in the population are exposed to the extension practices. [32] show that the ATE (which measures the mean effect of treatment on an individual randomly selected in the population) corresponds exactly to the population potential adoption rate when exposure (awareness) is the treatment. [32] also show that average treatment effect on the treated (ATT or ATE1) and the average treatment effect on the untreated (ATU or ATE0) correspond to the adoption rate in the exposed sub-population and the potential adoption rate in the non-exposed sub-population respectively.

On the other hand, the observed proportion of adopters in the population is shown to be a measure of the combined rate of population exposure and adoption (JEA)[1]. That is, the proportion of individuals who are exposed to the technology and who have adopted it. The difference between the observed population JEA and the population potential adoption rate as measured by the ATE parameter is the population adoption gap (GAP), which is also called the population non-exposure bias (NEB). Finally, the population selection bias (PSB) is defined as the difference between the adoption rate in the exposed sub-population (measured by ATTA) and the full population potential adoption rate (measured by ATE).

[1] Diagne and Demont (2007) argue that the JEA parameter is not truly informative about adoption *per se* because it also combines the two types of conceptually different information in a way that cannot be separated: (1) information about knowledge of the extension practice (diffusion) and (2) information about the use of the extension practice in the population (adoption).

3.2 Empirical model

The parametric estimation procedure described in detail by [32] and adopted by [29] is adapted and extensively used in this paper. The parametric estimation proceeds by specifying a parametric model for the conditional expectation of the observed adoption status *y* given the vector of covariates *x* restricted to the subsample of the individuals who are (*w*=1) of the extension (FADAMA production-FPP[2]) practice:

$$E(y|x, w=1) = g(x, \beta) \quad (1)$$

where *g* is a known (possibly non-linear) function of the vector of covariates *x* and the unknown parameter vector β which is to be estimated using standard Least Squares (LS) or Maximum Likelihood Estimation (MLE) procedures using the observations (y_i, x_i) from the subsample of exposed farmers (*w*=1) only, with *y* as the dependent variable and *x* the vector of explanatory variables. The variable *w* is an indicator for exposure to the FPP where w_i =1 denotes exposure of individual *i* and w_i =0 otherwise. With an estimated parameter $\hat{\beta}$, the predicted values $g(x_i, \hat{\beta})$ are calculated for all the observations *i* in the sample (including the observations in the non-exposed sub-sample) and ATE, ATE1 and ATE0 are estimated by taking the average of the predicted $g(x_i, \hat{\beta})$ *I* =1,…,*n* across the full sample (for ATE) and respective sub-samples (for ATE1 and ATE0):

$$\hat{ATE} = \frac{1}{n}\sum_{i=1}^{n} g(x_{i,}\hat{\beta}) \quad (2)$$

$$\hat{ATE}1 = \frac{1}{n_e}\sum_{i=1}^{n} w_i g(x_{i,}\hat{\beta}) \quad (3)$$

$$\hat{ATE}0 = \frac{1}{n-n_e}\sum_{i=1}^{n} (1-w_i) g(x_{i,}\hat{\beta}) \quad (4)$$

The effects of the determinants of adoption as measured by *K* marginal effects of the *K*-dimensional vector of covariates *x* at a given point $\bar{x}$ are estimated as:

$$\frac{\partial E(y_1 \mid \bar{x})}{\partial x_k} = \frac{\partial g(\bar{x}, \hat{\beta})}{\partial x_k} \quad k = 1,\ldots\ldots,K \quad (5)$$

where x_k is the *k-th* component of *x*.

In the empirical analysis of this study, we have estimated ATE, ATE1 and ATE0, the population adoption gap ($\hat{GAP} = \hat{JEA} - \hat{ATE}$) and the population selection bias ($\hat{PSB} = \hat{ATE}1 - \hat{ATE}$) parameters using the parametric regression-based estimators above assuming a probit model so as to have $g(x_i, \beta) = \Phi(x\beta)$. Thus in this particular case, the parametric estimation of ATE reduces to a standard probit estimation restricted to the aware sub-sample. In our analysis, we have also estimated a probit model of the determinants of awareness P (*z*)-Pr*ob*(w=1|z) (also

[2] FPP which stands for FADAMA production practice is interchanged with AFDAMA extension practice in some cases

called the propensity score) with $P(z) = \Phi(zy)$; where Φ is the standard normal cumulative distribution with density function; $\phi(t) = \left(1/\sqrt{2\pi}\right)\exp\left(-t^2/2\right)^z$ is the observed vector of covariates determining awareness of the FPP and is the parameter vector being estimated. This estimation of the determinants of awareness is important on its own as it can provide valuable information about the factors influencing farmers' awareness of the existence of the FDAMA extension procedures. These factors, which are mostly related to the diffusion of information, can vary from those influencing the adoption of the improved parboiling equipment once being aware of its existence.

3.3 Study Area, Sampling and Data

The study was conducted in 2 out of the 3 South Western[3] FADAMA beneficiary states of Lagos, Ogun and Oyo. Ogun and Oyo States were selected in the first stage of the sampling (Lagos state was excluded during the selection process because the state is mainly metropolitan and has insignificant number of rural and farming settlements). In the second stage, 6 local government areas (LGAS) were randomly selected from each of the 20 beneficiary LGAs of the selected 2 states (Ogun and Oyo). Using the "Confidence interval" approach [34][4] and a response rate of between 75 and 95 percent, our desired sample size was estimated to be 1013 households. A total number of 1,177[5] copies of questionnaire were eventually distributed to the household heads in the third stage of the sampling process. The proportion to the size 'approach' of each of the two selected states and the 6 LGAs in the population was used to allocate the optimum samples. This sampling method ensured representativeness (in the samples) of communities and households for assessing the technical efficiency and productivity gap of FADAMA crop farmers in South Western Nigeria.

Data used in the study were mainly primary and they were obtained through a cross-sectional survey conducted to collect information on farmers' awareness of and use of the three major FPPs (Crop management practices-CMP, Soil fertility management practices-SFMP and Soil water management practice-SWMP). The farmers adopted these extension practices to produce maize, okro, tomato, pepper and garden egg. Information on variables that affect awareness and adoption of the FPPs were also elicited from the farmers. They included variables which are socio-demographic (Age of household head in years), either household is male or female-headed, Household size, education level of the household head in years, farm size (ha),

[3]The south west Nigeria is also known as the south west geographical zone of Nigeria (Faleyimu, Agbeja and Akinyemi, 2013). It lies between longitude 2°311 and 6°001 East and Latitude 6°211and 8° 371N (Agboola, 1979) with a total land area of 77,818 km^2. The study area is bounded in the East by Edo and Delta states, in the North by Kwara and Kogi states, in the West by the Republic of Benin and in the south by the Gulf of Guinea.

[4] See also (Chawla and Sondhi, 2011 and Gupta, 2011).

[5] Realized/achieved sample size

farming experience (years). They also included variables on information access and institutional factors (Membership of farmer/community group, distance of farm from homestead (km), distance of farm to the nearest market (km), contact with extension agent (number) and whether households own radio, television and mobile telephone (ICT materials).

4. Results and Discussion

4.1 Farm household characteristics

Table 2 reports the descriptive statistics disaggregated by their adoption status for the 1,177 surveyed farmers. Adopters are defined as households that used either of crop management (CMP), soil fertility management (SFMP) or soil water management (SWMP) management practices[6]. In our study, adopters are also defined as households that, apart from using CMP or SFMP or SWMP, they also planted at least one of the commonly identified improved varieties of maize, okro, tomato, pepper and garden egg in the study (FADAMA II environment) area during the period of the survey. Results show that mainly CMP, SFMP and SWMP were adopted by 391 households representing 33.22 percent of the total sample. The average age of the household head was about 50.71 years, and there was no significant age difference between the adopters and the non-adopters. About 79 percent of the surveyed households were male-headed, but there was a significantly higher proportion of male-headed households (97.95) among the adopters compared to non-adopters (68.70). Similarly, household size, which averaged 8.5 members, did not differ significantly between the two groups.

A typical household head had about 12.42 years of formal education, but heads of adopting households were significantly slightly more educated (12.84 years) than those of non-adopting households (12.21 years), supporting the proposition that formal education is positively associated with technology adoption [35] and [36]. The total size of land owned or cultivated by each household with the non-adopting households possessing significantly larger farm sizes (4.39 hectares) than the adopting households (4.08 hectares). The years of farming experience differ between adopting (25.19) and non-adopting households (26.72). Majority of the surveyed households (93.11%) belonged to farmer/community groups but membership to these groups was significantly higher for non-adopting than for adopting households. For each of the adopting and non-adopting households, distances from homes to farms were shorter than the distances from the farms to the nearest markets. The two different distances were however significantly longer for the non-adopting households than for the adopting households. Ownership of information access assets was 74.09, 58.88 and 59.73 percent for mobile phone, radio and television sets respectively. However, the proportions of adopters owning each of these ICT assets were

[6] We will referring to crop management practices as CMP, soil fertility management practices as SFMP and soil water management practices as SWMP respectively.

significantly higher for the adopting households than for the non-adopters. This is an indication that the adopters may be more exposed to agricultural information than non-adopters.

Table 2: Household characteristics by adoption status of FPPs

Characteristics	Non-adopters (N=786)	Adopters (N=391)	Total (N=1177)	Difference	P-value
Socio-demographic factors					
Age of household head (years)	50.80025	50.51407	50.70518	.286188	0.6399
Proportion of male-headed households (%)	68.70	97.95	78.50	-29.25	0.000
Household size (total number of members)	8.511	8.41	8.48	0.1022	0.629
Education level of the household head (years)	12.21	12.84	12.42	-0.64	0.0059
Farm size (ha)	4.39	4.08	4.29	0.32	0.0278
Farming experience (years)	26.72	25.19	26.22	1.53	0.0086
Information Access and Institutional Factors					
Membership of farmer/community group (% households)	93.26	92.83	93.11	0.0041	0.0000
Distance of farm from homestead (km)	4.93028	4.292839	4.718522	0.637441	0.0126
Distance of farm to the nearest market (km)	8.510814	7.951407	8.324979	0.5594076	0.0420
Contact with extension agent (Number)	2.39	2.74	2.51	-0.35	0.0000
Own radio ((% households)	65.52	45.52	58.88	20.00	0.0123
Own television ((% households)	67.05	45.01	59.73	22.04	0.005
Own mobile telephone ((% households)	88.55	45.01	74.09	43.54	0.0053

4.2 FPPs, Crops on which the identified Extension Practices were used, their Sources of awareness and extent of the use in the study area

4.2.1 Major FPPs

The descriptive results on FPPs (CMP, SFMP and SWMP) identified in the study area in Table 3 revealed that out of overall sample of 1177 respondents, 66 and 558 were adopters and non-adopters respectively of CMP in Ogun State, while 42 and 511 were adopters and non-adopters respectively of CMP in Oyo State. In Ogun State, the percentages of adopters of CPM by LGAs are as follows: Abeokuta North (13.27), Odeda (10.58) and Obafemi Owode (9.44). For Oyo State, the percentages are: Ibarapa North (6.25), Akinyele (7.69) and Ido (92.31). On SFMP (Table 3), the results for Ogun State showed that 46 and 578 respondents were adopters and non-adopters respectively, while for Oyo State, 49 and 504 respondents were adopters and non-adopters respectively. For Ogun State, the percentages of adopters of SFMP by LGAs are as

follows: Abeokuta North (9.18), Odeda (7.51) and Obafemi Owode (6.44). For Oyo State, the percentages are: Ibarapa North (12.50), Akinyele (6.15) and Ido (9.71). Results further showed that for SWMP (Table 3), 91 and 533 respondents for Ogun State and 97 and 456 respondents for Oyo State were adopters and non-adopters respectively. The percentages of adopters of SWMP by LGAs in Ogun State are: Abeokuta North (11.22), Odeda (12.97) and Obafemi Owode (18.03). For Oyo State, the percentages are: Ibarapa North (18.75), Akinyele (15.38) and Ido (18.71).

The results on the adoption of the three management practices described above indicate that more respondents in Ogun and Oyo States adopted SWMPs when compared to the percentages of the respondents who adopted crop management and soil fertility management practices in the study areas.

Table 3: Extension practices by adoption status: (State by LGA)

Extension practices			Adopters		Non-adopters	
	State	LGA	Frequency	Percentage	Frequency	Percentage
Crop management	Ogun	Abeokuta north	13	13.27	85	86.73
		Odeda	31	10.58	262	89.42
		Obafemi Owode	22	9.44	211	90.56
	Oyo	Ibarapa north	5	6.25	75	93.75
		Akinyele	15	7.69	180	92.31
		Ido	22	7.91	256	92.09
Soil fertility management	Ogun	Abeokuta north	9	9.18	89	90.82
		Odeda	22	7.51	271	92.49
		Obafemi Owode	15	6.44	218	93.56
	Oyo	Ibarapa north	10	12.50	70	87.50
		Akinyele	12	6.15	183	93.85
		Ido	27	9.71	251	90.29
Soil water management	Ogun	Abeokuta north	11	11.22	87	88.78
		Odeda	38	12.97	255	87.03
		Obafemi Owode	42	18.03	191	81.97
	Oyo	Ibarapa north	15	18.75	65	81.25
		Akinyele	30	15.38	165	84.62
		Ido	52	18.71	226	81.29

4.2.2 Crops on which the identified extension practices were used, their sources of awareness and extent of the use.

On Tables 4 are presented the distribution of the respondents according to the crops on which the identified practices were used, sources of awareness and extent of the use of the extension practices. Awareness promotes demand and demand is a force for rapid adoption and spread of agricultural innovations. This is an indication that adoption level of improved technologies is affected by farmers' awareness of technological information pertaining to the crop. Hereunder, the results are described based on the characteristics (1. crops on which the identified extension practices were used, 2. their sources of awareness and 3. extent of the use) of each of CMP, SFMP and SWMP as follows:

CMP: The results in Table 4 show that a little over half (55.03%) of the respondents used CMP for maize production, followed by tomato (18.28%), Okro (16.64%), garden egg (7.68%) and Pepper (2.38%). Further results revealed that the sources of awareness of CMP were Ministry, LGA, Agricultural Development Programme (ADP), and FADAMA (46.25%). Other sources of awareness and the percentages of respondents affected by the awareness are as follows: Agricultural development extension Agents (28.52%), LGA, ADP, FADAMA, co-farmers (8.59%), LGA Extension Agents (6.40%), Ministry extension agents (6.22%), non-governmental organization (NGO) (1.65%), FADAMA/NFD II (1.65%), co-farmers (0.37%), International Institute of Tropical Agriculture (IITA) (0.18%), and Ministry LGA and ADP (0.18%). Moreover, the respondents claimed that the extent of adoption ranges from about three quarter of the time (10.42%), half of the time (11.88%), a quarter of the time (13.16%) and three quarter of the time (56.67%).

SFMP: On SFMP, the result revealed that majority (60.65%) of the respondents used SFMP on maize production. This is followed by Tomato (14.35%), Okro (13.89%), Garden egg (8.80%) and Pepper (2.31%) respectively. The sources of awareness of SFMP and the respective percentage of respondents affected by the awareness are as follows: Ministry, LGA, ADP, FADAMA (48.15%), Agricultural development Extension Agents (25.46%), LGA, ADP, FADAMA, co-farmers (8.80%), LGA Extension Agents (7.87%), Ministry Extension Agents (5.09%), NGO (2.31%), FADAMA,NFD II (1.39%) and co-farmers (0.93%) respectively. On the extent of adoption of these practices, results revealed the following: Those who used them all the time (60.65%), about a quarter of the time (14.35%), about half of the time (10.65%), about three quarter of the time (8.80%) and about three quarter of the time and all (5.56%).

Table 4: Table showing the crops on which CMP, SFMP and SWMP practices were used, sources of awareness and extent of use of the practices

		Crop Management Practices		Soil Fertility Management Practices		Soil Water Management Practices	
		Number	Percentage	Number	Percentage	Number	Percentage
Crops	Maize	301	55.03	131	60.65	186	44.93
	Okro	91	16.64	30	13.89	92	22.22
	Tomato	100	18.28	31	14.35	102	24.64
	Pepper	13	2.38	5	2.31	12	2.90
	Garden egg	42	7.68	19	8.80	22	5.31
Sources of awareness	Ministry extension agent	34	6.22	11	5.09	20	4.83
	Lga extension agent	35	6.40	17	7.87	16	3.86
	Agric. Development extension agent	156	28.52	55	25.46	120	28.99
	NGO	9	1.65	5	2.31	6	1.45
	FADAMA/NFDII	9	1.65	3	1.39	3	0.72
	Co- farmers	2	0.37	2	0.93		
	IITA	1	0.18				
	Ministry, LGA, ADP, FADAMA	253	46.25	104	48.15	206	49.76
	LGA, ADP, FADAMA, co-farmers	47	8.59	19	8.80	43	10.39
	Ministry, LGA and ADP	1	0.18				
Extent of use	About a quarter of the time	72	13.16	31	14.35	42	10.14
	About half of the time	65	11.88	23	10.65	58	14.01
	About three quarter of the time	57	10.42	19	8.80	38	9.18
	All the time	310	56.67	131	60.65	251	60.63

SWMP: About 45% of the respondents used soil SWMP on maize production, followed by Tomato (24.64%), Okro (22.22%), Garden egg (5.31%) and Pepper (2.90%) respectively. Furthermore the sources of awareness of these practices and the respective percentage of respondents affected by the awareness are as follows: Ministry, LGA, ADP, FADAMA (49.79%), Agricultural development Extension Agents (28.99%), LGA, ADP, FADAMA, co-farmers (10.39%), Ministry Extension Agents (4.83%), LGA Extension Agents (3.86%), NGO (1.45%) and FADAMA, NFD II (0.72%). On the extent of adoption of these practices, results revealed the following: Those who used them all the time (60.63%), about half of the time

(14.01%), about a quarter of the time (10.14%), about three quarter of the time (9.18%) and about three quarter of the time and all (6.04%).

Generally, there is an indication of uneven dissemination of these FPPs by extension agents in the study area yet farmers are in need of information and practices that will raise their level of income. [37] opined that there are enough packages on the technological shelves and that the missing link is an effective agricultural system to disseminate available technology. With respect to awareness, [38] asserted that awareness is the first stage in the adoption process. In the study of [39], it was shown that despite the high level of awareness among the farmers, adoption of technologies was relatively low. An aggressive awareness campaign was recommended while putting in place of farmers' adult education programme and farm income expansion policy were advocated for. The results on the extent of the use of the considered extension practices imply that more efforts are needed by engaging more capable hands from the extension sector. This is to boost awareness and efficient adoption of these practices. In support of this, [40] had earlier recommended that dissemination of research results should be boosted through the deployment of more extension agents to reach more areas.

4.3 Determinants of exposure (knowledge) of FPPs

In our study, about 94.31% of the sample households were exposed to at least one of the CMP, SFMP and SWMP. Based on this information, we estimate a probit regression of the factors that affect the propensity of exposure to at least one of the management practices (Table 5). Results indicate that up to 50% percent of the hypothesized variables have statistically significant coefficients at 5% level. Variables capturing access to extension (number of contact with extension workers) and ownership of ICT (information and communication technology assets) returned significant coefficients, though with unexpected negative signs at 1%. This suggests that, CMP, SFM and SWMP were not actually introduced to the sampled farmers by the 'familiar' extension agents/workers and that the use of ICT materials did not contribute to further exposure to the improved technologies. A cursory look at the results on Tables 4 (above) showed that sources of awareness to and exposure to CMP, SFMP and SWMP were mainly through the combination of agents of the Ministry, LGA, ADP and FADAMA. It was likely that there were arrangement and or agreement between the farmers, groups of farmers and these agents for periodic joint activities to promote these technologies. Location (LGA) dummies for Abeokuta north, Obafemi Owode, Odeda, Akinyele and Ido LGAs all returned positive and significant coefficients at 1% level suggesting that households in the five LGAs have significantly higher propensity to get exposed to the CMP, SFMP and SWMP. All other variables, the coefficients of which are not significant are suggesting that they are irrelevant in explaining the difference of rates of awareness of CMP, SFMP and SWMP.

Table 5: Determinants of the probability of exposure to extension practices

Variables	Coefficients	Std error	Z	P>/Z/
Number of contact with extension workers	-0.5094112	0.1313311	-3.88	0.000
Participation in extension training activities	-0.2580693	0.3512024	-0.73	0.462
Household size	0.0167143	0.0218595	0.76	0.444
Distance to the nearest market	0.0006621	0.0145062	0.05	0.964
Ease of access to extension training and research institution	-0.0286777	0.089253	-0.32	0.748
Own ICT materials (cell phone, radio, television: 1=yes, 0=otherwise)	-0.7218807	0.2447402	-2.95	0.003
Education of household head (years)	-0.0146856	0.0190432	-0.77	0.441
Age of household head (years)	-0.0032294	0.0581921	-0.06	0.956
The square of age	-0.0000677	0.0005601	-0.12	0.904
Abeokuta north LGA (dummy)	0.792045	0.3048856	2.60	0.009
Obafemi owode LGA (dummy)	0.6424498	0.2273113	2.83	0.005
Odeda LGA (dummy)	0.7834347	0.2319823	3.38	0.001
Akinyele LGA (dummy)	0.9700423	0.2650784	3.66	0.000
Ido LGA (dummy)	0.6807991	0.2261256	3.01	0.003
Constant	3.6108	1.527484	2.36	0.018
Number of observation	1154			
Log likelihood	-122.6597			
LR Chi^2 (14)	60.12			
Prob>chi^2	0.0000			
Pseudo R^2	0.1175			

Source: Survey Data (February-May, 2019)

4.4 Rates and determinants of adoption of the extension practices

4.4.1 Adoption rates for extension practices

Table 6 presents the results of the actual (JEA) and potential (ATE) adoption rates of the CMP, SFMP and SWMP and also the adoption generated by the incomplete diffusion of new extension (FADAMA) practices during the survey (2018/19) period in the study area. The ATE means the effect or the impact of a "treatment" on a person randomly selected in the population. In the context of this present study, a "treatment" corresponds to exposure to CMP, SFMP and SWMP, and the ATE on the adoption outcomes of the population members is the (potential) population adoption rate. That is, the adoption rate when all farmers have been exposed to the FPPs. The diffusion results showed that about 94.31% were aware of at least one extension practice during the survey (2018/19) period. This incomplete diffusion of the extension practice restricted the actual adoption (JEA) rate of at least one extension practice to about 33%, whereas

the potential adoption rate (ATE) was 36% in the same period. This implies that the extension practices' adoption rate in the study area would have been 36% in 2018/19 if the whole population had been exposed to the practices, instead of the joint exposure and adoption rate of 33%. Thus when compared to the sample adoption rate of 36%, there is a population adoption gap of 3% (though not substantial) due to the population's incomplete exposure to the extension practices. The estimated adoption gap is statistically and significantly different from zero at 1% level.

The findings imply that there is potential for increasing the adoption rate by 3% once all farmers become aware of at least one FPP and once other constraints of e.g. improved seeds of maize, okro, tomato, pepper and garden eggs (which are the crops on which these practices are used) and credit (cash) are addressed. The results of the ATE1, which is by definition, the average treatment effect on the treated, show that among the sample population, 35% of households exposed to the FPPs adopted at least one of them. The non-exposed (untreated) subpopulation mean potential adoption rate, given by ATE0 is estimated at 54%. The estimated population selection bias which is measured by the difference in the potential adoption rate in the exposed subpopulation and the consistently estimated population adoption rate is estimated at 1% and it is statistically significant and different from zero. This significant selection bias suggests that the adoption probability for a farmer belonging to the subpopulation of informed farmers is not the same as the adoption probability for any farmer randomly selected from the whole population.

Table 6: Adoption rates and adoption gap of the extension practices (full sample n=1177)

Estimator	Parameter	Std. error	Z	P>/Z/
Proportion of exposed households	0.9419411	0.006887	136.77	0.000
ATE (Potential adoption rate)	0.3617601	0.0125162	28.90	0.000
ATE1(Adoption rate among the exposed)	0.350506	0.0121821	28.77	0.000
ATE0 (Adoption rate among the non-exposed)	0.5443457	0.0296112	18.38	0.000
Joint exposure and adoption rate (JEA)	0.330156	0.0114748	28.77	0.000
Adoption gap (GAP = ATE-JEA)	-0.0316041	0.0017192	-18.38	0.000
Population selection Bias (PSB)	-0.0112541	0.0014485	-7.77	0.000

4.4.2 Determinants of adoption of extension practices (FPPs)

Results on the determinants of adoption of extension practices for the ATE probit model are presented in Table 7. Results show that factors such as extension contact, household size, land holding, gender, input access, ownership of ICT assets, credit access and location dummies of Obafemi Owode and Ido LGAs among others, have a significant effect on the adoption of extension practices. The coefficient of extension contact is positive and significant at 1% level suggesting that constant contact

with extension increases the propensity to adopt FPPs. The coefficient of household size is negative and significant implying that households with larger number of members have a lower propensity to adopt FPP. In the study area, larger households may find it more important to make use of the larger number of individuals in the households to generate income from other sources. The size of land owned by the household returned a positive and significant coefficient suggesting that farmers with larger holdings are more likely to adopt FPP extension than those with smaller land holdings. Similar results on the influence of farm size on technology adoption were found by [41-42] and [33]. This also implies that crop farm size in the study area positively influenced the probability of adopting the FADAMA extension practices.

Table 7: Determinants of adoption of extension practices-ATE probit model

Variables	Coefficients	Std error	Z	P>/Z/
Number of contact with extension workers	0.4129495	0.1209325	3.41	0.001
Participation in extension training activities	0.5119852	0.3918593	1.31	0.191
Household size	-0.054634	0.0255563	-2.14	0.033
Land holding (farm) size (ha)	0.5415878	0.2211773	2.45	0.014
Gender of household head (Male=1; Otherwise=0)	2.61528	0.4210121	6.21	0.000
Distance to the nearest market	0.0242912	0.0248806	0.98	0.329
Ease of access to extension training and research institution	-0.0975693	0.1106763	-0.88	0.378
Ease of access to input	-0.243602	0.1091401	-2.23	0.026
Own ICT materials (cell phone, radio, television: 1=yes, 0=otherwise)	2.077087	0.2667468	7.79	0.000
Education of household head (years)	-0.0300427	0.0387727	-0.77	0.438
Age of household head (years)	-0.0528188	0.0661098	-0.80	0.424
The square of age	0.0002778	0.000636	0.44	0.662
Access to credit (: 1=yes, 0=otherwise)	-2.295532	1.155143	-1.99	0.047
Interaction for education and credit access	0.0146258	0.0319218	0.46	0.647
Interaction for age and credit access	0.029621	0.0195228	1.52	0.129
Total livestock units	0.0000572	0.0009211	0.06	0.951
Abeokuta north LGA (dummy)	-0.2307266	0.405225	-0.57	0.569
Obafemi owode LGA (dummy)	-0.5980127	0.3543717	-1.69	0.092
Odeda LGA (dummy)	-0.3321466	0.3462087	-0.96	0.337
Akinyele LGA (dummy)	0.3003175	0.3777339	0.80	0.427
Ido LGA (dummy)	-1.611569	0.3657967	-4.41	0.000
Constant	-2.11774	1.953124	-1.08	0.278
Number of observation	1087			
Log likelihood	-518.44687			
LR Chi^2 (22)	371.33			
Prob>chi^2	0.0000			
Pseudo R^2	0.2637			

The coefficient of gender of household head is positive and significant at 1% suggesting that the probability to adopt at least one of CMP, SFM and SWM practices increases with being a male farmer. Results also showed ease of access to input and access to credit returning negative and statistically significant coefficients. Though these two factors are important in the adoption of improved technology, the estimated results suggest that their access by the sampled farmers in the

study area was not easy during the survey period. The coefficient of ICT ownership was found to be positively and statistically significant at 1%, implying that households that owned ICT materials like radio, television and mobile phones have a higher propensity to adopt FPPs than those who do not own these ICT materials. The importance of ICT item for video screening and training as they affect adoption of improved technology was highlighted by [43] and [29]. The ownership of ICT materials may also enhance technology adoption as they facilitate information dissemination as regards the availability of inputs, labour and other productivity enhancing resources. The coefficients of the location dummies for Obafemi Owode and Ido LGAs were negative and statistically significant at 10 and 1 percent respectively implying that farmers in these LGAs have lower propensity to adopt the FPPs.

5. Conclusion

This study was conducted to analyze the adoption of crop production (FADAMA extension) practices and the determinants of farmers' awareness (exposure) to and adoption of these practices. The empirical questions that were addressed centered on: the major (identified) extension practices, the crops produced using them and their sources of awareness. The other pertinent research questions had to do with: the characteristics of farmers by adoption status, exposure to/knowledge of the improved extension practices and their determinants and the adoption rates of extension practices and the determinants of adoption. Of the three management practices described in the study, we find that more respondents in Ogun and Oyo States adopted Soil Water Management (SWMPs) when compared to the percentages of the respondents who adopted crop management (CMPs) and soil fertility management (SFMPs) practices in the study areas. Generally, there is an indication of uneven dissemination of these FPPs by extension agents in the study area yet farmers are in need of information and practices that will raise their level of productivity and in effect, their income. Sources of awareness of and exposure to CMPs, SFMPs and SWMPs were mainly through the combination of agents of the Ministry, LGA, ADP and FADAMA. On the determinants of exposure to extension practices, location (LGA) dummies for Abeokuta north, Obafemi Owode, Odeda, Akinyele and Ido LGAs all returned positive and significant coefficients at 1% level suggesting that households in the five LGAs have significantly higher propensity to get exposed to the CMP, SFMP and SWMP.

The study has shown that there is potential for increasing the adoption rate (of FPPS) by 3% once all farmers become aware of at least one FPP and once other constraints of improved seeds (of the crops on which these practices are used) and credit (cash) are addressed. We also find that adoption of extension practices are influenced by factors such as extension contact, household size, land holding, gender, input access, ownership of ICT assets, credit access and location dummies of Obafemi Owode and Ido LGAs among others. These factors are essentially the main determinants (drivers) of the adoption of the FPPs in the study area. Their significance will be evident when they are worked upon in other communities, especially the non-FADAMA environments. Some implications which can be drawn from the findings on the determinants of adoption of the FPPs are as follows: constant contact of the households with extension increases their propensity to adopt FPPs; households

with larger number of members have a lower propensity to adopt FPPs (larger households may find it more important to make use of the large number of individuals in the households to generate income from other sources); farmers with larger holdings are more likely to adopt FPP extension than those with smaller land holdings; the probability to adopt at least one of CMP, SFM and SWM practices increases with being a male farmer; households that owned ICT materials like radio, television and mobile phones have a higher propensity to adopt FPPs than those who do not own these ICT materials (the ownership of ICT materials may also enhance technology adoption as they facilitate information dissemination as regards the availability of inputs, labour and other productivity enhancing resources) and farmers in Obafemi Owode and Ido LGAs have lower propensity to adopt the FPPs. In all, these findings are a direction to the significance of improving farmers' awareness and adoption of productivity enhancing crop production practices. For instance, more farmers (particularly those not in the FADAMA villages) around Abeokuta north, Obafemi Owode, Odeda, Akinyele and Ido LGAs need to be sensitized to make use of the available FADAMA extension opportunities in those locations. Also, access to credit to facilitate inputs (including land resource) and ICT assets' acquisition should be prioritized by policy makers and other relevant stakeholders. This can be achieved through the improvement of the extension services which are specific of the various intervention projects such the FADAMA agriculture.

Finally, future research work on the impact of some outcomes on the adoption of the considered FPPs is suggested. This will give further direction on the upscaling and outscaling of these production practices to the benefit of the generality of poor households and to policy planners.

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Competing interests

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