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Adoption of and farmers' exposure to soil and Water Management (SWMGT) Practices in the Sahel Savanna of West Africa: Average Treatment Effect (ATE) Estimations.

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Abstract

This paper approaches the soil and water management (SWMGT) adoption estimation from the perspective of the modern evaluation theory. As a result, the analytical procedure adopted for the study follows the Average Treatment Effect (ATE) estimation framework. The data gathered for the analysis are part of the baseline data collected from a sample of 572 households in 20 villages in Maradi (Niger Republic) and katsina (Nigeria). Results show that about 45 percent of the respondents have adopted the soil and water management (SWMGT) practices, out of 398 (70%) households that had knowledge or were aware of the SWMGT options. The joint exposure and adoption rates from three different models have been estimated at 39%. Results for joint exposure and adoption (within the SWMGT exposed sub-population) rate are also similar for the three models (59%) with similar range of 95% confidence interval (between 52% and 65%). With the intervention of the SSACP through the

IAR4D, it is expected that the adoption rate could be increased by at least 14% if an effective awareness of these SWMGT practices through the Innovation Platform system is undertaken.

Key words: Adoption, Exposure, Average treatment Effect, Innovation Platform, Integrated Agricultural Research for Development.

1. Introduction

Agriculture continues to provide employment, food and income to millions of people in sub-Saharan Africa (SSA). But productivity levels in various sub-sectors vary significantly depending on such factors as the dominant agro ecologies and the cropping or farming systems. In general agriculture in the sub-region is characterized by limited use of external inputs and continuous deterioration of the resource. Also, more than seventy percent of the working population of Sub-Saharan Africa depends on agriculture and agriculture related business for livelihoods. But most African countries currently suffer from very low agricultural yields compared with the rest of the world. Since a large population of the continent's inhabitants are subsistence farmers, these low yields, result in low economic development, food security, poverty and high level of infant and child mortality. Sustainable agriculture is defined as agricultural practices that are economically viable, socially acceptable, environmentally friendly and technically appropriate. It can also be referred to as the ability of agricultural systems to keep production and distribution going continuously without falling (i.e. how agricultural growth and development can be sustained into the future). For this to be achieved there should be understanding of the prospects and constraints of sustainability in agricultural production in Sub-Saharan Africa.

Among the constraints to sustainable agricultural production in Africa are land degradation, low use of farm inputs, problem of land tenure and fragmentation, low level of rural infrastructural development, bulk exports of unprocessed agricultural commodities (mainly cash crops), low institutional and human capacity building, unfavorable economic policy to mention a few. Of all the agricultural constraints mentioned above, land degradation has been identified as one of the most serious ecological and economic problems facing tropical countries (Bayard *et.al.* 2006). Furthermore, soil fertility degradation has also been described as the single most important constraint to food security in Sub-Saharan (SSA) (TS BF-CIAT/ICRAF, 2002).

Sub-Saharan Africa is located within the most fragile region of the world, very environmentally degraded (Mbagwu, 2008). It is an area that is known for the worst devastation in the environment. The main causes of land degradation/devastation are soil erosion by water and wind, deforestation, alkalinisation, soil fertility decline, water logging, salinization, and lowering of the water table. Other causes are soil pollution, forest degradation, rangeland degradation, acid sulphate formation, soil pollution, soil destruction through mining and quarrying activities, urban and industrial encroachment into agricultural land and destruction of irrigation schemes, furthermore, there are potential effects of climate change, including global warming, which may lead to modification in the general atmospheric circulation, causing changes in the rainfall pattern (Mbagwu, 2003). Worldwide, about 85 percent of land degradation is caused by soil erosion, by water and wind. Therefore, health of African soils has become a constant challenge for farmers and agriculturalists in the continent (Omotayo and Chukwuka, 2009). Conflicting interests in the exploitation of soil resources by various stakeholders has led to mismanagement; and in some cases, degradation of soils. In recent decades, unsustainable land cultivation practices (e.g. inadequate replacement of soil nutrients taken up by crops) have led to accelerated depletion of the natural soil base available for food production (Hossner and Juo, 1999). Soil productivity maintenance remains major environmental issues in countries of the SSA (Oyetunji *et. al*. 2001). Low soil fertility inevitably leads to low agricultural productivity, since agricultural development is fundamentally affected by productivity status of land resources. Poor soil management and the fragile nature of tropical soils generally account for heavy nutrient losses through soil erosion and nutrient leaching in soils (Hossner and Juo, 1999). In countries of SSA, unsuitable soil management activities including deforestation, indiscrimate vegetation removal, overgrazing and use of marginal lands for agricultural purposes which often precede eventual degradation of soil resources and environmental damage (Henao and Baanante, 2006). Poor cultivation practices have resulted in decrease of soil fertility, reduction of soil organic matter (SMO), and increase in occurrence of acidified soils (Aihou *et al.,* 1998). Decline in soil fertility as a result of land degradation decreases farmland productivity (Amede, 2003). Escalating rates of soil nutrient mining makes nutrient loses highly variable in agricultural areas of sub-humid and humid savannas of West Africa, where they range from moderate to severe loss of nutrients (Henao and Baanante, 2006). Smaling (1993) estimated that annual net nutrient depletion rates per hectare exceeded 30 kg N and 20 kg K in arable soils of several countries in SSA. In many parts of SSA where poor soil conservation methods prevail, long term productivity of soil is projected to decline considerably unless soil management practices improve.

Proper soil conservation then becomes imperative when considering the issues regarding soil fertility improvement in SSA. This becomes evident in the light that the lives of greater percentage of the populace in the region are directly connected to agriculture and agricultural based industries. Among the soil restoration techniques which have been thought to be able to sustain soil fertility and improve yield in African agriculture is the “use of organic resources for soil fertility improvement in SSA. Though this has been in practice since the earliest times, the strategies by which the materials were applied may differ from recent conventional methods through technology development and adaptive strategies to meet peculiar modern needs. Since land degradation is a form of soil erosion and nutrient depletion which threatens food security and sustainability of agricultural production in Sub-Saharan Africa, many government and development agencies have responded and invested substantial resources in promoting soil conservation practices as part of efforts to improve environmental conditions and ensure sustainable and increased agricultural production (Kassie et. al. 2007). One of the agencies that have risen up to the challenge of low agricultural productivity resulting from several constraints including land degradation and soil infertility is the forum for Agricultural Research in Africa (FARA). As a follow up to the above, the sub Saharan Africa challenge programme (SSA CP) through its implementer, the Forum for Agricultural Research in Africa (FARA) is using the IP[1] system of the IAR4D[2] to advocate for the sustainable use of natural resources to address the challenge of soil fertility problems and thereby ensuring sustainable agricultural productivity. There are three major soil conservation and other land management options that farmers in Sahel Savanna of the Kano-Katsina-Maradi Pilot Learning Site (KKM PLS) of the (SSA CP) are using. These include: (i) Soil and water management (mulching, water harvesting, trenches/terraces, irrigation and conservation tillage); (ii) Crop protection (use of fungicide, insecticide, herbicide and botanical pesticide); and (iii) Crop management practices (row planting, planting density, thinning, inorganic fertilizer application, animal manure, etc). Soil and water management practices are of particular importance given its cost effectiveness and environmental friendliness. These options can moderately be within the resource poor farmers' reach. It is therefore pertinent to evaluate the adoption of these soil and water management options. This will afford stakeholders better opportunities to ascertain the importance of shifting appropriate attention to policies in natural resource management as it affects sustainable agricultural production.

In this study however, we focus on soil and water management practices, as one of the traditional and conventional means of combating land degradation and soil fertility problems.

[1] IPs are "Innovation Platforms" which form the basic units of operation within the sub-Saharan African Challenge programme (SSA CP). The workings of these are described in this paper
[2] The IAR4D is the acronym for "Integrated Agricultural Research for Development" system which is the new research paradigm in agricultural research development (AR4D) that the SSA CP is implementing. The concept of this is being tested by using the IP system approach of research.

The study examines the soil and water management practices and the factors that determine their adoption.

2. Analytical Framework

Several studies have been carried out on adoption of agricultural technologies. Few of these studies include those on improved crop technologies (Adesina and Zinnah, 1993; Adesina and Baidu-Forson, 1995; Adesina and Seidi, 1995; Abebaw and Belay, 2001) and on soil conservation technologies (Bayard et. al. 2006; Onweremadu and Matthews-Njoku, 2007; Mazvimavi and Twomlow, 2009). These studies and quite a number of other common adoption studies in the econometrics literature have addressed adoption on the basis of three models: (a) linear probability, (b) logistic function (logit) and (c) the normal density function (probit) models. In spite of their wide and common application to adoption issues, these models may have suffered from what we call "nonexposure bias" or from exposure bias (Diagne and Demont, 2007; Diagne, 2010). As a consequence, they generally yield biased and inconsistent estimates of population adoption rates even when based on a randomly selected sample. The nonexposure bias results from the fact that farmers who have not been exposed to a new technology cannot adopt it "even if they might have done so if they had not known about it". This results in the "population" adoption rates being underestimated[3].

For the same reasons of population nonexposure selection bias, the causal effects of the determinants of adoption cannot be consistently estimated using a simple logit, probit or tobit model that does not control for exposure (Diagne and Demont, 2007). This difficulty inherent in interpreting the coefficients of the simple probit, logit or tobit adoption model when diffusion of technology in the population is not complete has been pointed out by

[3] As in Feder et. al. 1985; Sunding and Zilberman, 2001 (reported by Diagne and Demont, 2007), the two concepts of adoption and diffusion are often used interchangeably used in the voluminous adoption literature. The definition adoption of a technology in this paper is however adapted from Diagne and Demont, 2007) to mean its use at the individual level or at the aggregate population level as in (Feder et. al. 1985). The term diffusion which is also used in this paper is to mean the extent of "knowledge" of (or "exposure" to) the technology in the population (which does not necessarily imply its use).

Besley and Case (1993), Saha et. al. (1994) and Dimara and Skuras (2003). In effect, it turns out that the population adoption rates correspond to what is defined in the treatment effect literature as "average treatment effect" commonly denoted by *ATE* (Diagne and Demont, 2007). ATE measures the effect or impact of a "treatment" on a person randomly selected in the population. In the adoption context, a "treatment" corresponds to exposure to a technology and the ATE on adoption outcomes of population members is the (potential) population adoption rate. That is, the adoption rate when "all" members of the population have been exposed to the technology. The difference between the population adoption rate and the actual adoption rate is the population nonexposure bias, which exists solely because of the incomplete diffusion of the technology in the population. It measures in some sense the "unmet" population demand for technology and will, therefore be simply called the population "adoption gap". Another quantity that is also the subject of attention in the treatment effect literature is the "ATE on the treated", which is commonly denoted by *ATE1*. The ATE1 is a measure of the effect of treatment in the treated subpopulation and in the adoption context; it corresponds to the adoption rate among the exposed.

Following the above exposition of adoption challenges, and to avoid bias estimations, the analytical procedure adopted for this study follows from the Average Treatment Effect (ATE) estimation framework. The paper approaches the soil and water management (SWMGT) adoption rate estimation from the perspective of the modern evaluation theory (Imbens and Angrist, 1994; Heckman, 1996; Wooldridge, 2002). Under the ATE estimation framework (Adapting Diagne et. al. 2009) it is assumed that every farmer in the population has two "potential" adoption outcomes: with and without exposure to a technology (the treatment). If we assume w to be a binary variable indicating the observed status of exposure to at least one SWMGT[4] option, where w=1 if the farmer is exposed and w=0 if the farmer is not exposed. Let y_1 be the "potential" adoption outcome of a farmer when exposed (i.e. when

[4] SWMGT in this paper is used to denote Soil and water management, whose adoption we are studying.

w =1 for him or her) and y_0 is his or her potential adoption outcome when not exposed (w =0 for him or her). The observed adoption outcome y can be expressed as a function of the two potential adoption outcomes y_1 and y_0 and the treatment status variable w as $y = wy_1 + (1-w) y_0$. The population means impact of exposure to the SWMGT options on population adoption outcomes is given by the expected value $E(y_1-y_0)$, which is by definition the average treatment effect (ATE) of exposure. Because exposure to the SWMGT options is a necessary condition for their adoption, we have y_0 =0 for any farmer whether exposed to the SWMGT options or not. Hence, in this adoption context, ATE is reduced to the expected value $E(y_1)$ which is the population mean potential adoption outcome. The exposed subpopulation mean potential adoption outcome is given by the conditional expected value $E(y_1|w=1)$, which is by definition ATE1, the average treatment effect (of exposure) on the treated. Similarly, the non exposed (untreated) subpopulation mean potential adoption outcome denoted by ATE0 is given by $E(y_1|w = 0)$. Also, with y_0=0 the expression of the observed adoption outcome variable as a function of the two potential adoption outcomes and the exposure variable reduces to $y= wy_1$, an expression that shows clearly that the observed adoption outcome variable is a combination of the exposure and adoption outcome variables. This justifies calling the population mean "observed" adoption outcome $E(y) = E(wy_1)$ the population mean joint exposure and adoption parameter denoted as JEA to differentiate it from the population mean adoption parameter $E(y_1)$, which as we know is ATE and a measure of the potential demand of the technology by the population in terms of adoption. The difference between the JEA and ATE parameters (i.e. the difference between the populations mean "observed" adoption outcome and the population mean "potential" adoption outcome) is the population non exposure bias (NEB), also called the population adoption gap (GAP): NEB = GAP = $E(y)-E(y_1)$. The population selection bias (PSB) defined as the difference between the mean potential adoption outcome in the exposed subpopulation is given by $PSB = ATE1 - ATE = E(y_1 | w = 1) - E(y_1)$[5].

3. Study Area, Data and sampling

The data used in our analysis came from a sample of 600 farmers in 20 villages in Maradi (Niger Republic) and katsina (Nigeria). The data is part of the baseline data collected by the Sahel Savanna task force of the kano- katsina–Maradi pilot learning site of the Sub-Saharan Africa Challenge programme in West Africa. The villages were selected from four “Innovation Platforms IPs” that make up the Sahel Savanna task force. The four IPs are (i) crop-livestock (katsina, Nigeria); (ii) groundnut; (iii) vegetable; (iv) soil fertility IPs in Maradi, Niger Republic. Each of the 4 IPs is composed of 5 villages where the Integrated Agricultural Research for Development “IAR4D” is implemented. There are also five “conventional” and five “clean” corresponding villages in each of the IPs. These are “counterfactuals”, i.e. where the KKM PLS is not intervening, but used as controls. The selection of the villages was not random as it purposively included all the 20 villages (factual and counterfactual) earmarked for the baseline. Ten farmers were randomly selected in each village (factual and counterfactual) for a total sample size of 600 farmers. The data collected were included in 4 types of survey questionnaires: (i) household, (ii) plot (iii) IP characterization and (iv) village characterization. The data requirement for this study is implemented from the household survey questionnaire. The data collected included in particular the farmer knowledge and adoption of soil and water management options (mulching, water harvesting, trenches, terraces, irrigation and conservation tillage). The data also include production data, such as the value of the total productivity, farm size, access to extension services, credit, farming experience etc. Socio demographic data include farmer’s age, educational level, marital status, gender, household size etc.

[5] For more on ATE estimation procedure (See Wooldridge 2002 chapter 18 and Diagne et. al. 2009 pp3-9).

4. Results

(a) Characteristics of Farmers

Specific characteristics of the farmers that are closely related to the adoption of soil and water management practices are presented on Table 1. The mean value of productivity, based on the estimations from the data set amounted to $ 659.79[6]. Average farm size across the survey sites was approximately 2.78 ha. The average farm size calculated in this study can be realistic when considering the vast nature of available land in the Sahel. Soil fertility problem may not however allow for optimum use of these parcels of land. As at the time of the baseline survey, only 256 respondents have adopted the soil and water management practices, out of 398 respondents that had knowledge or were aware of the SWMGT options. The percentage of adopters of SWMGT in this study about (45%) is relatively higher than by 40% of respondents who used agroforesty practices as one of the soil conservation management options in the findings of Nkonya (2002). This suggests that the Innovation Platform system of the IAR4D can cause a further rise in the number of adopters of swmgt in the Sahel Savanna. The mean age of the household head was about 45 years. Married farmers were 516 and 56 were not married at the time of survey. The mean size of the farmer's household was found to be 8 people per household. Farming experience in years per farmer was approximately 27 years. Farmers owing farms in homestead, upland and in wetland were 372, 450 and 122 respectively. Two hundred and thirty five (235) farmers had access to credit, while 262 farmers have used at least one soil and water management options in the past. Farmers that reported having had at least one extension contact were 452 and 432 respondents have interacted with other farmers and groups. About 34 percent (192) of the respondents have received training in agriculture.

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[6] Farmers from two countries (Nigeria and Niger Republic) were involved in the survey, so the need to adopt a uniform currency for our estimations; in this case, the United States (US) Dollars. As at the time of the survey in 2008, a $ was exchanged for the ₦118 (Nigerian Naira) and 285 CFCA.

Table 1: Characteristics of the respondents

Characteristics	Result
Value of total productivity (mean)	$ 1959.79
Farm size (mean)	2.78ha
Adopters of swmgt (n)	256
Awareness/Knowledge of swmgt (n)	398
Number of swmgt options available	5
Age of household head (mean)	44.92
Marital status	
(a) married(n)	516
(b) not married (n)	56
Number of schooling years (mean)	1.80
Household with member living away (n)	161
Household size (mean)	8people
Farming experience (mean)	26.86
Having homestead farm(n)	372
Having upland farm(n)	450
Having wetland farm (n)	122
Having access to credit (n)	235
Have used swmgt in the past (n)	262
Have had extension contact (n)	452
Interaction with research or other farmers/ groups(n)	432
Frequency of extension contact (mean)	1.24
Has received training in agriculture (n)	192

This figure is very low considering the importance of agricultural training in developing the farmers' skills. A possible reason for the small number farmers who have received agricultural training could be because of the non-participation of the majority of farmers in programs and the absence of adequate interaction with research and extension where information on such training could be sourced. The above is also corroborated by the low rate of extension visit to a farmer which stood at 1.24.

(b) SWMGT adoption rates

Results of the estimation of adoption rates are shown on Table 2. Estimated results for the joint exposure and adoption rate based on three different methods of estimation (classic probit joint exposure and adoption model, ATE semi parametric estimates and ATE probit adoption model) show the same point estimates (39%). These results represent the direct sample computation estimate, which we know from the above results to be consistent with no additional distributional or functional form assumption (only random sampling is assumed). These results also yield the same range for the 95% confidence interval (between 35% and 43%). This suggests that the assumption underlying the three models are plausible as far as the estimation of the joint exposure and adoption rate for the whole population and its determinants is concerned (Diagne and Demont, 2007). Results for joint exposure and adoption (within the SWMGT exposed sub-population) rate are also similar for the three models (59%) with similar range of 95% confidence interval (between 52% and 65%). This, we also know to be consistent with no additional distributional or functional form assumption. The full population adoption rate (ATE), which informs on the demand of the technology (swmgt options) by the target population, is estimated to be 40% by the ATE semi parametric and ATE probit adoption models. This suggest that the adoption of soil and water management practices in the Sahel Savanna of West Africa could have been 40% in the year preceding the baseline (2007) instead of the actually observed 39% joint exposure and adoption rate, if the whole population were exposed to the adoption (use) of SWMGT options in 2007 or before. The corresponding estimates of the population adoption "gap" (i.e. the non exposure bias), are -14% and -17%, respectively.

The adoption rate among the presently SWMGT exposed sub population (ATE1) is estimated to be 59% by both the ATE semi parametric and ATE probit models, while the estimated adoption rate for the non–exposed subpopulation (ATE0) are 43% for the ATE semi parameteric and 44% for the ATE probit model. These results are significantly different from zero at 5% (ATE1) and (ATE0) 10% levels respectively. Consequently, the null hypothesis that the presently SWMGT -exposed subpopulation is equally likely to adopt the SWMGT options as in the whole population of farmers is rejected. The expected population selection biases (PSB) are (ATE semiparametric) 18% and (ATE probit adoption model) 22%

respectively. The positive PSB indicates that the exposed farmers are significantly more likely to adopt at least one swmgt practice than any farmer randomly selected from the baseline survey area.

Table 2: Estimates of Swmgt adoption rates and their 95% confidence intervals

Parameters	Classic probit joint Exposure and Adoption model	ATE Semi Parametric estimates	ATE probit adoption model
Joint exposure and adoption rate (probability of knowledge and adoption of at least one swmgt option):			
-In the full population	0.39 (0.35:0.43)***	0.39 (0.35:0.43)***	0.39(0.35:0.43)***
-Within the swmgt exposed Farmers sub-population	0.59(0.59:0.65)***	0.59(0.59:0.65)***	0.59(0.59:0.65)***
Swmgt practices adoption rate (prob. of adoption of at least one Swmgt options):			
-In the full population (ATE)		0.40(-0.13:0.94)*	0.40 (-0.13:0.94)*
-Within the swmgt exposed sub Population (ATE 1)		0.59(-0.21:1.38)*	0.59(-0.21:1.38)*
-Within the sub population not exposed swmgt (ATE 0)		0.043(0.018:0.070)**	0.044(0.018:0.070)**
Estimated population adoption gap			
Expected pop. Adoption gap (Non-exposure bias)		-0.014(-0.024:-0.006)**	-0.017(-0.03:-0.007)*
Expected pop. selection bias (PSB)		0.18(-0.080:0.44)*	0.22(-0.18:0.51)*

Source: Data Analysis

(c) Determinants of farmer’s exposure to soil and water management practices options.

On Table 3 we present the probit results of the determinants of the probability of getting exposed to the soil and water management options. Quite a number of variables show statistically significant coefficient at 5% and 1% levels: experience in farming, having homestead and upland farms, frequency of extension contact, interaction with research or other farmers/ groups, number of years of schooling and number of years of residence in the locality by the farmer. These variables are significant at 1% and 5%.

At 1% level; upland farms, frequency of extension contact, adoption of SWMGT practices in the past and number of years of residence in village are statistically significant. Extension and interaction play vital institutional role. According to Nkonya (2002), institutions impact land management practices via the services they provide and policies that they design, implement and/or enforce. For instance as Nkonya (2002) reported, many studies have shown that local institutions are important for enacting and enforcing by-laws and regulations for soil conservation methods. This is because effectiveness of many soil conservation methods calls for collective adoption. This implies that implementation of soil conservation practices requires strong local institutions. In the study area, these local institutions reach out to the farmers through extension which in turn facilitates interaction among the different stakeholders and groups. At 5%, experience in farming, interaction, homestead farm, and number of schooling years are statistically significant. Experience in farming, especially by using soil and water management options will render the farmers to know the SWMGT practices more than those that have less farming experience.

Table 3: Probit estimates of the determinant of the probability of exposure to the swmgt options

Variables	Estimated Co-efficient	Standard error	Marginal effect dy/dx	Standard error
Experience in farming (yr)	0.84	0.30**	0.20	0.71**
Homestead farm (1,0)	-0.007	0.27**	-0.002	0.07**
Upland farm (1,0)	0.28	0.24***	0.07	0.06***
Wetland farm (1,0)	0.21	0.23	0.06	0.02
Frequency of extension contact	1.27	0.16***	0.32	0.04***
Number of interaction with research or other farmer/group	-0.23	0.081**	-0.58	0.21**
Number of schooling yrs	0.092	0.031**	0.02	0.01**
Used swmgt in t past (1,0)	1.58	0.25***	0.34	0.04***
No of years of residence in locality	-0.93	0.20***	-0.27	0.07***
Having household member living away(1,0)	-0.26	0.20	-0.07	0.06
Farm size	-0.15	0.11	-0.04	0.03
Household size	-0.04	0.30	-0.01	0.01
Age of household head	0.0005	0.007	0.00	0.00
Access to credit (1,0)	-0.03	0.03	-0.01	0.01
Const	-0.64	0.56		
No of observation	518			
LR chi^2 (14)	365.13			
Prob >chi^2	0.0000			
Pseudo R^2	0.55			
Log likelihood	-148.06			

Farmers who have contact with extension are significantly more likely to know the SWMGT options than farmers with no extension contact. Farmers who regularly interact with researchers or other farmers/groups or other stakeholders like the private, NGO, etc are significantly more likely to know soil and water management practices than farmers who do not interact with any of the aforementioned. Educated farmers are more likely to know SWMGT practices than those that are less educated. Farmers who have adopted the swmgt practices in the past and those who have lived or resided in villages where SWMGT are practiced through the intervention of conventional agricultural research for development (ARD) are significantly more likely to know the soil and water management options than those with no such attributes. Awareness and knowledge of the SWMGT options in this regard are very crucial. It has been asserted that population pressure, poverty, land tenure insecurity, policies and institutions, poor infrastructure and services and more importantly farmers' lack of knowledge about soil conservation methods are the underlying causes of land degradation (Pender et. al., 2001). In the same vein, lack of awareness and or of the knowledge of the use of soil and water management options may have caused the low level of their use in the study area, thereby affecting the overall farm productivity. The findings here point to the urgent need to improve extension services and motivate farmers to interact the more. The integrated agricultural research for development is encouraging this and it is hoped that when emphasis is laid on this, awareness of better and improved swmgt options will increase among the farmers.

5. Conclusion

This paper used the average treatment effect estimation framework to estimate the soil and water management (SWMGT) practices adoption rate and their determinants in the KKM PLS Sahel Savanna of West Africa. The SWMGT probability of adoption in the population is estimated to be 40% instead of the actual slightly less estimate of 39% joint exposure and adoption rate, if the whole population were exposed to the SWMGT options in 2007 (the year proceeding the baseline period 2008) or before. It is worthy of mentioning that though there have been some level of intervention in the study area in the past, these interventions have not actually emphasized on the adoption of natural resource management option such as soil and water management practices which resource poor farmers can practice at convenient cost. This informs the reason for the very small difference between the potential and the observed adoption estimate of swmgt in the study area. With the intervention of the SSACP through the IAR4D, it is expected that the adoption rate could be increased by at least 14% (non exposure bias = 14%) if an effective awareness of these SWMGT options through the IAR4D is undertaken. The study also shows that the exposure to swmgt practices and options is affected by factors such as experience in farming, extension services, farmer's interaction, number of years of schooling, adoption of SWMGT in the past and number of years of residence in the village. Of these factors, extension and interaction are very crucial and vital aspects of the IAR4D. These can be improved upon by implementing effective policy options which emanate from the operations and management of the IP system in the study area.

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