Agricultural Research & Technology
Open Access Journal
ISSN: 2471-6774

Juniper Publishers
key to the Researchers

Research Article
Volume 21 Issue 1 - April 2019
DOI: 10.19080/ARTOAJ.2019.21.556150

Agri Res & Tech: Open Access J

Factors Influencing Zai Pit Technology Adaptation: The Case of Smallholder Farmers in the Upper East Region of Ghana

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Submission: March 18, 2019; **Published:** April 03, 2019

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Abstract

Low agricultural productivity resulting from low erratic rainfall, high evaporation, and deteriorating soil fertility among farmers in the upper East region has led to a mission for sustainable production practices with greater resource use efficiency. To lessen water stress and reduce runoff rains, water harvesting technologies like the zai pit technology is an alternative option whose influence on agricultural productivity cannot be under estimated. This study therefore seeks to assess the influential factors of zai pit technology adaptation among 296 smallholder farmers in the Upper East region of Ghana. Out of the 296 sampled population 155 respondents were adopters of the technology already while 141 were not. The study used binary logistic regression to analyses the factors influencing the adoption of zai pit adoption among farmer. The results from the studies shows that socio-demographic characteristics of farmers such as, farmer‘s age, years of experience, number of non-formal trainings attended, beneficiaries of NGOs, and membership of associations, were significant and plays an important role in farmers adaptation of zai pits technology. On the contrary variables like, land size, sloppiness of land, household size, holding of formal title to land and used of improved planting materials were not significant variable to farmer's adaptation of the zai pit technology in the study area. Based on the results it was recommendations that farmers should be encouraged to join farmer groups or association and also attend non- formal training on agricultural practices to improve adoption and utilization of zai pits.

Keywords: Binary logit; Smallholder farmers; Upper east; Zia pit technology

Abbreviations: EPA: Environmental Protection Agency; GDP: Gross Domestic Products; SPSS: Statistical Packages for Social Sciences; ICARDA: International Center for Agricultural Research on Dry Areas; NARS: National Agricultural Research System; SWC: Soil Water Conservation; TAM: Technology Acceptance Model; PU: Perceived Usefulness; PEOU: Perceived Ease-of-Use

Introduction

Low soil fertility is a major limitation to rain fed agriculture among smallholder farming in Africa [1]. Nutrient depletion and inadequate water in the soil of most African countries for some time now has transformed originally fertile lands that could yielded between 2t ha^{-1} and 4t ha^{-1} of cereal grain, into infertile lands where cereal crops yields less than 1t ha^{-1} [2]. Insufficient water couple with soil infertility is a major drawback to rain fed agriculture among smallholder farming in Africa [1]. To be able to restore soil to sufficient level of fertility, water harvesting techniques and improved soil fertility management technologies should be promoted among the smallholder framers. The soil fertility interventions include use of mineral fertilizer and organics such as animal manure and green manure among others [3]. The use of these technologies enable farmers to deepen their production and thereby increase economic benefits due to increased yields.

Water as identified to be one of the important factors that facilitates plant growth needs to be sustained in the soil to improve plant growth. Soil moisture method farmers can adopt includes, macro and micro catchment technologies and rooftop harvesting technologies. Micro-catchment is a method of collecting runoff rains near the growing plant and replenish the soil moisture which are generally used to grow plants like maize, sorghum, groundnuts and millet. The micro-catchment methods includes zai pit, also known in Niger as Tassa and in Mali as Towalen, which has been identified as one of the successful interventions that improve rainfall capturing and lessen runoff and evaporation, and in a long run improves agricultural productivity [4].

Zai is a term that refer to small planting pits that typically measure 20-30cm in width, are 10-20cm deep and spaced 60-80cm apart. Zai is an ancestral practice to regenerate degraded and crusted soils by breaking up the surface crust to improve water infiltration. It is a traditional land rehabilitation technology to rehabilitate degraded drylands and to restore soil fertility to the benefit of farmers living in drylands. The technique was adopted to reclaim severely degraded farmland that water could not penetrate. This technology is mainly applied in semi-arid areas on sandy/loamy plains, often covered with hard pans, and with slopes below 5% [5].

The application of the zai technique can increase production by about 500 % if well executed [6]. Sawadogo [7], explained that pits have been used to diversify plants biomass in Burkina Faso and the practice has help improve soil fertility and crop yield in the area. The zai pit is most suitable for cultivated lands characterized by crusted soils, hardpan formation, compaction, inadequate ventilation, reduced penetrability and limited plant root development [8]. With these characteristics pit digging enables more water penetration and runoff water is trapped due to the earthen bund formed downslope of the pits [9]. Zai pits are especially relevant to areas receiving 300-800mm annual rainfall [10]. Higher rainfall amounts could cause water-logging of the pits. Zai allows collecting 25% of a run-off coming from 5 times its area [11].

One of the major constraints to agriculture development in the Upper East Region of Ghana is land degradation due to desertification. Mr. Asher Nkegbe, the Regional Director of the Environmental Protection Agency (EPA) due to this problem introduced the zai pit technology as a new sustainable water harvesting technique intervention in the region. This provides a window of opportunity for farmers to improve crop performance in this harsh and changing climate. The future seems brighter for the farmers and their families, says Mr. Nkegbe.

Materials and Methods

Study area

This study was conducted in the upper east region of Ghana, the studies was narrowed to two districts where the zai pit technology was introduced first in the region. The two districts were the Kassena-Nankana West district and the Talensi district. Kassena-Nankana West District is one of the thirteen districts in the Upper East Region of Ghana. It is located approximately between latitude 10.97° North and longitude 01.10° West. It has a total land area of approximately 1,004sq. km. The District falls within the interior continental climatic zone of the country characterized by dry and wet seasons. The Talensi district was part of the Talensi-Nabdam district in the Upper East region. The separate Talensi district was created in 2012 with Tongo as the capital. The district lies between latitude 10° 15' and 10° 60' North of the equator and longitude 0° 31' and 1° 05' West of the Greenwich meridian. It has a land area of 838.4km^2.

In the rural localities of these two districts, nine (9) out of ten (10) households (93.4%) are agricultural households while in the urban localities, 75.4 percent of households are into agriculture. Most households in the district (98.2%) are involved in crop farming. Crop farming, animal rearing and hunting are the main economic activities in the two districts. Agriculture is mainly rain fed with little irrigation and serves as the main source of employment and account for 90.0 percent of local Gross Domestic Products (GDP). The main agricultural produce are groundnuts, sorghum, millet, rice and maize.

Sampling strategy

This study used primary data collected through questionnaire from smallholder farmers in the Upper East region of Ghana. The purposive stratified sampling was adopted in household interviews to ensure representative adopters and non-adopters of the technology were sampled within the area of study. The study makes use of the [12] sample size determination formula to determine the sample size. That is

$$n = \frac{t^2(z)(h)}{d^2}$$

$$n = \frac{1.96^2 \times 0.481 \times 0.401}{0.05^2} = 296 \ldots\ldots\ldots(1)$$

Where, n = sample size

t = value of selected alpha level of 0.025 in each tail = 1.96 for 95% (that is the alpha level of 0.05 which indicates the level of risk the researcher is willing to take, the true margin of error may exceed the accepted margin of error).

Z = proportion of population of farmer engaged I the zai technology.

h = proportion of population of farmer who are not engaged in the zai technology.

d = accepted margin of error for proportion begin estimated= 0.05 (error researcher is willing to accept).

The first stage of data handling involved data cleaning. The data was first of all cleaned by examining the questionnaire to ensure they were complete and had been consistently filled. The household survey data was analyzed by the use of Statistical Packages for Social Sciences (SPSS) software. The study employed analytical techniques like descriptive statistics and binary logistic regression. Descriptive statistics such as frequency tables, percentages mean and standard deviations were used to analyze farmers' socio-economic characteristics. Chi - square analysis was employed to test the relationship between farmers 'socioeconomic characteristic and adoption of zai pits technology. To ascertain the differences of means between adopters and non-adopters, the statistically significant paired t- tests was used. Binary logistic regression was used in zai pit adoption model to determine factors influencing adoption of zai pits. That is

$$Log\left(k/1-k\right) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots + \beta_{10} x_{10} + e \ldots\ldots\ldots(2)$$

Where;

K= is the probability of adopting zai pits

(1-K) = is the probability that a farmer does not adopt zai pit

α = y intercept

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β = regression coefficients

e = error term

$x_1 - x_{10}$ = independent variables

The independent variables were the socio – economic characteristics as shown below;

X1 = Household size

X2 = Non – Formal Training

X3 = Member of association.

X4 = Total Farm Size

X5 = Sloppy Land

X6 = Formal Title

X7 = Used Improved Planting Material

X8 = Farmers experience

X9 = Beneficiary of NGO.

X10 = Age of farmer

Review of related literature

Water scarcity impact on agricultural productivity: One of the major impediments to rain fed agricultural in arid and semi-arid areas is scarcity of water. Low productivity in arid and semi-arid areas are credited to marginal and unpredictable rainfall, worsened by high runoff and evaporation loose among other factors [13]. Unpredictable rainfall and droughts are included in the influential factors of agricultural production among smallholder farmers mostly in rural areas [14]. The mainstream of agricultural lands in Africa are arid and semi-arid lands as a result effort to increase productivity of rain-fed system in these areas is a step in the right direction. Several water harvesting techniques alongside irrigation systems should be adopted by farmers to improve water moisture deficit in arid and semi-arid areas, since there is a promising increase in productivity if the soil moisture is maintained. The best way to deal with water scarcity challenge which is a major threat to food security, is to embrace water harvesting techniques to manage water for rain-fed agricultural [15].

A number of case studies by the International Center for Agricultural Research on Dry Areas (ICARDA) affirmed that productivity gaps can be reduced by engaging in improved soil and water management practices by farmers [16]. Improved water management in the long run serves as a catalyst for economic growth among farmers in arid and semi-arid areas since the productivity of farmer will increase. Numerous researchers has come out with ways to address the challenge of water scarcity to enhance productivity, among their suggested water harvesting techniques are the zai pits, negarims, semi-circular bunds and half-moons [17]. This study focuses on the zai pit technique technology as a water harvesting technique in the most sim-arid area in Ghana.

Definition of zai pit technology

The zai pit technology originated from Burkina Faso, although some scholars trace it origin to Dogon in Mali [18]. “Zai” in Burkina Faso, refers to small planting pits typically measuring 20-30cm in width, 10-20cm deep and spaced 60-80cm apart. There are different names ranging from counties to countries, for instance it is known as “tassa”, “towalen” in Niger and Mali respectively. However, the English term used for this pit includes “planting basins”, “micro pit” and “small water harvesting pits”. Zai pits are most relevant in areas that receives 300-800mm rainfall annually [10]. Zai pits technology has caught the attention of many NGOs and for that matter intensive campaign is embarked on it adoption in Zimbabwe and other parts of Africa [19]. Zai pit technology is practiced in Niger [20], South Africa [21], Zambia [22,23], Ethiopia [24] and recently in Ghana. [25] recognized how the central plateau of Burkina Faso experienced major improvement in millet and sorghum productivity from around 400kg ha^{-1} in 1988 to 650kg ha^{-1} in 1996-2000. The rise was mainly due to improved soil and water preservation as well as addition aspects of ISFM. In Ghana, the zai pit technology is currently practiced in the upper east region of the country, which was introduce by the Director of the Environmental Protection Agency (EPA). During the inception of this technology, about 100 farmers from selected communities like Kazugu, Kayilo, and Kulia Yiduriand Wuug embraced the technology and participated in it. Report from some participant like Thomas Aluah, Apiato Masumdok and Pastor Michael Tamponab just to mention but few testified to it that the technology has help them increase their productivity and were welling to continue it practice.

Factors that influence the farmers adaption of zai pits technology: Adaptation and utilization of water harvesting techniques is one of the important conditions, for agricultural development especially in the arid and semi-arid areas. Despite the technologies developed and tested on farms by the National Agricultural Research System (NARS) to reduce the effects of water scarcity in semiarid areas, farmer’s adaptation remains low rendering continuous low productivity [17]. Factors inducing zai pits adaptation vary from place to place and from household to household due to differences in socio-cultural, economic and biophysical conditions [26]. Slingerland & Stork [27], examined determinants of practice of zai and mulching in north Burkina Faso and they found that farmers applying zai pits had larger households, more means of transport and more livestock, which is consistent with their need for manpower and manure.

Wildemeersch et al. [28] identified that, lack of enough knowledge on erosion and other key resources such as manure, agricultural equipment and transport facilities limit the application of zai pit technology in Tillaberi Niger. In northern Burkina Faso, [29] found that, variables like education and perceptions of soil degradation were bases for the adoption of zai technique. Ndah et al. [30] also found out that, the great potential adoption of zai pits displayed by farmers from Malawi and Zambia case relates to pos-

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itive institutional factors such as well-structured extension system and integration of the lead farmer approach [31]. The above studies emphasis on farmers 'characteristics and resource availability to describe adoption problems in different regions. However, in Ghana research on factors influencing farmers 'adoption of zai pits is scanty, therefore it will not be prudent to infer the results of the above studies in Ghana. Furthermore, zai pits have their own unique characteristics and requirements different from other rain water harvesting technologies hence it is important to establish factors that influence its adoption.

Socio-economic factors and adoption of zai pit technology to enhance food security: The studies of [32], revealed that low uptake of improved technologies and incorrect soil fertility management practices compromise sustainability and food security among smallholder farmers. The driven force of agricultural growth of any nation is high outputs to farmers' production. To increase the productivity of farmer, a larger number of farmers are expected to adopt improved agricultural technologies that increase productivity and also be more efficient in the use of resources like land and water in an environmental sustainable manner (World Bank Group, FAO and IFAD, 2015).

Adekambi, Diagne, Simtowe, & Biaou [33] is also of the view that different variables such as age and education affect adaptation of agricultural technologies either positively or negatively. He found out in his studies that, higher education influence adoption decision positively since it is associated with ability to synthesis more information on technologies that are on offer and this leads to improvement of the general management of the farm. On the other hand, more education can also lead to individuals having more available occupation option thereby spend less time to attend to this farm activities affecting adoption of agricultural related technologies negatively.

The number of hours involve in digging a zai hole has also been another influential factor to its adaptation. Barro & Lee [34] noted that it takes about 300hour/ha to dig the zai pit, whiles [9] assert that 450hours/ha is involved in digging the zai pit plus another 250hour/ha to apply fertilizer in the holes, hence the zai pit is more suitable when practiced by a group of farmer together instead of individual farmers. This means wealth farmer are more likely to benefit from this technology since they can employ more laborers to work for them.

Murgor, Saina, Cheserek, Owino, & Sciences [35] found that, financial issues like cost of hired labour, transportation cost, construction cost etc. are limitations for farmers to adopt improved agricultural technologies. It is difficult to increase agricultural productivity without credit facilities, with the fact that most farmers are poor in resource. Another expects, higher investment and management in livestock leads to increased readiness of dung. Better-quality livestock keeping brings revival of indigenous foliage and greater accessibility of fodder [36]. Research findings indicates that rainwater in Africa is at 127mm yr^{-1} contrary to North America's 258mm yr^{-1}, South America's 648mm yr^{-1} and global mean of 249mm yr^{-1} [37].

Impact of zai pits technology on output of farmers: Research has revealed that, zai technology escalates crop yields and straw (residue) production on highly degraded soils and helps to lessen the opposing effects of dry spells, which are frequent during the cropping period in the dry land areas [9,38]. A study by [9] revealed that, zai pit technology increased sorghum yields by 310kg ha^{-1} as compared to the non-zai pit situation in the village of Donsin. Zai pits technology (also known as Tumbukiza) produced significantly higher dry matter yields than conventional method in Western Kenya [39]. In semi-arid areas, a drought can lead to total crop failure but experience from Zambia [22] shows that, planting basins can improve the possibility of maintaining some production with very low rainfall. During an impact assessment of Soil Water Conservation (SWC), agroforestry and agricultural intensification in 5 villages on the northern part of the Central Plateau of Zambia, farmers agreed unanimously that soil water conservation (SWC) and in particular zai had a positive impact on household food security [36]. In West Africa, [40] found that, the use of zai alone would not improve much the productivity (only 200kg ha^{-1} of sorghum grain) but when the zai is associated with manure and fertilizer large crop yield increases can be obtained (1700kg ha^{-1} of sorghum grain). Again, in Niger manure application with zai showed a 2-69 times better grain yields than zai pit with no nutrient amendment [38].

Theoretical framework

Technology acceptance model (TAM): This is the commonest and most used model of acceptance and use of technology [41]. It was developed by Fred Davis and Richard Bagozzi with its main assumption as, when a person intends to act, they will be free to act unhindered [42]. However, in reality and practical acceptance and adoption is constrained by limited ability (such as cognitive, psychomotor or materials), time environmental or even unconscious habits that hamper the autonomy to act. The model assert that when users are faced with a novel technology, the choice about how and when to apply that technology is influenced to a large extent, the perceived usefulness (PU) which was described by [42] as "the degree to which a person believes that using a particular system would enhance his or her job performance", and the perceived ease-of-use (PEOU) also been described as " the degree to which a person believes that using a particular system would be free from effort" [42].

According to [43], both PEOU and PU are subject to external variables mainly social factors, cultural factors and political factors. The social factors are language skills and enabling conditions, whiles political factors are the effects of the technology use on politics and political crisis. Attitude is about the user of the technology evaluation of the attractiveness to employ a certain technology. Behavioral intention is the measure of the probability of an individual to apply the technology. Technology Acceptance Model (TAM) enables understanding of the role of perception on usefulness and ease of use in determining the desire to apply the technology and the level to which the technology will be adopted. Additional, external variable affects the behavioral intention

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to use and the actual usage of the technology given their indirect effect on PEOU and PU.

To make use of the two models, this study proposes that technology adoption is a multifaceted, inherently social, developmental process, individuals create distinct yet flexible views of the technology that affect their adoption choices. The adoption is influenced by the perception of the inherent features of the technology, social-economic factors like educational level, involvement of males in the process of adoption and post-implementation extension services offered to the farmers to determine the extent of consequent spread.

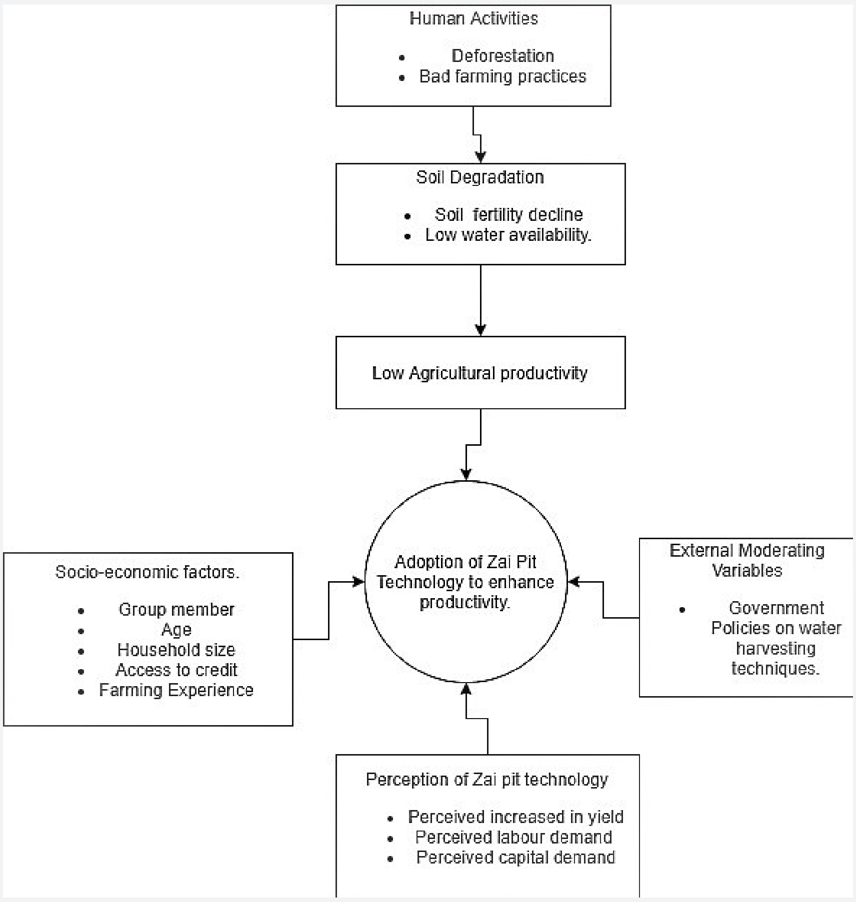

Figure 1: Conceptual Framework.

Source: Author.

Roger's innovation diffusion theory: Rogers's doctoral dissertation in 1957 which study's rural and agricultural sociology, focusing on the trends of use of new weed spray by Iowan farmers. Rogers made an appraisal on related findings on the way people embraced a new technology or idea; studies in varied disciplines such as medicine, agricultural and marketing, at the end he realized so many similarities and he used it to formulate an all-embracing, theoretical framework.

According to Rogers innovation can be define as a new object, idea, technology, or practice. Innovation can either be tangible, physical objects like new device or machine or intangible objects like a new design method or educational method. Also, the concept of innovation originality could relate to both place and population. This model is general in nature giving it extensive application.

Diffusion can also be defined as the spatial and temporal movement of the new technology to different economic units. Kaminski [44] put a difference between adoption and diffusion by defining diffusion (aggregate adoption) as the process in which a technology is transferred through various channels over time amongst the members of a community. He identify four elements, firstly, the technology that is the new idea, practice or object being spread, secondly, communication channel which represent how information on the new technology move from change agent (extension, technology suppliers) to the final consumers or adopters example farmers, thirdly, the time period over which a technology is adopted in a social system and lastly, the social system.

On the other hand, Rogers emphasize that adoption is where someone (farmer) is motivated to either using or not to use a novel technology at certain period of time. Feder et al. [45] also differentiated between individual (farm level) and aggregate adoption. They are of the view that, individual adoption is the degree of use of a new technology (innovation) in the long-run where the indi-

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vidual has adequate information on the new technology and it's potential whereas aggregate adoption is measured by the aggregate level of use of a given technology within a given geographical area. Ruttan [46], also described aggregate adoption as the spread of a new technique within a population. The difference between adoption and diffusion is essential for theoretical and empirical evaluation of the levels of the two economic phenomena. Kaminski [44] and Mahajan & Peterson [47], brought reasons for the process of attaining information and the time intervals created in respects to the rate of adoption by people (farmers) in the society (Figure 1).

Based on the theoretical framework, the study was guided by the above conceptual framework. Erratic rainfall experienced, high temperature which causes evaporation and bad farming practices has rendered almost all the land in the study area infertile with little water sustain in them. These problems leads, to low productivity since the nutrient and water in the soil are not enough to support plant growth. This situation calls for an intervention to eradicate the problem hence the adaption of the Zai pit technology, which helps to sustain water in the soil for a long time and also increases soil fertility when combined with organic or inorganic substances. Zai pit technology is the dependent variable. Adoption of the Zai pit technology is influence by independent factors like the socio-economic factors, perceptions farmers have about the technology and external factors like government policies on water harvesting techniques which the farmer has no or little control over it.

Results and Discussion

Factors influencing zai pit technology adaptation

Out of the 296 farmers interviewed for the studies, 72.6% representing 215 farmers were males and the remaining 27.4% representing 81 farmers were females. The number of farmers who were adopters were slightly higher than the number of farmers who were non-adopters of the technology with percentages of 52.4% and 47.6% (155 and 141) respectively. About 103 farmers representing 66.5% out of the adopter were males with only 52 farmers representing 33.5% were females. In the case of the non-adopter the number of females was 29 respondents representing 20.6% and 112 respondents representing 79.4% were males. Buyu [48], is of the view that gender difference is one of the determinants of choice of soil conservation and water harvesting technique. Gender difference is known to determine the choice of soil conservation and water harvesting technique [48]. Women base their choices in terms of the opportunity cost of realizing better yields while men consider cost related matters such as labor and time requirements [48]. This is probably because female famers are equally committed as male farmers to find mitigation measures to food insecurity and overall improvement of their families 'wellbeing (Table 1).

Table 1: Socio-demographic characteristics of maize farmers(both adopter and non-adopters of the technology) in the northern savannah zone of Ghana.

	Adopters	Non- Adopters	Total
Gender			
Male	103(66.5)	112(79.4)	215(72.6)
Female	52(33.5)	29(20.6)	81(27.4)
Total	155(100)	141(100)	296(100)
Age(Years)			
Below 20	17(11.0)	16(11.3)	33(11.1)
21 – 40	75(48.4)	67(47.5)	142(48.1)
41 – 60	53(34.2)	30(21.3)	83(28.0)
61 and above	10(6.5)	28(19.9)	38(12.8)
Total	155(100)	141(100)	296(100)
Education Level			
No Formal Education	15(9.7)	44(31.2)	59(19.9)
Primary Education	94(60.6)	80(56.7)	174(58.8)
Secondary Education	22(14.2)	10(7.1)	32(10.8)
Tertiary Education	24(15.5)	7(5.0)	31(10.5)
Total	155(100)	141(100)	296(100)
Main Occupation			
Farming	124(80.0)	121(85.8)	245(82.8)
Business	8(5.2)	12(8.5)	20(6.8)
Government Worker	23(14.8)	8(5.7)	31(10.4)
Total	155(100)	141(100)	296(100)

Source: Survey 2018. NB. Numbers in brackets are the percentages of the respondents. N = 296

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Majority of the farmers (174 farmers) with a percentage of about 58.8% had attain primary education out of which 94 respondentss were adopters and 80 respondents were non-adopters. Respondents with tertiary education recorded the least the number with 31 respondents standing for 10.5% of which out of this number, 24 respondents representing were adopters and 7 respondents were non-adopters. Respondents with no formal education recorded 19.9% which represent 59 respondents out of this 15 were adopters whiles 44 were non-adopter. Those with secondary education recorded 10.8% standing for 32 respondents out of these 22 respondents were adopters whiles 10 respondents were non-adopters. These studies are consistent with the work of [49], who found out in his studies that, higher education influence adoption of decision positively since it is associated with ability to synthesis. Education levels of the farmers may influence chances of implementing and/or adopting the water harvesting techniques. Low education levels of the interviewed respondents may have significantly contributed to the low or non-adoption of water harvesting techniques. This is because, education increases one access to information and therefore creates awareness and contributes to adoption of water harvesting systems. Chianu & Tsujii [50], reported that farmers ‘educational achievement can increase the probability of water harvesting technology adoption.

The results revealed that, a higher percentage of young aged farmers (21-40 years) 48.4% respondents had adopted zai pits as compared to older farmers (61 and above years) 6.5%- and middle-aged farmers (21-40 years) 34.2%. In general, the results showed that farmers in their middle ages recorded higher percentages 82.6% (21 – 40 years and 41 -60 years) as compared to very young and older farmers who together also recorded 17.4% (below 20 years and 61 and above years). These results could be associated to the fact that, zai pit technique is labor intensive. According to a study by [51] the age of the farmer is a significant variable that can impact use of soil conservation technologies. Generally, older farmers may be more conservative, less flexible and more uncertain about the benefits of zai pits.

It was shown from the results that, majority of the farmers (82.8%) depends on farming activities for survival and generation of income with very few depending on business and government work for income with percentages of 6.8% and 10.4% respectively. The gap between the farmers who had adopted the technology and the non-adopters was very small. According to [52], agricultural activity is one of the many possible sources of employment and income for farm households across the world. This perhaps may be one of the reasons why adoption of the water harvesting technologies is low (Table 2).

Table 2: Dummy explanatory variables that influence the adoption of zai pit technology by farmers in the Upper East region of Ghana.

Variables	Adoption		Total	Chi-Square Tests
	Adopters	Non – Adopters		
Member of Association/ Farmers Group				
Yes	143(92.3)	114(80.9)	257(86.8)	$\chi^2 = 31.449$ df=1 p=0.005
No	12(7.7)	27(19.1)	39(13.2)	
Total	155(100)	141(100)	296(100)	
Land Sloppy				
Yes	111(71.6)	71(50.4)	182(61.5)	$\chi^2 = 8.712$ df=1, p= 0.003
No	44(28.4)	70(49.6)	114(38.5)	
Total	155(100)	141(100)	296(100)	
Formal Title to Land				
Yes	117(75.5)	63(44.7)	180(60.8)	$\chi^2 = 17.02$ df=1, p=0.002
No	38(24.5)	78(55.3)	116(39.2)	
Total	155(100)	141(100)	296(100)	
Beneficiary of NGO				
Yes	113(72.9)	106(75.2)	219(74.0)	$\chi^2 = 23.289$ df=1, p=0.001
No	42(27.1)	35(24.8)	77(26.0)	
Total	155(100)	141(100)	296(100)	
Use of Improved Planting Materials				
Yes	110(71.0)	98(69.5)	208(70.3)	$\chi^2 = 28.339$ df=1, p=0.004
No	45(29.0)	43(30.5)	88(29.7)	
Total	155(100)	141(100)	296(100)	

Source: Survey 2018. NB. Number in brackets represent the percentages of respondents. N = 296

The studies revealed a great number of adopted farmers of zai pit technology joining farmers association with a percentage of 92.3% as again 7.7% who are not part of farmers associations. The number of non-adopter who are part of farmers associations is also greater than those who are not members of associations with percentages of 80.9% and 19.1 respectively. In a nutshell the

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numbers of farmer both adopters and non-adopter who are members of farmers association is greater than their counterparts who are not members with percentages of 86.85 against 13.2%. The results revealed a positive significant relationship between membership of farmers association adoption ($\chi^2 = 31.449$, p=0.005). This could be the reason why a large number of farmers were recorded to be adopters since the information about the technology may be spread to them in the groups.

Considering the gap between farmers who have sloppy land and those who do not have is relatively wide, with majority of farmers who have adopter the technology has sloppy land (71.6%). Adopted farmers without sloppy land recorded the least percentage (28.4%) followed by non-adopter with sloppy land. In general, most farmers in the study area have sloppy land (61.5) as compared to farmers who don't have sloppy land (38.5%). A positive significant relationship was recorded between landscape (sloppy land) and adoption of zai pit technology ($\chi^2 = 8.712$, p=0.003). The majority of adopters of the technology having sloppy land can be attributed to the fact that zai pit technology is a measure of collection of runoff rain [17].

Based on the results, both adopter and non-adopters of the technology who have benefited from NGOs are greater than their counterparts who have not benefited from any NGOs with percentages of 74.0% as against 26.0%. Adopters recorder the highest number of people who have benefited from NGOs (113) followed by non-adopters (106). The external support provided by NGOs to farmers had a significant and positive relationship with zai pit technology adoption ($\chi^2 = 23.289$, p=0.001). This suggests that promotion by external organizations plays a significant role in adoption of soil water management technologies as revealed by [31] in his studies. This result is also in agreement with the work of [53] who established a positive and significant relationship of external service and adoption of rain water harvesting technology.

The results suggest majority of the adopters have formal title to their lands (75.5%) with relatively fewer adopters not having formal titles to their lands (24.5%). On the other hand, there was a great number of non-adopter not having formal title to their lands as compared to those having title to their lands with percentages of 55.3% and 24.5% respectively. The result revealed a significant relationship between farmers holding formal titles to their lands and zai pit adoption ($\chi^2 = 17.02$, p= 0.002).

Majority of the adopters were identified to be using improved planting materials with very few of the adopters not using improved planting materials with percentages of 71.0% as against 29.0%. In the case of the non-adopters too majority of the farmers were using improved planting materials as compared to their counterparts who were not using improving planting materials having percentages of 69.5% and 30.5% respectively. In general, it was revealed that majority of the farmers were using improved planting materials as compared to those who were to using improved planting materials (Table 3).

Table 3: Continuous variables that influence the adoption of Zai pit technology in the Upper East region of Ghana.

Variable	Adoption	No. Respondents	Mean	Std Deviation	T	df	Sig. 2 tailed
Household Size	Adopter	155	6.4	2.48	-2.607	268.7	0.007
	Non-Adopters	141	4.3	2.08			
Age	Adopters	155	47.9	14.21	0.953	276.4	0.316
	Non-Adopters	141	46.1	12.01			
Years of Experience	Adopter	155	21.7	12.53	1.503	280.2	0.121
	Non-Adopters	141	20.2	13.12			
Farm Size	Adopters	155	7	4.83	-2.142	283.1	0.025
	Non-Adopters	141	5.7	5.22			
House Members Working	Adopters	155	2.8	1.8	-2.718	259.4	0.006
	Non-Adopters	141	2	1.64			
Non-Formal Training	Adopters	155	2.5	5.37	-4.835	269.7	0.001
	Non-Adopters	141	1.6	1.34			

Source: Survey 2018

From the table above, the t-test result revealed a significant difference between household adopters (6.4) and non-adopter (4.3). Also, there was a significant difference (p= 0.006) that exist between household members who work in the farm among the adopters and the non-adopters. The average household for adopters and non-adopter were 6.4 and 4.3 respectively. The results showed that adopters had more labour sources compared to the non- adopters with confirms the assertion [54] that large household suggests more provision of labour particularly in the preparation and maintenance of water harvesting technologies.

Moreover, the average age of the adopters was 47.9 years whiles that of the non-adopter was 46.1 which suggest the farmers in the study areas are in their youthful ages. Though the difference in farmer's age was not statistically significant, studies by [55,56] revealed that older farmers are used to short term planning thus are more reluctant to invest in soil conservation technologies which take long before realizing the benefits. Contrary, [57] in his studies reported that older farmers could be more aware of soil infertility in their farms henceforth are more willing to try new technologies that curtail the negative effects.

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The total average farm size of adopter was highly than their counterpart non-adopters with mean of 7.0 and 5.7 respectively. There exists a significant difference at less than 5% probability level. This result is in agreement with the studies [58] who find out that farmers who had bigger farm size were likely to adopt rain water harvesting techniques. Averagely, farmers who has adopted the technology has received more non-formal training than the non-adopters (2.5 and 1.6) respectively. This result shows that non formal training plays a crucial role in the adoption of zai pit technology. The result agrees with a similar-studies by [59] which revealed significant and positive association between training and adoption of water harvesting technologies (Table 4).

Table 4: A Logistic Regression for the Predictors of Zai Pit Technology Adoption in the Upper East Region of Ghana.

Variables	B	S.E.	Wald	Df	Sig.	Exp(β)
Household Size	0.16	0.08	3.56	1	0.059	1.2
Non-Formal Training	1.02	0.26	14.08	1	0.001	2.82
Member of Association	0.5	0.2	9.63	1	0.002	1.63
Total Farm Size	0.03	0.05	0.5	1	0.482	1.04
Sloppy Land	0.51	0.36	2.02	1	0.145	1.61
Formal Title to Land	-0.41	0.34	1.51	1	0.221	0.76
Improved Planting Materials	0.63	0.37	3.1	1	0.08	1.88
Farming Experience	1.06	0.45	5.46	1	0.02	2.97
Beneficiary of NGO	1.54	0.38	16.87	1	0.001	4.64
Age of Farmer	1.32	0.56	6.3	1	0.013	4.2
Constant	-12.41	2.35	27.68	1	0	0

The logistic regression table revealed that, non-formal training attended by farmers had a significant and positive influence on adaptation of zai pit technology with exp (β) value of 2.820. Farmer belonging to farmers groups and associations also had a positive impact on adaptation of zai pit technology with exp (β) value of 1.63. The value of the exp (β) signifies that, for 1 unit increase in the farmers joining or belonging to an association, the probability of farmers adoption would increase by a factor of 1.63. The result also shows that, there was a statistical significant relationship between farmers farming experience and adaptation of zai pit technology with exp (β) value of 2.97. Age of farmers also had a positive impact on the adoption the zai pit technology with exp (β) value of 4.20 which signifies a unit increase in age of farmers, the probability of adaptation will increase by 4.420. The results shows that beneficiary of NGOs was significant and had a positive relationship with adoption of zai technology with exp (β) value of 4.46 which means a unit increase in the beneficiaries of NGOs would render an increase in the probability of adaptation by 4.46.

On the other hand, the logistic model results revealed that, farm size, sloppy land, household size, used of improved planting materials and formal title to farm lands were not significant variables in the adaptation of the zai pit technology. Holding of formal title to farming land had an insignificant negative effect on adoption of the technology, however it was anticipated that farmers who have title deeds are more likely to adopt the technology as compared to those who don't have the title deeds. Many smallholder farmers who apply these technologies on leased land lose the benefit of their investments because the owners withdraw the land for their own use soon. Tenure insecurity explains farmers 'unwillingness to invest effort in measures to improve soil conservation and enhance fertility [60,61].

The results obtain from land size, family size sloppy land and use of improved planting material (insignificant) is in contrast to the studies of [62], who find out that the size of the farm was a major a predictor in the adoption of soil water conservation measures in Chile. The result was also in contrast with the studies finding of [61,63] who also identified significant positive relationship between land size and farmers decision to adopt soil conservation and water harvesting techniques.

Conclusion and Recommendation

Out of the 296 farmers interviewed for the studies, 72.6% representing 215 farmers were males and the remaining 27.4% representing 81 farmers were females. The number of farmers who were adopters were slightly higher than the number of farmers who were non-adopters of the technology with percentages of 52.4% and 47.6% (155 and 141) respectively. Majority of the farmers (174 farmers) with a percentage of about 58.8% had attain primary education out of which 94 respondents were adopters and 80 respondents were non-adopters. Respondents with tertiary education recorded the least number with 31 respondents standing for 10.5% of which out of this number, 24 respondents representing were adopters and 7 respondents were non-adopters. In general, the results showed that farmers in their middle ages recorded higher percentages 82.6% (21 – 40 years and 41 -60 years) as compared to very young and older farmers who together also recorded 17.4% (below 20 years and 61 and above years). It was shown from the results that, majority of the farmers (82.8%) depends on farming activities for survival and generation of income with very few depending on business and government work for income with percentages of 6.8% and 10.4% respectively.

The results from the studies shows that socio-demographic characteristics of farmers such as, farmer's age, years of experi-

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ence, number of non-formal trainings, beneficiaries of NGOs, and membership of associations, agents play an important role in farmers adaptation of zai pits. On contrary variables like variables like land size, sloppy land, household size, formal title to land and used of improved planting materials were not significant variable to farmer's adaptation in the study area. The most common source of information in the adoption of zai pits was non-government extension agents. Majority of the farmers who had adopted zai pits used animal manure as a soil fertility amendment.

Considering the verdicts from this study, the researcher, recommendations that farmers should be encouraged to join farmer groups or association and also attend non- formal training on agricultural practices to improve adoption and utilization of zai pits. Also, it is recommended that zai pit technology should be promoted by the government and NGOs as a water harvesting technique in the study area.

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