



Factors Influencing Sustainable Land and Water Management Technologies Uptake in Northern Ghana

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doi: 10.17097/ataunizfd.681352

Geliş Tarihi (Received): 28.01.2020 Kabul Tarihi (Accepted): 29.06.2020 Yayın Tarihi (Published): 25.09.2020

ABSTRACT: Climate change continues as a threat to smallholder farmers in Northern Ghana, which is arid in nature and prone to draught conditions. Sustainable Land and Water Management (SLWM) technologies have been introduced to smallholder farmers in the area as adaptation strategies to mitigate the negative effects of climate change. Adoption of the SLWM technologies have the potential of reducing the negative impact of climate change, and also improve crop yield. There is a dearth in knowledge in understanding factors that influence the uptake of the SLWM technologies in Northern Ghana. The study therefore, examined the factors influencing SLWM technology uptake in Northern Ghana. The study was undertaken among 300 smallholder farmers in the three Northern Regions of Ghana through a multi-stage sampling technique. Data were gathered through a survey and a Poisson model was employed to assess the drivers and intensity of adoption. Results showed that factors such as support received, labour, water availability, exposure, access to information and farm size influenced the uptake of the SLWM technologies. The study recommends that policy makers should work towards improving the factors that influence the uptake of the SLWM technologies. It is also important to adopt private-public partnership model in the implementation of the SLWM technologies.

Keywords: Adaptation, Sustainable land, Water management technologies, Technology uptake

Kuzey Gana'da Sürdürülebilir Arazi ve Su Yönetimi Teknolojilerinin Kullanımını Etkileyen Faktörler

ÖZ: İklim değişikliği, kurak iklim özelliklerine sahip ve kuraklık bakımından hassas olan Kuzey Gana'da küçük ölçekli çiftçiler için tehdit oluşturmaya devam etmektedir. Bölgede küçük ölçekli çiftçilerin iklim değişikliğinin olumsuz etkilerinden daha az etkilenmelerini sağlamak amacıyla uyum stratejileri kapsamında Sürdürülebilir Arazi ve Su Yönetimi (SAY&SSY) teknolojilerinin tanıtımına yönelik çalışmalar yürütülmüştür. SAY&SSY teknolojilerinin yaygınlaştırılması yoluyla iklim değişikliğinin olumsuz etkilerinin azaltılması ve aynı zamanda ürün veriminin artırılması mümkündür. Kuzey Gana'da SAY&SSY teknolojilerinin kullanımını etkileyen faktörlerin anlaşılmasında önemli düzeyde bir bilgi eksikliği mevcuttur. Bu çalışmada, Gana'daki SLWM teknolojisinin kullanımını etkileyen faktörler incelenmiştir. Araştırma, 3 farklı Kuzey Gana bölgesinde yer alan 300 küçük ölçekli çiftçi üzerinde çok aşamalı bir örnekleme tekniği kullanılarak gerçekleştirilmiştir. Veriler bir anket aracılığıyla toplanmış ve SAY&SSY teknolojilerinin kullanımını etkileyen itici faktörlerin ve bu faktörlerin şiddetinin değerlendirilmesinde Poisson modeli kullanılmıştır. Çalışmanın yürütüldüğü bölgelerde SAY&SSY teknolojilerinin kullanımını etkileyen temel faktörlerin; sağlanan destek, iş gücü, su varlığı, maruz kalma, bilgiye erişim ve arazi büyüklüğü olduğu belirlenmiştir. Bu çalışmada elde edilen sonuçlar politikacıların SAY&SSY teknolojilerinin kullanımını etkileyen faktörlerin iyileştirilmesine yönelik çalışmalar yapmaları gerekliliğini ortaya koymaktadır. SAY&SSY teknolojilerinin yaygınlaştırılmasında özel kamu ortaklığı modelinin benimsenmesi önemlidir.

Anahtar Kelimeler: Adaptasyon, Sürdürülebilir arazi yönetimi, Su yönetimi teknolojileri, Teknoloji kullanımı

Bu makaleye atıfta bulunmak için / To cite this article: Adam, H., Amadu, M.F., Damba, O.T., 2020. Factors Influencing Sustainable Land and Water Management Technologies Uptake in Northern Ghana. Atatürk Univ. J. of Agricultural Faculty, 51 (3): 297-308. doi: 10.17097/ataunizfd.681352

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INTRODUCTION

Land is one of the most important factors of production and used for several purposes, including agriculture, industry, infrastructure and other development services. Despite the importance of land, its degradation is on the rise, a situation which risks depriving the future generation of their livelihood resources. Recent estimates indicate that nearly 2 billion hectares of land consisting of cropland, grassland and forest areas are already seriously degraded, some irreversibly (Gowing and Palmer, 2008). These degradation reduces productivity, and also disrupts vital ecosystem functions, and affects biodiversity and water resources, and increases vulnerability to climate change, as well as negatively affecting livelihoods (Gowing and Palmer, 2008). Degradation continues to be a major threat to agricultural lands, which is about 60% of the total land area of Ghana and these lands prone to severe erosion resulting in a cost to the nation amounting to between 1.1-2.4% of its Gross Domestic Product (GDP) (Institute of Statistical Social Economic Research, 2005). A number of activities results in the degradation of land. These include mining, deforestation, and non-appropriate farming practices (continuous cropping, chemical fertilizer application, etc.). Arable land is continuously lost to urbanization, road construction and mining activities. There is a relationship between land degradation and food production. Land degradation impacts negatively on the livelihood of both present and future communities/households who directly depend on it for their sustenance.

As land becomes scarce, it becomes increasingly overexploited in its use. Sustainable Land and Water Management (SLWM) has been identified as a prerequisite for enhanced agricultural production, food security, incomes and livelihoods for its population. The World Bank defined SLWM as “a knowledge-based procedure that helps to integrate land, water, biodiversity, and environmental management (including input and output externalities) to meet rising food and fiber demands while sustaining ecosystem services and livelihoods. The SLWM is necessary to meet the requirements of a growing population. Improper land management can lead to land degradation and a significant reduction in the productive and service (biodiversity niches, hydrology, carbon sequestration) functions of watersheds and landscapes”. Vancutsem (2008) explains that “Land management covers the debate about norms and visions driving the policy-making, sector-based planning both in the strategic and more operative time spans, spatial integration of sectoral issues, decision-making, budgeting, implementation of plans and decisions and the monitoring of results and evaluation of impacts.” SLWM technologies are

largely influenced by both social and economic drivers of land degradation attributed to population growth and food deficits in (Cordingley et al., 2015). Researchers over the years have developed various SLWM technologies that will enhance productivity without adverse impact on land and environmental services for farmers across the globe, and these have been found to increase yield, reduce soil erosion and reduce cost of production in several agriculturally rich countries (Bolliger et al., 2006a). In Sub-Saharan Africa, the application of SLWM technologies during trials in countries such as Ethiopia, Kenya, Tanzania, and Zimbabwe led to an improvement in yield between 20-120% among smallholder farmers (Rockstrom et al., 2007).

The SLWM technologies introduced by researchers include integrated nutrient management, conservation tillage, crop rotation, agroforestry, water harvesting, livestock integration and integrated pest management (Bolliger et al., 2006b). Creating awareness and building the necessary technical capacity at all levels of the agriculture value chain to support the promotion of SLWM technologies as a way of ensuring sustainable management of land and environment have been envisaged as a major output in Ghana's Medium-Term Agriculture Sector Investment Plan (METASIP).

To this end, there have been a number of interventions aimed at protecting the environment, particularly land and water, from degradation and improving the livelihood strategies of smallholder farmers for the benefit of both the present and future generations. Two main SLWM interventions that have been implemented in the Northern Savannah ecological zone considered land degradation is a critical component to achieving SLWM. The first was Ghana Environmental Management Project (GEMP), which was meant to support the implementation of Ghana's National Action Programme to Combat Drought and Desertification (NAP). The goal of the GEMP was to strengthen Ghanaian institutions and rural communities to enable them to reverse land degradation and desertification trends in three regions of Northern Ghana and to adopt sustainable water and land management systems that improve food security and reduce poverty. The second is the Ghana Sustainable Land and Water Management Project (GSLWMP), which aims at promoting and scaling up land management practices within these communities towards enhancing agricultural productivity and restoring eco-systems integrity. Through GEM and GSLWMP implemented between 2008-2013 and 2014-2020 respectively, and other MOFA projects, various technologies have been strengthened or implemented to help control and manage the

practices of smallholder farmers in order to protect the environment from degradation.

However, despite these interventions, major gaps in the achievement of SLMW included limited knowledge on the various available SLWM technologies and their associated benefits to potential users. Another limiting factor to the promotion and adoption of SLWM technologies in Ghana is the weak capacity of extension agents to demonstrate SLWM technologies to farmers. Furthermore, there is paucity of documentation in a single platform/database of all the available SLWM technologies that have been developed and proven for easy use for extension service provision by both public and private sector service providers. This study therefore seeks to assess the various sustainable land and water management technologies as well as the factors influencing a smallholder's choice of the technologies in the Northern region of Ghana.

Sustainable Land and Water Management Technologies

In Ghana, while the SLWM technique is to “demonstrate improved sustainable land and water management practices aimed at reducing land degradation and enhancing maintenance of biodiversity in selected micro-watersheds” it also seeks to strengthen spatial planning towards linking watershed investments. Implementation of various focused on three significant components.

First, the SLWM seeks to enhance the capacities of implementing institutions by providing integrated spatial planning tools that will enable such institutions to undertake strategic economic decisions related to water and land in the Northern, Upper East and West regions. The second component is to focus on providing support to community floods and land management at the micro-watershed level. This component incorporated “labour-intensive civil works investments into small-scale flood and water management infrastructure and finally, the SLWM provides additional support to project management and coordination state institutions.

According to a World Bank Report (2015), the agricultural landscape and the corridor areas under sustainable land and water management have been made productive through farming techniques such as contour bunds, zero tillage, crop rotation, intercropping with legumes, composting, mulching, protecting buffer zones and planting trees along river banks. Governments in Ghana has implemented various SLWM technologies since 2011 and about 10,000 land users are said to have adopted SLWM practices covering an area of over 3,000 hectares with over 24,000 community members benefiting from the project intervention. Out of the latter, an estimated 40% are said to be women.

The SLWM is defined as a knowledge-based procedure that helps integrate land, water, biodiversity and environmental management to offset the consequence of rising food and fibre demands while at the same, sustaining ecosystem services and livelihoods (The World Bank, 2006). The SLWM is necessary to meet the requirements of a growing population. Improper land management can lead to land degradation and a significant reduction in the productive and service functions of watersheds and landscapes (The World Bank, 2006).

The SLWM also includes ecological, economic and socio-cultural dimensions (Hurni, 1997). These three are not separate rather they are interconnected. They are also referred to as the ‘3Es’ of sustainable development - Equality, Economy, and Ecology (UNESCO, 2006).

Ecologically, the SLWM technologies – in all their diversity – effectively combat land degradation. But a majority of agricultural land is still not sufficiently protected, and the SLWM needs to spread further. Socially, the SLWM helps secure sustainable livelihoods by maintaining or increasing soil productivity, thus improving food security and reducing poverty, both at household and national levels. Economically, the SLWM pays back investments made by land users, communities or governments. Agricultural production is safeguarded and enhanced for small-scale subsistence and large-scale commercial farmers alike, as well as for livestock keepers. Furthermore, the considerable offsite benefits from the SLWM can often be an economic justification for them.

It is now widely accepted that the SLWM practices provide an effective way of improving the management of water resources and the reduction of soil, vegetation and biodiversity degradation, which helps to increase and maintain crop, forest and forage yields. The SLWM practices application could contribute to mitigating the effects of climate change and significantly improve food security and the resilience of the rural population to external shocks. The implementation of the SLWM practices, techniques and technologies is therefore a promising solution for most African countries (Winterbottom, 2013).

MATERIAL AND METHOD

Study Area

The Northern Ghana is made up of Northern, Savannah, North East, Upper East and Upper West regions. The Northern Regions are much drier than southern areas of Ghana, due to their proximity to the Sahel and the Sahara. The vegetation consists predominantly of grassland, especially Savanna with clusters of drought-resistant trees such as baobabs and acacia. The dry season occurs between January

and March. The wet season is between July and December, with an average annual rainfall of 750 to 1050 mm. The highest temperatures are reached at the end of the dry season, the lowest in December and January. However, the hot Harmattan wind from the Sahara blows frequently between December and at the beginning of February. Temperatures can vary between 14 °C at night and 40 °C during the day. The study randomly selected two districts out of the three (3) districts implementing SLWM technologies and included Yagba-Kubori and West Mamprusi.

The Upper East Region is located in north Ghana and is the second smallest among the administrative regions in Ghana, occupying a total land surface of 8,842 square kilometers or 2.7% of the total land area of Ghana. The study randomly selected two (2) districts, which includes Kasena-Nankana East and Bawku West districts out of the four (4) districts implementing SLMW technologies.

The Upper West Region of Ghana is located in the northwestern corner of Ghana. Two (2) districts out of the four districts implementing SLWM technologies were randomly selected for the study.

Data

A total of 300 household members interviewed in the study area. Data was collected through a multi-stage sampling technique. First, two districts were randomly selected from each of the three regions. Second, 5 communities were randomly selected from each district. Finally, 10 households from each community were randomly selected for survey. Table 1 details the sampling of study communities. With regards to the level of uptake of existing SLWM technologies by farmers, the study delved into level of adoption of SLWM technologies, the factors responsible for uptake.

Table 1. Sampling of study communities

Region	District	Communities
Northern	West Mamprusi	Takorayiri, Gugya-pala, Buakudow, Tiya, Bugya-Kuraa
	Mogduri	Buhiyingah, Yagaba, Prima, Goriba, Loagri
Upper East	Kasena-Nankana	Awenia, Nakongdong, Afania, Achangoson, Aniu-Adongo
	Bawku West	Namog, Sheiga, Zopkalga, Kunkuo, Farig
Upper West	Sisala West	Kusala, Gbal, Jawia, jeffesi, Bullu
	Wa East	Zinye, Vissee, Gudayiri, Naaha, Manwu

Source: Field Survey, 2018.

MATERIAL AND METHOD

Theoretical Framework

Based on the number of SLMW technologies adopted by smallholder, it takes the attributes of a Poisson model due to (1) the SLMW technologies can be counted in whole numbers, (2) occurrences are independent, so that a farmer adopting one technology neither diminishes nor increases the chance of another technology; (3) the average frequency of adopting an SLMW technology for a time period in question is known and (4) it is possible to count how many technologies can be used. The count nature of the technologies makes the Poisson

model which is applied in analysing counts of events assumed to occur randomly in time (Gart, 1975). Based on the attributes of count attributes of the SLMW technologies, with respect to factors affecting levels of uptake/adoption, the study made use of the Poisson model as the data was free from excess zeros and under/over-dispersion. These are usually the main challenges of count data. Based on this, the density function for the Poisson regression is defined as:

$$f(y_i / x_i) = \frac{e^{-\lambda_i} \lambda_i^{y_i}}{y_i!}, y_i = 0,1,2,3,\dots \quad (1).$$

Where, y_i is the number of technologies adopted by a farmer i and x_i are explanatory variables that are hypothesized to influence adoption

levels. Further, the conditional mean parameter λ_i as a function of the regressors, x_i and a parameter vector, β is defined as:

$$\lambda_i = E[y_i / x_i] = \exp(x_i' \beta) \tag{2}$$

Where $\exp(x' \beta) = \exp(\beta_0) + \exp(\beta_1 x_1) + \exp(\beta_2 x_2) + \exp(\beta_3 x_3) \dots + \exp(\beta_k x_k)$

The conditional mean specification in (2) implicitly defines a regression model of the form:

$$y_i = \lambda_i + \varepsilon_i = \exp(x_i' \beta) + \varepsilon_i \text{ With } E(x_i \varepsilon_i) = 0. \tag{4}$$

Model Specification

The SLMW adoption = f (age, gender, marital status, education, household size, farm size, exposure, access to information, cost of technology, occupation).

Table 2 below explains the various factors influencing SLMW adaptation, means of measurement with the *prior* expectation.

Table 2. Means of measuring dependent and independent variables

Dependent Variable	Independent Variable	Means of Measurement	A prior Expectation
SLMW Adoption (Adopting=1, 0=Otherwise) (Dummy)	Age	Years	-
	Gender	Dummy (Male=1 0=Otherwise)	- / +
	Marital Status	Dummy (Married=1,0=Otherwise)	+
	Education	Years	+
	Household Size	Number	+
	Farm	Acres	+
	Exposure	Dummy (Association Membership=1, 0=Otherwise)	-
	Access to Information	Dummy (Yes=1, 0=Otherwise)	+
	Cost of Technology	Dummy (Yes=1, 0=Otherwise)	-/+
	Occupation	Category/ Types	-/+

Source: Field Data, 2017.

RESULTS AND DISCUSSION

Socio-demographic Characteristics of Respondents

Findings from the study revealed a mean age of 47.6 years of the respondents, which implies that farmers were relatively young. Findings further suggest that relatively active people are engaged in farming in Northern Ghana, which is good for the future of agriculture. This is contrary to the findings of several studies that the youth do not longer want go into farming (Ministry of Food Agriculture, 2011).

As seen from the results in Table 3 below, majority (71.7%) of the respondents were males, while females constituted the minority (28.3%). On

marital status, the study found the majority (91.3%) of the respondents are married. Only a small proportion (4.3%) of the respondents were single. While 4.0% and 0.3% were widowed and divorced respectively.

Formal education is critical for innovation adoption, hence the study wanted to establish the level of formal education attained by respondents in relation to the SLMW technology adoption in the study area. From the study, it was realised that access to education is still very low among smallholder farmers. As seen in Table 3, majority of respondents lacked formal education, while the highest number of respondents with formal education were primary education. Also, about 8.7%, 7.7%, and 2.0%

attained JHS/Middle, JHS, and tertiary education respectively.

Furthermore, about 16 of the respondents representing 2.0% had attained Arabic education. The finding is reflective of the general observation that smallholder farmers generally either have low education or lack formal education.

Household size tends to influence the labour force of households, and for that matter the study sought to establish the household size of respondents. As established by the findings, the average household size was generally large, as most (39.5%) of the households were above 10 members, followed closely by household within the brackets of 9-12 members (24.7%). The least household belonged to the household less than 3 members (0.3%).

With regard to economic activities, as seen in Table 3, farming recorded the highest numbers of

people with 286 individuals, representing 95.3% of the respondents engaged in it. Trading, artisanal activities and wage labour recorded 3.0%, 0.3%, and 0.7% respectively. The finding is typical of rural households where farming remains the main occupation (Ministry of Food and Agriculture, 2007; Ghana Statistical Service, 2013).

In terms of farming systems, majority of the respondents largely practiced the two main types of farming systems, which includes the mixed farming and crops only. About 70.7% of the respondents were engaged in mixed farming, while respondents representing 29.3% were into only crops. These results can be attributed to the large number of farmers practicing mixed farming in order to conserve nutrients and also reduce water run-off.

Table 3. Socio-demographic characteristics of respondents

Variable	Description	Frequency	Percentage
Gender	Male	215	71.7
	Female	85	28.3
	Total	300	100
Marital Status	Married	274	91.3
	Single	13	4.3
	Widowed	12	4.0
	Divorced	1	0.3
	Total	300	100
	Formal Education	No Education	195
Primary		34	11.4
JHS/Middle		26	8.7
SHS		23	7.7
Tertiary		6	2.0
Arabic		16	5.3
Total		300	100
Household size	Less than 3	1	0.3
	3-5	46	15.3
	6-8	59	19.7
	9-12	74	24.7
	Above 10	118	39.5
	Total	300	100
Major Occupation	Farming	286	95.3
	Trader	9	3.0
	Artisan	1	0.3
	Wage labour	2	0.7
	Others	2	0.7
	Total	300	100
Farming system	Mixed farming	212	70.7
	Crops only	88	29.3
	Total	300	100

Source: Field Data, 2017.

Levels of the SLMW technology uptake among farmers

Technologies are developed by researchers to be used to enhance productivity, both in increasing yields and improving quality. Rahman (2007) argues that if technologies that are developed by researchers are not properly adopted and used by farmers, all the effort and resources used in developing the technologies are in vain. Therefore, the study sought to establish the level of SLWM technology adoption among farmers. The findings revealed that the adoption rate across all the identified technologies were generally low across the communities, with none rating above average as shown in Table 4 below. This is contrary to the finding of World Bank (2015) report on the SLWMP which indicated high levels of adoption. This adoption rate is obtained

from interaction with Ministry of Food and Agriculture (MoFA) regional and district directorates, as well as literature the study gathered about the 15 SLWM technologies actively being disseminated to farmers in the study area. These include planting trees, bush fire control, bunding, farming across slopes, use of compost, planting drought resistant varieties, fallowing land, crop rotation, following weather advice, planting early maturing varieties, residue management, mulching, row planting and Zai. Zai is a conventional soil management technology where organic matter is buried in small pit to restore soil fertility and ensure water conservation (Danso-Abbeam, Dagunga and Ehiakpor, 2019). Zai technology was first practiced by smallholder farmers in Burkina-Faso in the 1960s (Reij et al. 2009).

Table 4: Levels of the SLWM technology uptake

SLWM	Frequency	Percentage
Planting trees	107	36
Bush fire control	105	35
Bunding	104	34.7
Farming across slopes	134	44.7
Use of compost	119	39.7
Planting drought resistance varieties	21	7
Fallowing land	17	5.7
Crop rotation	40	13.3
Following weather advice	8	2.7
Planting early maturing crops	20	6.7
Planting cover crops	44	14.6
Residue management	5	1.5
Mulching	9	3
Row planting	10	3.3
Zai	6	2

Source: Field Data, 2017.

Tree Planting

According to proven scientific facts, the more trees we have the more the occurrence of rainfall. There is a saying that “when the last tree dies, the last man dies”, which implies that trees are critical to human survival. Tree planting has been one of the oldest technologies disseminated extensively to fight desertification, which is fast approaching towards the regions Northern Ghana. Due to the challenges in sustaining livelihoods among some rural folks, they have turned to the destruction of the forest resources for agriculture and harvesting of timber/fuel wood for survival. As seen in the Table 4, the study found that

out of the 300 farmers, only 107 respondents representing 36% adopted tree planting.

Bush fire control

The study assessed the extent to which farmers are adopting bush fires prevention or control as a strategy to sustain the environment and findings revealed that that only 102 respondents representing about 35% adopted bushfire control. Respondents attributed the poor adoption of bushfires prevention and control to the attitudinal behavior and cultural practices associated with farming.

Bunding

Bund construction helps prevent run-off and conserve water in farmlands. Due to the current erratic rainfall patterns largely attributed to climate change, bunding has become one of the SLWW technologies being promoted by MoFA among farmers. Farmers use either stones or earth to construct the bunds. The earth bunding activities occur in most areas; however, farmers in the Upper East Region largely use stone for their bunding. As revealed in Table 4. About 134 out of the 300 respondents representing 34.5% adopted bunding. Most of the respondents attributed the low adoption of bunding to high labour intensity nature and the extra cost incurred in its construction. Majority of the farmers representing about 44.7% of the farmers adopted contour ploughing as the SLMW technology. This was attributed to the fact that there is widespread availability of stones used and also because it does not involve cost in its construction.

Composting

Compost is one of the old technologies extensively promoted over two decades ago to gradually complement the use of inorganic fertilizer. Continuous use of inorganic fertilizer has been found to have negative impacts on soil structure as well as increase the cost of production (Tadesse et al., 2013). Findings revealed that that 39.7% of respondents adopted the use of compost. Farmers attributed the low level of compost usage to the low level of sensitization in the area.

Planting drought resistance varieties

As seen in Table 4 21 respondents representing 7.0% adopted improved crop varieties. Farmers attributed low adoption due to the cost of these varieties. Improved seed varieties has been identified as one of the ways of enhancing yields but these seeds requires additional farming practices which hitherto was not practiced by farmers and hence comes at an additional cost build-up in production. This cost build-up was captured as cost of technology according to farmers and a source of demotivation to adopting SLMW. Others indicated that resistant varieties are not readily available for them to buy, even if they have the money.

Fallowing of Land

Findings from the study further revealed as shown in Table 4 below, that 5.7% adopted fallowing. The low figure recorded was due to the increasingly scarcity of land attributed to increasing population, infrastructure development and other competitive uses of land. Farmers are now managing with limited land, and therefore the practice of fallowing of land is no longer possible. This implies

that farmers need to pay attention to other land management strategies, such as composting and Zai, which are effective in agricultural intensification and climate adaptation.

Crop rotation

Only a few (40) out of the 300 have adopted crop rotation, representing 13.3%. The implication is that although crop rotation is one of the effective strategies to intensify farming and ensure sustainable soil and water management, the practice is not widespread.

Following weather advice

Farming practices are carried out according to rainfall seasons. Failure to carry out a particular practice at the right time may result in crop failure. Due to climate change, the rainfall patterns have changed and farmers have to become flexible to the period of farming practice in order to get good harvest. The meteorological department in collaboration with MoFA educates farmers on specific periods to undertake farming practice in order to maximise use of the recent erratic rainfalls. A perusal of Table 4 revealed that adoption of weather advice is poor among farmers, as only a few (8) representing 2.7% have adopted weather advice. This implies that most of the farmers carry out the various practices based on their own decisions, and this likely to affect their farm output. Therefore, sensitisation of farmers needs to be intensified in order to change their behaviour.

Planting early maturing varieties

Research efforts have been made to reduce the duration of some crops in order to reduce the adverse effect of rainfall, temperature and precipitation variability with in a vulnerable climate change as an adaptation strategy. As such, a number of early maturing crop varieties have been developed and transmitted to farmers through MoFA and other development projects and interventions. The study therefore assessed the extent of adoption of early maturing varieties. Only 20 out of the 300 respondents adopted planting early maturing crops. The low adoption according to the farmers during a focus group discussion can be attributed to lack of money to purchase seeds. Others argued that they do not have access to them when they need them. Also, private seed companies and vendors should set up outlets and vending points in the various operational areas to ensure easy access, availability and prompt delivery of seed to farmers. Low usage of early maturing varieties was attributed to a lack of seed vendor shops in the farming communities of the study area.

Planting Cover Crops

Cover crops such as mucuna prevent water runoff and fix nutrients in the soil. As such, the Ministry of Food and Agriculture (MoFA) educated farmers on the need to adopt and intercrop mucuna with cereal crops or use it for crop rotation. Findings from the study revealed that only a few (44) representing 14.6% of the respondents adopted cover crops. However, respondents attributed the low mucuna adoption to scarcity of the mucuna seed and land.

Crop Residue Management

Results as shown in Table 4 above indicated that crop residue adoption was 1.5% of the respondents. The low rate of adoption is surprising because the technology does not incur extra cost and this was attributed to land preparation difficulty in the presence of crop residue and since residues are also used as firewood.

Mulching

In order to conserve moisture around the plants, farmers adopt mulching. Results from Table 4 above further showed that the practice is not widespread, as only 3% of the respondents adopted mulching.

Row planting

Row planting makes it easy for weeding and other practices such as fertilization to take place. It also allows plants to grow well due to less competition for nutrients between the crops and weeds and less insect infestation. The extent of row planting by the farmers was therefore examined during the study. Table 4 showed that 3.3 percent of the respondents adopted row planting. The implication is that the adoption level was poor. Farmers attributed the low adoption rate to the time consuming nature of the technology and will mostly adopt it if there is funding for it.

Zai

Zai is a technology recently introduced into the country from Burkina Faso, which is used as an effective strategy to conserve both water and nutrients in the soil. It is a land preparation practice whereby farmers dig areas of their farmland where crops are to be planted to about 15 centimetres, and manure put in before crops are planted. As seen in Table 4 above, only 2% of the respondents have adopted Zai. This implies that the technology adoption is not yet widespread. The very low

adoption can partially be understood because the technology at the moment is concentrated in the upper East region. According to respondents, the practice is very good, but it is labour intensive in terms of digging the small pits especially when you have a large farm.

Factors influencing SLMW Technology Uptake

Results of the Poisson regression estimates as shown in Table 5 below on the factors influencing the adoption levels of the SLWM practices identified marital status, exposure, access to information, and cost of technology as the factors influencing uptake. Out of the ten independent variables, only four were statistically significant. The Pseudo- R^2 of 10 confirmed that about 10% variation in the independent variables influence smallholder farmers' adoption of the SLMW technology in the study area. Possibly, the high percentage of unexplained variability in the levels of adoption could reflect unobserved heterogeneity that we were not able to control for with the available data. However, while low Pseudo R-square value was well-noted, the overall significance of model was satisfactory, as reported by the Wald Chi-square value.

Results as shown in Table 5 below showed marital status, exposure to grouping (membership to farmer-based organizations, urban dwellings), access to information and cost of technology as statistically significant at 1%, 5% except for marital status and access to information, which were significant at 10% respectively. All the significant variables were negative as well. This shows that as people get increasingly married, the probability of adopting SLWM decreased by 0.443. This is attributed to time spent by married couples at home and with their families relative to farming activities in the study area.

Also, the likelihood of farmers adopting SLWN decreases with both current and past association to farmer-based organizations and or urban dwellings. This confirms that exposure to existing technology through various media such as the print and electronic has significant but negative effect on new technology adoption (Maertens and Barrett, 2013). This further confirms the role of associations, social networks and urban dwellings on new technology adoption in Ghana due to the availability of information and strong collective action to accept or reject a new technology based on cost, and appropriateness.

Table 5. Results of the factors influencing the levels of adoption of the SLMW practices

Variable	Coefficient	Std. Err.	Z	P>Z
Age	-0.008	0.005	-1.61	0.108
Gender	0.171	0.187	0.91	0.361
Marital status	-0.443**	0.212	-2.09	0.037
Education	0.032	0.036	0.87	0.385
Household size	-0.008	0.055	-0.14	0.891
Farm size	-0.003	0.012	-0.29	0.775
Exposure	-0.523***	0.143	-3.64	0.000
Access to information	-0.258**	0.119	-2.18	0.030
Cost of technology	-0.326**	0.121	-2.69	0.007
Occupation	0.157	0.192	0.82	0.412
Constant	3.404	0.647	5.26	0.000
Pseudo R ²	0.099			
Probability Chi-square	0.000			0
LR Chi-square (10)	38.45			
Log likelihood	-175.45			

Note: *, ** and *** represents 10%, 5% and 1% statistical significance levels respectively.

Source: Field Data, 2017.

Furthermore, a unit increase in a farmer's access to information results in a 0.26 likelihood of not adopting the SLWM in the study area and this was evident in the low yield purported by farmers. This was attributed to the perception of high cost and appropriateness of the SLMW adoption especially among women, the aged and illiterate farmers in the area due to misinformation or indirect access to information about the SLMW. Also, information from extension delivery did not trickle down to farmers and was evident from in some of the practices undertaken by these farmers. This further shows the role of information in new technologies such as SLMW towards efficient and optimum yields and confirmed by Godfray et al. (2010) that access to technology information enhances efficiency and adoption.

Finally, findings further showed that, a unit increase in the cost of adopting SLMW will lead to a 0.33 decrease in adopting this technology. This can be attributed to the low income levels among rural farmers in the study area and further confirms the role of cost in designing new technologies especially among rural farmers. The pseudo R-square confirms the effect of these variables in the SLMW technology adoption and hence a value of 10% from the estimation. This further shows that, access to information, cost of technology, exposure to association and urban dwelling as well as cost of a technology should be prioritize in designing a new technology. This will influence the adoption rate. Ideally, the SLWM practices are sometimes complex for comprehension of farmers. Probably, either the information from extension agents is not effective enough for farmers to understand and adopt the SLWM practices or farmers are conservative and

therefore did not apply the SLWM practices taught them. In any of these situations, increments of farmers' access to information will lead to low adoption.

CONCLUSION

Sustainable, Land and Water management (SLWM) technologies is high among smallholder farmers in Northern Ghana. However, there were generally low levels of uptake across all the technologies identified in the three regions of the north. Motivation plays a key role in facilitating farmers' adoption of technology, as farmers with support or access to resources influence their adoption levels. This implies that increase in support to communities to adopt SLWM is likely to enhance the adoption of the SLWM technologies.

The SLWM technologies are making great impacts on the lives of poor rural farmers through increases in crop yield, prevention of water and manure run-off on farms, reduction in loss of livestock due to readily available feed, conservation of fertility and water, enough food to feed the family, reduction in poverty, increases environmental consciousness, reduction in bushfire destruction, improvement in rainfall among other. This implies that the promotion of the SLWM technologies will go a long way to improve the lives of poor rural farmers as well as reduce poverty. At the community level, the SLMW technologies require scale-up for easy.

Some farmers willing to adopt the SLWM technologies, are challenged by limitation of membership of the SLWM projects.

The SLWM is of critical importance because the issue of climate change and climate variability

has become a global affair. The smallholder farmers are the worse affected by the adverse effects of climate change. This therefore calls for the integration of the SLWM technologies in all agricultural interventions. The review of agricultural policy strategies revealed inadequate capturing of the SLWM issues, which is critical for its promotion among farmers. For instance, interventions such as AgSSIP, FASDEP I, FASDEP II, as well as METASIP did not sufficiently capture the SLWM issues.

Personnel and logistics are key in the successful delivery of the SLWM technologies in Ghana. Currently, the farmer-to-extension ratio is very low due to reduced interest in agricultural extension education. Districts and community extension agents lack basic logistics such as vehicles and motorcycles hindering visits to farming communities.

Effective up scaling of the SLWM technologies since a lot more people have no access to the support of the SLWM technologies. Major agricultural development projects by both public and private sector should integrate the SLWM technologies in their implementation, since the SLWM holds a key to future agricultural sustainability.

Private sector involvement is therefore required for sustainability aspect of the SLWM technologies. Especially in the seed sector which will enhance availability and accessibility to early maturing seed varieties in the farming communities. The PP will give the MoFA the facilitative, monitoring and certification role to private seed companies leading to the creation of vendor centres in the communities.

With the proposed integration of the SLWM technologies in all agricultural programmes, the MoFA and other agricultural development projects should ensure that all agricultural extension staff are trained in the SLWM technologies.

Statement of Conflict of Interest

The authors declare that there was no conflict of interest in respect of this study.

Authors' Contribution

HA (Conceived and Designed the study); MFA (Data Collection and Analysis); OTD (Quality control and data analysis).

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