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*Full Length Research Paper*

# **Analysis of social media mainstreaming in E-extension by agricultural development programmes in North Central Zone, Nigeria**

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**Social media is a new trend in communication and a new platform for sharing, engagement and networking in all spheres of life including agriculture. This study analysed social media mainstreaming in e-extension services delivery by the Agricultural Development Programmes (ADPs) in North Central Zone of Nigeria. Four ADPs of Kogi, Federal Capital Territory, Nasarawa and Niger states that participated in the Research Extension Farmer Input Linkage (REFIL) activities in November 2017 were purposively selected and used for the study. Secondary data were generated from the REFIL reports and descriptively analysed. Result established insufficient field extension agents to effectively reach out to 1.412 million farm families in the zone. Also, the result reveals zero exclusion of social media such as Facebook, WhatsApp, Chats, YouTube and Mobile phone tools in the ADPs communication strategies. ADPs communication targets dwelled more on old media such as radio (21%) and television (50%) were costly and achieved low projected targets. Mainstreaming social media in e-extension will be more effective to reach out to farm families and overcome observed field manpower shortage problems. Modern networking tools and proactive creative measures such as Facebook, WhatsApp, YouTube, Chat, mobile phone tools of short message sending and voice call are recommended for inclusion in their communication strategies. In this regard, REFIL organisers and Federal Department of Extension should facilitate ADPs innovativeness and staff training on social media to improve competence and skills of actors in the agricultural value chain providers in extension delivery to the agribusiness community.**

**Key words:** Social media, communication, extension, agriculture, Nigeria.

## **INTRODUCTION**

Social media (SM) technology has revolutionized and added value to communication through content

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**Table 1.** Social network user penetration worldwide, by Region, 2011-2017 % of population in each group.

Years	2011	2012	2013	2014	2015	2016	2017
Middle East and Africa	66.7	74.3	80.5	83.8	87.2	90.3	92.8
Central and Eastern Europe	69.9	71.9	74.3	75.9	76.8	77.3	77.9
Latin America	65.2	68.9	72.4	74.9	79.1	80.4	82.3
North America	63.4	65.6	66.6	67.5	68.1	68.6	70.0
Asia-Pacific	52.4	58.3	64.2	68.6	72.1	75.5	78.0
Western Europe	53.1	57.9	61.5	64.1	65.9	67.6	68.9
Worldwide	58.2	63.1	67.7	71.1	74.1	76.6	78.7

NOTE: Internet users who use a social network site via any device at least once per month from eMarketer, April 2013 in Andres and Woodard (2013).

generation, interaction, engagement, sharing and networking. They are most popular communication tools and sources for breaking news among the millennial due to accessibility, globalization, multimedia combinations, and stylish effects. Suchiradiptra and Saravanan (2016) defined SM as web based tools of electronic communication that allow users to personally and informally interact, create, share, retrieve, and exchange information and ideas in any form that can be discussed, archived and used by anyone in the virtual communities and networks. Andres and Woodard (2013) viewed it as user generated information, opinion, video, audio, and multimedia that is shared and discussed over digital networks, and noted that social media refers to internet-based tools for sharing and discussing information among people.

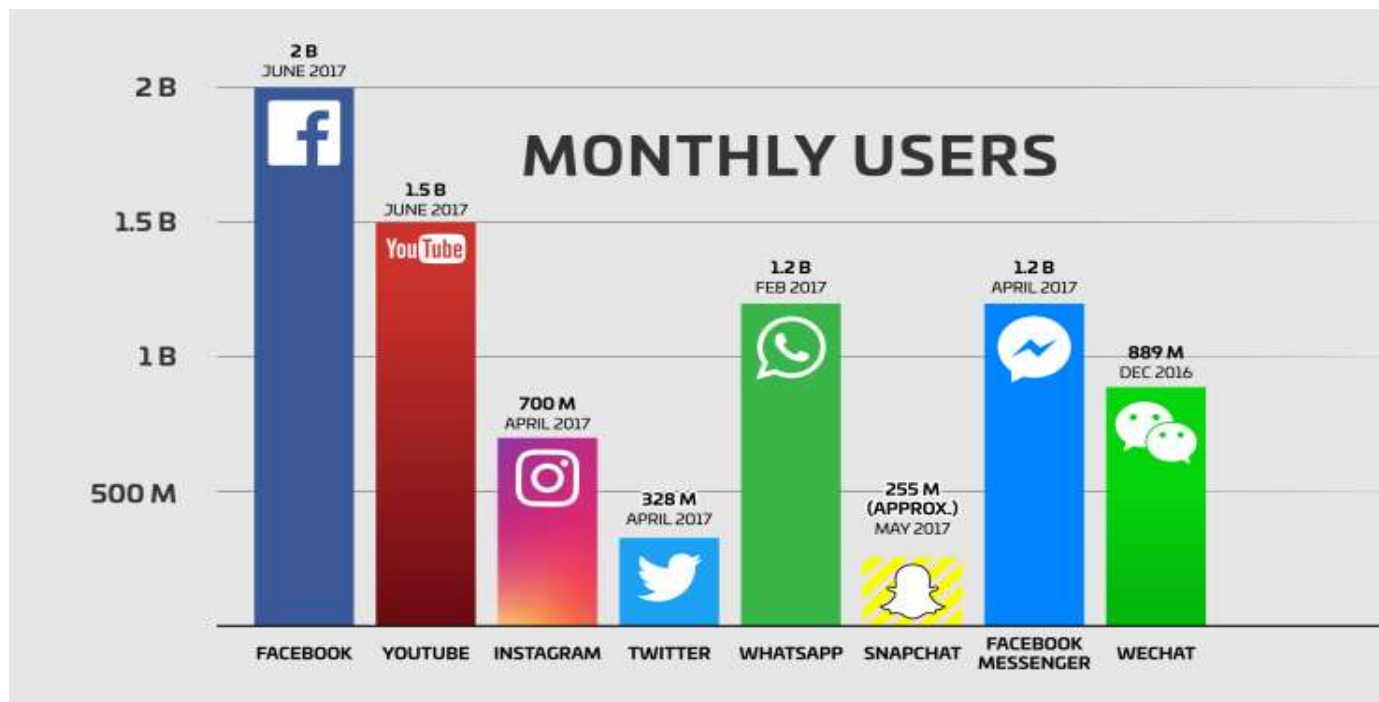
Edosomwan et al. (2011) traced SM history to many social networking sites created in the 1990s whereas in 2000 social media received a great boost with the witnessing of many social networking sites springing up. Among those that were launched as enumerated by Junco et al. (2011) included Lunar Storm, Six degrees, Cyworld, Ryze, and Wikipedia. In 2001, fotolog, Sky blog and Friendster were launched, and in 2003, MySpace, LinkedIn, LastFM, Tribe.net, Hi5 etc. In 2004, popular names like Facebook Harvard, Dogster and Mixi evolved. During 2005, big names like Yahoo!360, YouTube, Cyword, and Black planet all emerged. Also, Andres and Woodard (2013) listed social media to include (but are not limited to): Social networking sites e.g. Facebook, LinkedIn, Myspace; Video and photo sharing websites e.g. Flickr, YouTube; Blogs; Microblogs e.g. Twitter, Tumblr; Forums, discussion boards, and groups e.g. Google Groups, Yahoo Groups; and Wikis e.g., Wikipedia; Video on demand and podcasts; Video conferences and web conferences; Email and instant messaging; Socially integrated mobile text messaging; Websites with social plug ins and layers. As shown in Table 1, there is worldwide increase in the usage of SM and all the regions including Middle East and Africa ranked high users with 92.8% in 2017.

On this, Hartshorn (2010) noted there are several

differences between social media and social networks. Social media is still a media which is primarily used to transmit or share information with a broad audience, while social networking is an act of engagement of people with common interest to associate together and build relationships through community (Cohen, 2009; Hartshorn, 2010). SM offer actors in agricultural value chain particularly primary and secondary actors a voice, visibility, sense of belonging and global interconnection through the internet network unlike traditional media such as radio, newspaper and television. Cornelisse et al. (2011) outlined some merits of SM in advisory services thus; gives an opportunity to connect with one's audience, educate and helps to know more about the platform needs in the enterprise. It makes promotion of extension programs easier, allows real-time interaction with clients, helps extend outreach to new audiences, and promotes development of relationship among actors in the system. This informed the statement of Fulton (2016) that local farmers are being asked to cling closer to their smart-phones and computer screens to meet their information needs. For agricultural development practitioners, social media tools can expand the reach of various communities, strengthen partner relationships, support programmatic initiatives, and provide a vital means to increase the visibility of public profile and engagement (Andres and Woodard, 2013).

As shown in Figure 1, global social media log-in-users as at July 2017 were 2 billion for Facebook followed by YouTube with 1.5 billion, WhatsApp and Facebook Messenger got 1.2 billion respectively whereas WeChat had 889 million, Instagram had 700 million, Twitter recorded 328 million and Snapchat had 255 million. Above statistics of SM users confirmed its dominance in the twenty first century communication. Across the globe, 1.69 billion people are accessing social media via mobile phones whereas globally active mobile SM accounts penetration is 23 percent of which Nigeria and India have the highest share of web traffic through mobile in the world (ITU, 2015; Kemp, 2015).

Therefore, SM is crucial in e-extension strategy to meet information needs of millions in the agricultural value



**Figure 1.** Monthly social media users data.

Source: <https://techcrunch.com/2017/06/27/facebook-2-billion-users>

chain. E-extension is the use of internet technology or information communication technology as a platform for exchanging information and providing services to actors in the agricultural value chain. E-extension tools supports delivery of information in diverse styles such as voice, image, motion, instants messages, and applications. Report of Developing Local Extension Capacity (DLEC) by Huber et al. (2017) stated thus; “with regard to advisory methods, Nigerian AEAS uses a wide variety of approaches. However, we see the biggest opportunities in ICT-enabled extension, which we define as extension agents (EAs) systems and programs that utilize appropriate information and communication technologies for information sharing, capacity strengthening, program and performance management, and other EAs activities. Key opportunities for ICT-enabled extension include the use of Interactive Voice Response (IVR) to enable farmers to authenticate input quality and for the private sector to establish ICT-enabled extension that is profitable and sustainable”.

Meanwhile, social media usage has more to do with mindset than with age. Extension practitioners and farmers are among the owners and users of mobile phone which is the most popular communication tool to access and connect to social media (LeBoeuf et al., 2012; Fahy, 2013; Ifejika, 2013). Nigeria, with over 87million engaged in agricultural livelihood activities, needs a robust e-extension delivery services through SM platforms. While many farmers across the globe are

taking to SM to connect with experts and their peers, extension agents and extension organizations appear to have oversimplified idea of the rural dwellers and are stereotyping farmers and believing that they are not technologically savvy (Diem et al., 2011; Payn-Knoper, 2013). This requires investment in communication infrastructure by public extension agencies in 37 Agricultural Development Programmes (ADPs) as well as NGOs and agro-industries. Unfortunately, the situation in Nigeria is appalling with low deployment of information and communication technology tools by government agencies which created a huge constraint to doing agribusiness in the country. To buttress this, the surveys of the United Nations from 2008 to 2012 showed that Nigeria's e-government readiness ranking dropped in 2008 through to 2010 and 2012 but experienced a rise in 2014 (Oni et al., 2016).

Since 2015 till now, federal government e-Wallet mobile platform with over 4 million registered farmers is moribund and dormant while farmers suffer lack of knowledge and information in the research-extension-farmer-input-linkage-system (REFILS). Moribund federal government agricultural portal is <http://www.eagriculture.gov.ng/eAgricPortal/> just one out of many showing that intentions are not good enough. Also, a DLEC report by Huber et al. (2017) wrote that Market Development for the Niger Delta project (MADE) a non-governmental organization study on ICT revealed that 60 to 65 percent of Nigerian farmers are able to



receive SMS, and many companies have databases of farmers, but do not know how to use the information to increase their sales. The ADP extension staff strength and farm family ratio have not been exposed. Moreover, the social media deployed by the ADP in the north central zone of Nigeria has not been ascertained. This raises the following three research questions: What is the ADP extension staff and farm family ratio in the study area? Do ADPs in the study area deploy social media in their extension services to the farmers? How do ADP's projected communication targets compare with their achieved communications? These backgrounds informed the decision to carry out an analysis of social media mainstreaming in e-Extension by ADPs in north central zone of Nigeria. The specific objectives were to:

- (i) Examine ADPs extension staff strength and farm families
- (ii) Ascertain social media deployed by the ADPs
- (iii) Ascertain projected and achieved communication activities by the ADPs

## METHODOLOGY

The northern Nigeria occupies 70% of the country's land mass and constitutes 53% of the population. Its economy is mostly agrarian suitable for: growing of crops such as maize, beans, and tomatoes; livestock such as sheep goat and cattle; and fisheries activities. Presently, it has 20 ADPs out of 37 with few extension agents to cover millions of farm families in the agricultural value chain. The ADPs are key actors in the REFILS to strategize and plan work activities. In November 2017, the Federal Capital Territory (FCT, 2017) ADP hosted the fourth quarterly steering committee meeting of the north central zone FEFILS which was attended by 17 participants from five ADPs and two research institutions. The States were Benue, Kogi, Federal Capital Territory, Nasarawa, Niger, and Taraba. Interesting development noticed in the ADPs report at November meeting was funding of extension activities by development partners, NGOs and agro-industries such as USAID, JICA, IFAD, GIZ, JDC, SYNARGOS, Action Aid, FADAMA 111-AF, BASF, Premier Seeds, Ministries, Universities, and private individuals. Some technologies disseminated were on crops, livestock, fisheries, agro-forestry, extension demonstrations, nutrition, training, innovative platforms. On livestock, they carried-out de-worming and vaccination trainings. The women were offered training on backyard gardening, soap making methods for income generation, value addition to agricultural products, as well as linked to credit institutions.

For the study, north central zone was purposively chosen. The five State ADPs that attended REFILS activities hosted by Federal capital territory ADP in November 2017 formed the population of the study. While four states in the core north central zone namely Benue, Kogi, Federal Capital Territory, Nasarawa, and Niger were purposively chosen. The states were purposively chosen for two major reasons: First, REFILS activities are going on there. Second, they are the true representatives of the zone with large number of ADPs. Finally, the zone contains Nigeria's Federal Capital territory where important economic decisions are taken which affect the livelihoods of the country's inhabitants.

Secondary data were generated from the ADPs REFILS reports. The staff strengths of the ADPs extension agents and the number of farm families that need agricultural information were accessed and compared. The deployments of social media tools by the ADPs

in the REFILS reports were examined. This helped in understanding the extent to which the ADPs used the SM in extension service delivery those number of farm families. The need for SM use in the zone is explored through the REFILS reports on how different SM groups benefited in the use of its tools. The study also examined the ADP's 2017 projected and achieved communication targets to reach out to the number of farm families with the aim to understand the zone's e-extension service readiness. Data collected were analysed using descriptive statistics such as frequency counts, percentage and ratios.

## RESULTS AND DISCUSSION

Table 1 shows the staff strength of the four ADPs and farm families who need agricultural information. As indicated, extension agents (EAs) account for 61.6% of the total ADP's workforce of 809 who are expected to serve 1,412,865 farm families through face-to-face method in the four zones. The result established insufficient EAs to effectively cover the large farm families with face-to-face method in the agricultural value chain put at an average ratio of 1:3126 which was found to be higher in FCT, Kogi, and Niger States. It implies that the EAs are decreasing, being over laboured and unequipped to reach out to increasing millions of men, women and youths attracted to modern agribusiness in the zone. In support, Gakuru et al. (2009) reported that the number of extension workers in Kenya has been decreasing drastically while the number of small scale farmers has been increasing therefore creating the need for innovative services to address this gap. The shortage of EAs justifies the need to deploy e-extension tools such as social media (Facebook, YouTube, Chats, Instant Messaging, WhatsApp) and mobile phone services (SMS, Voice call) and mobile applications to improve extension service delivery for effective and efficient coverage. The result is in agreement with Huber et al. (2017) report regarding advisory methods, which indicated that Nigerian EAs uses a wide variety of approaches, but, will have the biggest opportunities in ICT-enabled extension. In Nigeria, NAERLS was, as of 2017, in the process of starting a call center with an interactive voice response system. Expected e-extension innovations by the ADPs to support EAs face-to-face service delivery are to establish call centers, help desk, record radio and videos messages, social media initiatives, SMS, voice call and mobile applications.

### Social media deployed in extension delivery services by the ADPs

REFILS reports (2017) of the four ADPs reveals zero deployment of social media tools such as Facebook, WhatsApp, Chat, Instant Messaging and YouTube in extension services delivery to reach 1,412, 865 farm families in the four states (Table 2). This is an indication that the ADPs were not e-extension ready to mainstream

**Table 2.** ADP staff strength and farm families in the North Central Zone.

ADP State	Total staff	Extension agents	EA/Farmer ratio	Number of farm families
FCT	126	46	1:3587	165,000
Kogi	126	85	1:4000	228,964
Nasarawa	177	105	1:1718	180,438
Niger	380	260	1:3200	838,463
Total	809	498	1:3126	1,412,865

Source: Compiled from REFILS Reports of Kogi State and Niger State Agricultural Development Programme. EA= Extension Agent; EA-FR= Extension Agent Farmer Ratio; NFF= Number of Farm Families.

social media in communication strategy. Recent study by Olaolu et al. (2018) on e-readiness of Benue State ADP in north central zone empirically established their non readiness for e-extension services due to low perception of ICT despite availability of ICT infrastructure, and competent staff to manage such innovation in extension agency. Suchiradipta and Saravanan (2016) found that the preferred SM platform among actors in agriculture was Facebook (64.7%) followed by WhatsApp (37.3%), Google+ (32.5%) and YouTube (20%). Meanwhile, evidence exists that SM is already being utilized and found to be beneficial to extension agencies and farmers. Salazar et al. (2018) found that internet access promotes the extent and intensity of adoption of innovation on farms. For instance, Kwara ADP Facebook (<https://m.facebook.com>) has 81 likes and 81 followers. Also, YouTube video created on 5<sup>th</sup> October 2017 on aquaculture livelihood enterprise in Nigeria (<https://www.youtube.com/watch?v=Oi7ZkNLzFg0>) recorded 58 views.

In addition, FAO YouTube on Turning points in modern aquaculture (<https://www.youtube.com/watch?v=4eAXwk2orY0>) had over 18,000 views, 10,000 download and 81 likes as at May 2016. Also, WhatsApp group platform (+2348066952076) of Catfish Farmers Association of Nigeria (CAFFAN), Anambra State chapter created on 25/11/2016 has 172 registered members who share information on aquaculture input supply such as fingerlings, feeds, credit mobilization from community bank, marketing, fish processing and packaging technologies. Other issues are to generate and share information on farm data, conduct training, alert members on meetings, build entrepreneurship knowledge, link up with CAFFAN national secretariat and fish feed companies through their distributors for price rebate among others. Also, Access Agriculture D-group is using YouTube video to disseminate agricultural technologies to reach 14,637 members in agricultural value chains ([www.accessagriculture.org](http://www.accessagriculture.org)). Above evidence justifies the need for social media inclusion in extension communication activities of the ADPs in the zone. Diem et al. (2011) and Payn-Knoper (2013) summarised their actions as thus; "while many farmers across the globe

are taking to social media to connect with experts and their peers, extension agents and extension organizations appear to have oversimplified idea of the rural dwellers and are stereotyping farmers and believing they are not technologically savvy". It entails the ADPs need to change old perceptions, take initiative and innovate to modern communication tools in extension service delivery.

#### **ADP's 2017 projected and achieved communication targets**

Data in Table 3 show ADP's 2017 projected and achieved communication targets to reach out to 1,412,865 farm families in the zone. The table reveals that most of the states have zero communication targets. As revealed, radio has the highest of the message targets (166), but achieved only 21.8% of its target followed by television with 98 targets but achieved 44.89% of its target whereas video had 12 projections and achieved 41.6% as well as photo documentation with 50% target achievement. It was observed that Nasarawa State ADP had more communication activities and achieved more targets than the other three ADPs on photo (50%), video documentaries (41.6%), radio (30%) and television (41.6%), whereas Niger ADP achieved more of its targets than the other ones in the areas of TV (75%) and Radio programmes (61.5%).

Availability of official mobile phone with zero percent initiative on bulk SMS services and helpline desk voice call were indicting evidence on ADPs no readiness for e-extension services in the zone. It implies that the ADPs have conservative attitudes as they dwell on the old media despite paucity of fund and high costs instead of innovating to the affordable new social media tools such as Facebook, WhatsApp and YouTube video through mobile phone. Deduced possible reasons for this include lack of initiative, reluctance to change and poor funding of the ADPs. In support of the later, Suchiradipta and Saravanan (2016) stated that social media readiness signifies the intent of a user to add value to their various services through the use of social media. Another implication of the result is that the ADPs in the zone are

**Table 3.** Targeted and achieved communication projections by ADPs in 2017 in the Zone.

Communication Tool	FCT	Niger	Nasarawa	Kogi
Mobile phonecontact	Yes	Yes	Yes	Yes
SMS &Voice call			00	00
Social media	0	0	00	
Emails	Yes	Yes	Yes	Yes
Radio	0 of 52P	32 of 52P (61.5%)	3 of 10P (30%)	0 of 52P
Television programme	0 of 12P	39 of 52P (75%)	5 of 12P (41.6%)	0 of 12P
Video documentaries	0	0	5 of 12P (41.6%)	0
Village video viewing	0 of 24P	0	0	0 of 24
Photo documentation	0	0	6 of 12 (50%)	0
Press release	0	0	0 of 24	0

Source: Compiled from REFILS Report (2017). Key: P = Projections.

under serving the farm families in the states for many reasons that include none utilization of SM tools, shortage extension staff, lack of initiative and others.

## CONCLUSION AND RECOMMENDATIONS

The study found that ADPs are dwelling mainly on old communication system and totally excluded social media tools in their communication strategies with potential to reach out to increasing numbers of farm families in the zone. Therefore, creativeness, initiative and capacity building are prerequisites for extension agencies to innovate to social media of which federal department of agricultural extension with others agencies and partners should take action. Also, REFILS zonal meetings should spearhead the advocacy for inclusion of social media in communication activities of the ADPs to enhance extension service delivery to millions of farm families in the zone and in other zones of Nigeria at large.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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*Full Length Research Paper*

# **Effect of Soil and Water Conservation (SWC) Measures on Soil Nutrient and Moisture Status, a Case of Two Selected Watersheds**

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The study was conducted in Guba-Lafto Woreda of North Wollo to find out the effect of stone faced soil bund on soil macronutrients (N, P, and K), organic carbon content, soil pH, cation exchange capacity (CEC), and soil moisture status. From two case study kebeles, two watersheds were purposively selected representing Dega (highland) and Woina dega (midland) agro ecological zones. Sixteen composite surface soil samples (0 to 20 cm depth) were collected from selected watersheds. A statistical paired samples t-test showed that, mean value of some soil parameters were significantly different at t and p-value between conserved and non-conserved farmlands. These indicated that, conservation practices reduce runoff, and helps keep nutrients on the field. The study also revealed that stone faced soil bund is essential for soil moisture retentions through reducing run-off velocity, conserving and storing water, and then increasing infiltration and percolation rates. Therefore, implementation of soil and water conservation (SWC) practices should be encouraged by different governmental and non-governmental sectors of Ethiopia, and it should be followed up by other inputs like application of organic fertilizers.

**Key words:** Soil and water conservation, soil and water conservation measures, stone faced soil bund, soil nutrients, soil moisture.

## **INTRODUCTION**

The economy of Ethiopia is based mainly on agriculture that provides employment for over 80% of the labor force, and 46.3% of the gross domestic product (GDP) (Gross domestic product). In fact, agriculture in Ethiopia is not only an economic activity but also a way of life for which agricultural land is an indispensable resource upon which the welfare of the society is dependent on. Such

dependence obviously leads to increased vulnerability of the economy to problems related to land degradation (Wegayehu, 2005).

Land degradation resulting from soil erosion and nutrient depletion is one of the most challenging environmental problems in Ethiopia, which directly reduces soil fertility. The Ethiopian highlands have been

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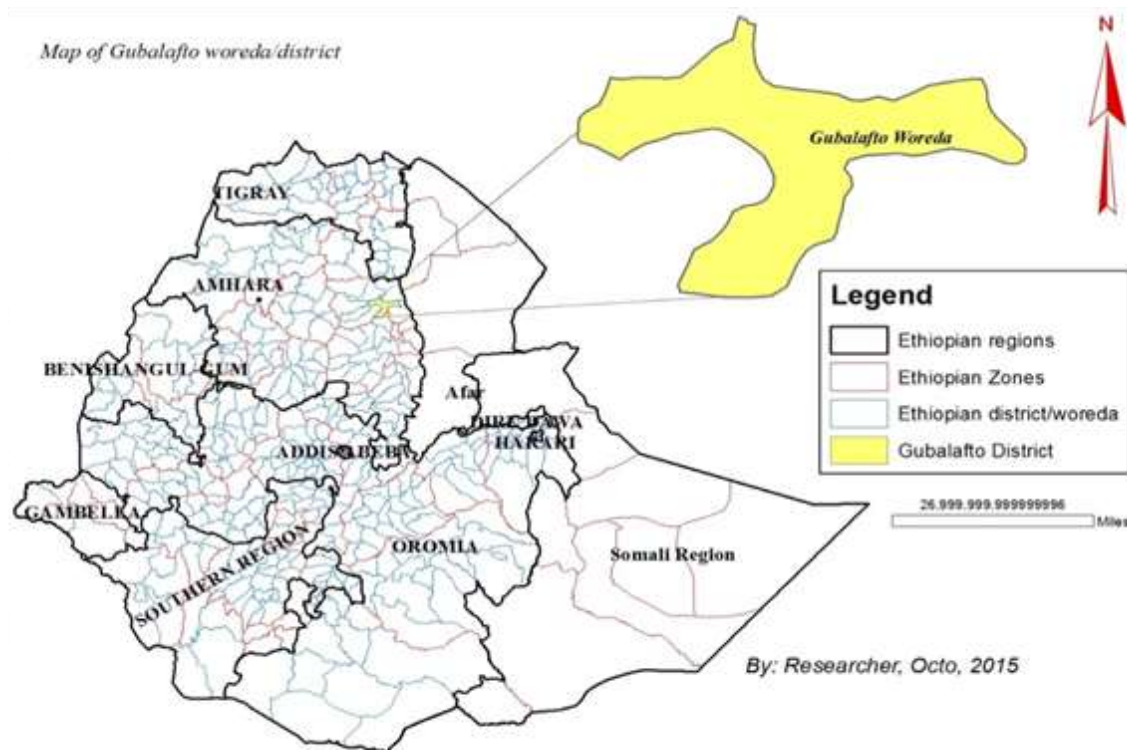


Figure 1. Location map of the study area.

experiencing declining soil fertility and severe soil erosion due to intensive farming on steep and fragile land (Amsalu, 2006).

The government of Ethiopia has made several interventions like mass mobilization, and soil and water conservation campaigns that have resulted in terraces, soil bunds, area closures, and planted with millions of tree seedlings. Nevertheless, the country still loses tremendous amount of fertile topsoil, and the threat of land degradation is broadening alarmingly (Teklu and Gezahegn, 2003).

According to FAO (2011), to reduce rural poverty and maintain food security, soil fertility need to be maintained, agricultural systems need to be transformed to increase the productive capacity and stability of small holder crop production. Greater attention is thus being given to alternative means of intensification, particularly the adoption<sup>1</sup> of soil and water conservation (SWC) practices.

Chemical fertilizers grow plants but for moisture deficiency periods do nothing to sustain the soil (Brady and Weil, 2002). This indicates that fertilizer application must be complemented with SWC practices to sustain agricultural production in rural livelihoods, where agricultural land is in short supply, where moisture is

deficient, and/or where SWC practices has the potential to increase yields of high-value crops (Braun et al., 2003).

SWC practices are increasing food production without further depleting soil and water resources, adding high amounts of biomass to the soil, causing minimal soil disturbance, conserving soil and water, restoring soil fertility, and increasing the resilience of farming systems to climatic risk (FAO, 2009, 2010c). Thus, this study was designed to examine the effect of stone faced soil bund on soil macronutrients (N, P, and K), organic carbon content, soil pH, cation exchange capacity (CEC), and soil moisture status in Guba-Lafto Woreda.

## METHODOLOGY

### Description of the study area

Figure 1 presents the location map of Guba-Lafto Woreda within the Amhara Region of Ethiopia. The Woreda is bordered in the south by the South Wollo Zone, Delanta and Wadla Woreda in the west, Meket Woreda in the north-west, Gidan Woreda in the northeast by the Logiya River which separates it from Kobo, and on the southeast by Habru. Woldiya is an enclave inside this Woreda, and it is the major town in the area. Geographically, the area is located between 39°6'9" and 39°45'58" East and 11°34'54" and 11°58'59" North.

Based on the 2014/2015 national census conducted by the Central Statistical Agency of Ethiopia (CSA), with an area of 900.49 square kilometers, Guba-Lafto Woreda has a population of 139,825. The major land use practices in the area includes arable

<sup>1</sup> Adoption refers to a potential as technical feasibility, economic viability and social acceptability of a technology when managed at field scale by a target population of farmers (Franzel and Helen, 1992).



**Figure 2.** Average monthly temperature and rainfall at Woreda from 1990 to 2012.

land (34.1%), grazing land (17.9%), forest (27.1%), and water bodies (6%), rocky land (5%) and others (9.9%), respectively (Dereje and Desale, 2016).

Dominant soil types in the area are Eutric Leptosols, while Eutric Cambisols, Lithic Leptosols, and Vertic Cambisols are also observed in the Woreda (Mohammed, 2010). A bi-modal nature of rainfall characterizes most parts of Guba-Lafto Woreda. The short rainy season (Belg), occurs between February and April while the long rainy season (Meher), occurs between June and September. Figure 2 shows mean historical monthly temperature and rainfall for Guba Lafto Woreda during the time period 1990 to 2012.

## Methods of soil sampling and laboratory analyses

### Soil sampling procedures

Kebeles in the Woreda were stratified into two agro-ecological zones highland and midland. One kebeles from each agro ecological zone totally two kebeles; Shewat kebele (highland) and Amaymicha kebele (midland) have been selected purposively as SWC practices are more available in these kebeles. These kebele provide us an opportunity to find out different SWC practices and to investigate the roles of these practices on soil nutrient and soil moisture status.

From two selected kebeles which are Shewat and Amaymicha kebeles, soil samples were collected from two selected watersheds<sup>2</sup>, which are Wege Alba watershed and Tikur Wuha watershed representing Shewat and Amaymicha kebeles respectively. In each watershed, four representative areas which are both the upper (loss zone) and lower streams (deposition zone) were selected purposefully to collect composite surface soil samples (0 to 20 cm).

From both watersheds, stone-faced soil bund is more available. Therefore, 8 composite soil samples were collected from farmlands with stone faced soil bund (>3 years old), and 8 composite soil samples from non-conserved farmlands giving a total sample size of 16 composite samples. Soil samples were taken by Auger to a

depth of 20 cm from different sampling locations. The soil samples represent upper stream and lower streams of selected watersheds to explore variability in nutrient, and moisture contents as function of slope gradient and land use practice.

### Soil laboratory analyses

The soil samples were submitted to Dessie regional soil laboratory. Total Nitrogen (Tot N%) was analyzed using the Kjeldahl wet oxidation process as described by Blakemore et al. (1987). Available soil Phosphorus (mg/ kg of soil) was analyzed based on Olsen method (Olsen et al., 1954).

Exchangeable potassium (cmol (+)/kg) was analyzed through ammonium acetate extraction. Soil organic carbon content (Org C%) was determined according to the Walkley-Black titration method. Soil pH was measured in distilled water and potassium chloride (1M KCl) suspension in a 1:2.5 ml (soil: liquid ratio) using pH meter.

Cation exchange capacity (CEC) was estimated titrimetrically by distillation of ammonium that was displaced by sodium from NaCl solution (Van Rееuwijk, 2002). The percentage of soil moisture content was determined using Gravimetric method by using the formula:

$$\% \text{Moisture} = \left( \frac{W_f - W_{od}}{W_{od}} \right) * 100$$

Where:  $W_f$  = weight of fresh soil sample and  $W_{od}$  = weight of oven-dried soil sample.

## RESULT AND DISCUSSION

### Effect of stone faced soil bund on some soil parameters

**Soil pH:** Table 1 presents that treated plots with stone faced soil bund had significantly higher soil pH than non-treated soil. Though, statistical paired samples t-test showed that, there is no significant differences ( $t = 2.222$ ;  $p = 0.062$ ) between the mean of soil pH from treated plots

<sup>2</sup> Watersheds or water catchments is an area where rainfall, surface runoff drains into one common stream, river or other water body. It can be a spatial unit which covers geographical surface that contributes to a major watershed (Sarah and Margaret, 2007)

**Table 1.** Effect of stone faced soil bund on soil pH.

Sub-watersheds	Sample	pH -H <sub>2</sub> O	
		Treated	Non-treated
Upper stream of Wege Alba watershed	1	6.43	6.18
	2	4.43	3.05
	Mean	5.43	4.62
Lower stream of Wege Alba watershed	1	6.28	5.79
	2	5.28	5.4
	Mean	5.78	5.6
Upper stream of Tikur wuha watershed	1	8.23	5.15
	2	7.23	4.65
	Mean	7.73	4.9
Lower stream of Tikur wuha watershed	1	6.40	5.92
	2	5.43	4.84
	Mean	5.92	5.38
Overall mean		6.2138	5.1218
Std. D		1.18634	0.99058

Test statistics t-value =2.222; p-value =0.062 and d.f.=7 @ 95% Conf.In.

with stone faced soil bund and non-conserved farmlands. The mean soil pH value for treated plots was 6.2, compared to 5.1 for the non-treated plots. This is in agreement with previous studies elsewhere (Mulugeta and Stahr, 2010).

The higher pH values for the treated fields might be related to the higher organic matter content (Table 1) which is also confirmed by the works of Mulugeta and Stahr (2010) who reported that soils with high organic matter content have a higher soil pH which favors better exchange of bases, and increase availability of nutrients that are needed for the growth of plants in a given soil and ecology. Soil pH associated with the type of parent material and extent of soil erosion. For every half-unit drop in soil pH, percent base saturation declines by about 15% (Baruah and Barthakur, 1998).

Considering the soil pH difference along slope gradient, the plots in the upper sub-catchments have significantly lower soil pH compared to the foot slope positions (Table 1). This relates to the fact that the upper catchment is erosional area while the lower catchment is depositional where the finer soil particles, exchangeable bases, and organic humus are deposited. Therefore, farmers need to be encouraged to implement SWC measures for maximizing soil pH.

**Soil organic carbon:** Table 2 presents the mean value of organic carbon content for treated plots with stone faced soil bund is 9.04% compared to 7.5% for the non-treated plots. A statistical paired samples t-test showed that, there is significant differences ( $t=2.407$ ;  $p=0.047$ )

between the mean of organic carbon content from treated plots with stone faced soil bund and non-treated plots.

This is in agreement with Mulugeta and Stahr (2010) that, soil organic carbon differences between the conserved and non-conserved micro-watersheds were statistically significant. The higher organic carbon content for the treated fields (Table 2) might be related to the higher organic matter content as total organic carbon is the carbon stored in soil organic matter (White, 1997).

Considering organic carbon content difference along slope gradient, the plots in the upper sub-catchments have significantly lower organic carbon content compared to the foot slope positions (Table 2). This relates to the fact that the upper catchment is erosional area while the lower catchment is depositional where the organic humus is deposited.

**Total nitrogen (N):** Table 3 presents that the plots treated with stone faced soil bund had significantly higher total nitrogen content compared to that of non-treated plots. The mean total nitrogen content for treated plots with stone faced soil bund is 0.07 and 0.03% for untreated plots, which is significantly difference ( $t=5.73$ ;  $p=0.001$ ) in between.

This finding is in agreement with the findings of Million Alemayehu (2003) that the mean total nitrogen content of the terraced site with the original slope of 15, 25 and 35% were higher by 26, 34 and 14%, respectively, compared to the average total nitrogen contents of their corresponding non-terraced sloping lands. It is important to note that the pattern of the N-status of the soil follows



**Table 2.** Effect of stone faced soil bund on soil organic carbon content.

Sub-watersheds	Sample	Organic carbon (%)	
		Treated	Non-treated
Upper stream of Wege Alba watershed	1	7.05	4.88
	2	8.9	7.85
	Mean	7.98	6.37
Lower stream of Wege Alba watershed	1	6.60	7.43
	2	11.27	7.26
	Mean	8.94	7.35
Upper stream of Tikur wuha watershed	1	9.16	6.94
	2	11.5	9.6
	Mean	10.33	8.27
Lower stream of Tikur wuha watershed	1	9.58	7.43
	2	8.3	9.40
	Mean	8.94	8.42
Overall mean		9.0450	7.5988
Std. Deviation		1.76519	1.47889

Test statistics t-value =2.407; p-value =0.047 and d.f.=7 @ 95% Conf.In.

**Table 3.** Effect of stone faced soil bund on total soil nitrogen (tot N) status.

Sub-watersheds	Sample	Total Nitrogen (%)	
		Treated	Untreated
Upper stream of Wege Alba watershed	1	0.050	0.027
	2	0.047	0.040
	Mean	0.048	0.034
Lower stream of Wege Alba watershed	1	0.064	0.020
	2	0.070	0.054
	Mean	0.067	0.037
Upper stream of Tikur wuha watershed	1	0.087	0.034
	2	0.086	0.003
	Mean	0.0865	0.018
Lower stream of Tikur wuha watershed	1	0.084	0.034
	2	0.085	0.031
	Mean	0.0845	0.031
Overall mean		0.072	0.033
Std. Deviation		0.016	0.010

Test statistics t-value =5.73; p-value =0.001 and d.f.=7 @ 95% Conf.In.

that of the carbon content.

The soil nitrogen in both treated and non-treated plots along slop gradient is low in upper stream compared to lower stream of selected watersheds. The reason is that lower zones are deposition zones and upper streams area consists of most of the time soil loss zones in which, nitrogen is the most readily lost because of its high solubility in the nitrate form.

**Available phosphorus (P):** Table 4 shows that mean value of available phosphorus (mg/kg) on treated plot with stone faced soil bund is 3.65 which is significantly higher than non-treated plots with mean value of 1.78. A statistical paired samples t-test showed that, mean of available phosphorus (mg/kg) is significantly difference [ $t = -3.13$ ;  $p = 0.017$ ] between treated and non-treated plots. It is in agreement that phosphorous (P) in the studied

**Table 4.** Effect of stone faced soil bund on available phosphorus (mg/kg).

Sub-watersheds	Sample	Available phosphorus (mg/ Kg)	
		Treated	Untreated
Upper stream of Wege Alba watershed	1	3.86	2.06
	2	0.96	0.86
	Mean	2.41	1.46
Lower stream of Wege Alba watershed	1	5.16	5.66
	2	3.8	2.44
	Mean	4.48	4.05
Upper stream of Tikur wuha watershed	1	3.22	0.7
	2	5.12	0.02
	Mean	4.17	0.36
Lower stream of Tikur wuha watershed	1	3.52	1.12
	2	3.6	1.4
	Mean	3.56	1.26
Overall mean		3.6550	1.7825
Std. Deviation		1.3064	1.74269

Test statistics t-value =3.13; p-value =0.017 and d.f.=7 @ 95% Conf.In.

micro-watersheds were found to be significantly different between the conserved and non-conserved plots. It is also reported that available phosphorus is much higher in the conserved one (Mulugeta and Stahr, 2010). When we compare mean of available phosphorus (mg/kg) in both treated and non-treated plots along slop gradient, it is low in upper stream compared to lower stream of selected watersheds. The reason is that lower zones are deposition zones, and upper streams most of the time loss soil zones corresponding high erosion rate in soil particles.

**Exchangeable potassium (K):** Table 5 shows that, the mean of exchangeable potassium from conserved plots with stone faced soil bund is 0.28 which is significantly higher than non-conserved farmlands with mean value of 0.26. A statistical paired samples t-test showed that, mean of exchangeable potassium (*cmol (+)/ kg*) is not significantly difference ( $t =1.03$ ;  $p =0.34$ ) between treated and non-treated plots. This study is in agreement with that of Wadera Lemma (2013) that, showed that adoption of SWC practices enhances the available soil potassium. It is reported that, plants deficient in potassium are unable to utilize nitrogen and water efficiently, and are more susceptible to disease (Shober, 2013). The mean of exchangeable Potassium (*cmol(+)/ kg*) along slop gradient is low in upper stream compared to lower stream of selected watersheds. The reason is that lower zones are deposition zones, and upper streams most of the time loss soil zones corresponding high erosion rate in soil particles in which, potassium is tightly held by soil particles, and so can be removed from fields by erosion.

**Cation exchange capacity (CEC):** The cation exchange capacity (CEC) is a measure of the number of adsorption sites per unit weight of soil at a particular pH. CEC (*cmol (+)/kg*) is affected quite dramatically by pH changes. Soils with high in organic matter have a high CEC. In contrast, soils dominated by kaolinite and hydrous oxide clays generally have a low CEC (Mulugeta and Stahr, 2010).

Table 6 presents that, treated plots with stone faced soil bund with mean value of 24.4 has significantly higher CEC than non-treated plots with mean value of 19.7. A statistical paired samples t-test showed that, mean of CEC is significantly difference ( $t =2.807$ ;  $p =0.026$ ) between treated and non-treated plots. It is in agreement with Million Alemayehu (2003) that, terraced area with original slope of 25 and 35% had higher mean CEC value than that of the corresponding non-terraced slopes by 6 and 49%, respectively.

The mean of CEC along slop gradient in both treated and non-treated plots, is low in upper stream compared to lower stream of selected watersheds. The reason is that CEC content positively correlates with organic matter content, and soil organic carbon. The CEC of a soil can be reduced by soil erosion through the loss of soil organic matter, and clay particles (Brady and Weil, 2002).

**Effect of stone faced soil bund on soil moisture status:** Table 7 presents that, mean value of soil moisture (%) on treated plots with stone faced soil bund is 33.5% which is significantly higher than non-treated plots with mean value of 25.6%. A statistical paired samples t-test showed that, mean of available soil moisture (%) is significantly difference ( $t =4.6$ ;  $p =0.002$ ).

**Table 5.** Effect of stone faced soil bund on exchangeable potassium.

Sub-Watersheds	Sample	Exchangeable potassium (cmol (+)/ kg)	
		Treated	Non-treated
Upper stream of Wege Alba watershed	1	0.28	0.31
	2	0.24	0.23
	Mean	0.26	0.27
Lower stream of Wege Alba watershed	1	0.29	0.25
	2	0.26	0.21
	Mean	0.28	0.23
Upper stream of Tikur wuha watershed	1	0.31	0.33
	2	0.21	0.28
	Mean	0.26	0.31
Lower stream of Tikur wuha watershed	1	0.38	0.29
	2	0.30	0.19
	Mean	0.34	0.23
Overall mean		0.28	0.26
Std. D		0.051	0.049

Test statistics t-value =1.033; p-value =0.34 and d.f.=7 @ 95% Conf.In.

**Table 6.** Effect of stone faced soil bund on cation exchange capacity (CEC).

Sub-Watersheds	Sample	CEC (cmol (+)/ kg)	
		Treated	Non-treated
Upper stream of Wege Alba watershed	1	21.13	20.68
	2	30.54	25.06
	Mean	25.84	22.87
Lower stream of Wege Alba watershed	1	19.60	15.87
	2	39.57	24.89
	Mean	29.59	20.38
Upper stream of Tikur wuha watershed	1	20.03	18.10
	2	21.08	13.74
	Mean	20.56	15.92
Lower stream of Tikur wuha watershed	1	22.78	19.45
	2	21.28	20.33
	Mean	22.03	19.89
Overall mean		24.4975	19.7638
Std. D		7.00055	3.96197

Test statistics t-value =2.807; p-value =0.026 and d.f.=7 @ 95% Conf.In.

between treated and non-treated plots. Joyce and Musiwa (1999) confirmed that SWC practices reduce the risks of total crop failure in drought years through enhancing soil moisture. Sutcliffe (1993) indicated that SWC practices are justifiable in moisture stressed areas

of Ethiopian highlands, where moisture conservation plays an important role in increasing yield. The mean of available soil moisture (%) in both treated and non-treated plots along slope gradient is low in upper stream compared to lower stream of selected watersheds. The

**Table 7.** Effect of stone faced soil bund on soil moisture status.

Sub-Watersheds	Sample	Available soil moisture (%)	
		Treated	Non-treated
Upper stream of Wege Alba watershed	1	34.84	22.05
	2	35.05	26.9
	Mean	34.95	24.48
Lower stream of Wege Alba watershed	1	38.17	26.7
	2	30.75	34.78
	Mean	34.46	30.74
Upper stream of Tikur wuha watershed	1	30.80	23.94
	2	32.39	21.69
	Mean	31.6	22.82
Lower stream of Tikur wuha watershed	1	35.04	23.62
	2	31.43	25.21
	Mean	32.24	24.42
Over all mean		33.5588	25.6113
Std. D		2.63819	4.17287

Test statistics t-value =4.611; p-value =0.002 and d.f.=7 @ 95% Conf.In.

reason is that lower zones are deposition zones corresponding with reduction in run-off velocity results in high levels of percolation and infiltration rate.

## Conclusion

The study showed that stone faced soil bund play a considerable role in enhancing soil nutrient and moisture status. Effect of stone faced soil bund on soil macronutrients, organic carbon content, soil pH, cation exchange capacity (CEC), and moisture status; as well as challenges to fully implement SWC practices were examined. A statistical paired samples t-test showed that, mean value of total nitrogen, available phosphorus, available potassium, organic carbon content, soil pH, cation exchange capacity (CEC), and moisture status were significantly difference (at t and p-value) between farm land with stone faced soil bund and non-conserved farmlands. That is why SWC practices are essential to enhance available soil nutrients by reducing runoff and soil erosion, helps keep nutrients on the field, and improves available soil moisture through storing water, and then increasing infiltration and percolation rates.

## RECOMMENDATIONS

Soil fertility decline and moisture stress were a significant crop production constraints in the Woreda. Thus, this study determined that stone faced soil bund improve soil characteristics including soil macronutrients (N, P, and

K), organic carbon content, soil pH, cation exchange capacity (CEC), and moisture status. Above all, to solve soil nutrient depletion and moisture stress in Guba-Lafto Woreda, the following key recommendations should be taken in to account.

- (1) The first recommendation is that, farmers need to be encouraged to implement SWC measures through the use of the productive safety net and Food-for Work payments.
- (2) Construction of SWC practices should be followed up by other inputs (for example, organic fertilizer application).
- (3) We should increase fallowing period, prevent cropland encroachment onto communal grazing areas, and control overstocking of dairy cows and oxen as it leads to overgrazing and further soil depletion.
- (4) Finally, federal and local governments should support and encourage further studies in the Woreda to improve soil fertility, and to solve subsistence crop production problems, hence leads to increasing of production and productivity of farmlands.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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