JOURNAL OF AGRICULTURAL INFORMATICS

AGRÁRINFORMATIKA FOLYÓIRAT

Publisher
Hungarian Association of Agricultural Informatics (HAAI)

The publishing of the Journal is supported by the European Federation for Information Technology in Agriculture, Food and the Environment (EFITA)

2020.
Vol 11, No. 2

ISSN 2061-862X

http://journal.magisz.org

The creation of the journal has supported by the New Hungary Development

TÁMOP 4.2.3-08/1-2009-0004

"Dissemination of research result on innovative information technologies in agriculture"

The project is financed by the European Union, with the co-financing of the European Social Fund.

Journal of Agricultural Informatics

Scientific Journal

Name: Agricultural Informatics

Language: English

Issues: 2-4 per year

Publisher: Hungarian Association of Agricultural Informatics (HAAI), H-4032 Debrecen, Böszörményi út. 138. Hungary

ISSN 2061-862X

PREFACE

Information technology is an everyday means that is found in all walks of life today. This is also true for almost all areas of agricultural management. The aim of this Journal is to improve scientific knowledge dissemination and innovation process in the agri-food sector. The Journal of Agricultural Informatics has been established in 2009 by the HAAI within a project of the Hungarian National Development Plan Framework. The peer-reviewed journal is operating with international editorial and advisory board supported by the EFITA (European Federation for Information Technology in Agriculture Food and the Environment).

Agricultural informatics serves not only the development of the management systems of the industry but also obtaining and publicising information on production, organisation and the market for the producer.

Technologies into network based business systems built on co-operation will ensure up-to-date production and supply in food-industry. The sector-level approach and the traceability of processed agricultural products both require the application of up-to-date information technology by actors of domestic and international markets alike.

This journal serves the publication as well as familiarization the results and findings of research, development and application in the field of agricultural informatics to a wide public. It also wishes to provide a forum to the results of the doctoral (Ph.D) theses prepared in the field of agricultural informatics. Opportunities for information technology are forever increasing, they are also becoming more and more complex and their up-to-date knowledge and utilisation mean a serious competitive advantage.

These are some of the most important reasons for bringing this journal to life. The journal "Agricultural Informatics" wishes to enhance knowledge in the field of informatics, to familiarise its readers with the advantages of using the Internet and also to set up a forum for the introduction of their application and improvement.

The editorial board of the journal consists of professionals engaged in dealing with informatics in higher education, economists and staff from agricultural research institutions, who can only hope that there will be a demand for submitting contributions to this journal and at the same time there will also be interest shown toward its publications.

Prof. Dr. Miklós Herdon

Chair of the Editorial Board

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Hungarian Association of Agricultural Informatics
European Federation for Information Technology in Agriculture, Food and the Environment

Journal of Agricultural Informatics. Vol. 11, No. 2.
journal.magisz.org

Application of e-information for Fall Armyworm control among maize farmers in Southwestern Nigeria

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INFO
Received 19.04.2020
Accepted: 23.07.2020
Available on-line 09.02.2021
Responsible Editor:
L.Varallyai

Keywords:
Suitability, Electronic message, Fall armyworm control, Agricultural pest

A B S T R A C T

This study assessed the application of electronic messages on Fall Armyworm (FAW) (*Spodoptera frugiperda*) disseminated to farmers in Southwestern Nigeria. Multi-stage sampling method was used to select 205 maize farmers. Using ex-post factor research design, electronic information on FAW were broadcast to farmers through formats such as voice calls and text messages. Each of the respondents received five batches of voice calls and text messages in English and Yoruba Languages for 2 – 3 weeks. Data were collected on the suitability of e-message, perception and constraints to electronic information use. Data collected were described and analyzed using Pearson Product Moment Correlation (PPMC) and linear regression at $\alpha_{0.05}$. Mean age of respondents was 40years and 69.3% could communicate in Yoruba while only 39.9% understood the English language. Majority of the farmers expressed unfavourable perception to the use of e-messages for FAW information. Constraints identified with e-message use were related to the poor interactivity of the medium, though suitable for 55.6% of the respondents. Level of education and perception were major determinants of the suitability of e-messages disseminated. Thus, dissemination of e-messages to farmers using local languages was advocated in agricultural interventions.

1. Introduction

Insect pests are a major menace to crop production worldwide. The outbreak of *Spodoptera frugiperda* Fall Armyworm (FAW) in the year 2016 has come with a major militating threat to maize production in Nigeria. Hectares of farmland have been destroyed by this occasional but destructive insect pest. The activity of this pest is insidious and its presence is noticed only after the havoc is done (Georgen *et al*, 2016). The pest has become a major problem for agricultural production in several nations of the world (Assefa and Ayalew, 2019). Although the level of severity of damage varies from one location to the other, the damage is a major threat to food security as it has destroyed maize farms worth millions of Naira.

Maize is a major cereal and one of the important staple crops grown by farmers in Nigeria. It is a major determinant of what constitutes household diet across all economic status in the country (Urassa, 2015). Thus, continuous attack of FAW on maize crops can be seen as a threat to national food security. The intensive control effort is therefore essential to ensuring maximum production of maize and attaining desired food security. Several concerted efforts such as the application of pesticides to control a similar pest that was successfully used for other types of pest control have been employed for FAW but proved abortive (Food and Agriculture Organisation of the United States (FAO) (2018)). This indicates that the pervasiveness of FAW can withstand the common control methods of pesticides and this has led farmers into a deeper confusion on how to control it. Some farmers and stakeholders have concluded that the pest is here to stay because of the strategic ways of the attack on tropical environments (Adesina, 2017). Different pest control methods such as cultural, biological, botanical and chemical measures have been proved effective by researchers and agricultural institutions. The careful combination of these control

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methods is called Integrated Pest Management system (IPM) which targets to reduce to the barest minimum, the heavy applications of agrochemicals on crops. Pest management is an essential component of any effort to increase food production and ensure food security (Alabi *et al*., 2006). Malene (2017) affirms that increasing food production requires concerted efforts at supporting smallholders and family farmers to reduce pesticides and chemical use. Thus, understanding pest management should be an essential aspect of information dissemination aiming at increasing food production (Alabi, Banwo and Alabi, 2006). IPM is an effective and environmentally sensitive approach to pest management. It is safer because it places less importance on the use of heavy chemicals and emphasizes orthodox methods along with the chemicals to ensure sustainable production of healthy crops (Aktar *et al*., 2009). IPM system aims at increasing food production and maximize farmers' income. It is not sufficient to identify these control methods alone without introducing it to the farmers. According to Toepfer et al and Adesina (2017), what is needed rapidly to address the real threat of Fall Armyworm (FAW) in Africa and bring support to farmers is a very urgent action which includes creating awareness using different methods.

Several steps have been taken to create awareness among farmers on related issues in the past. Such steps include the use of available communication channels through extension strategies. The information dissemination strategies embarked upon by the Nigeria agricultural agencies like the Agricultural Development Programme (ADP) right from inception were very adequate and effective until the last few years of neglect of the agricultural sector for the oil sector (Ogbalubi and Wokocha, 2013). This neglect had resulted in a retrogressing movement in the agricultural sector. Ani *et al* (2018) likewise posited that the agricultural sector in Nigeria has been performing poorly in recent years even though it remains the mainstay of the economy. Apart from the ADPs, the extension agencies like Agricultural Extension Research Liaison Services (AERLS) established purposely for extension services and extension service unit of every agricultural research institute are mandated with the responsibility of reaching out to farmers in their jurisdiction with information that is most relevant for agricultural development.

There are so many factors constraining ADPs and other extension providers from filling this gap accurately. One of such was mentioned by Haruna and Abdullahi (2013) as inadequate staff, noting that the ratio of extension worker to farm families was between 1:2000 and 1:3000 as at the year 2012 which has further worsened recently. The situation could have been fueled by the paucity of fund to agricultural extension services by the government or expected funding agencies. Farmers' inability to convert research outcomes into practices on the field can thus be explained. However, deploying modern means of information dissemination will go a long way in bridging this gap (Anunobi and Anunobi, 2018).

Use of mobile smartphones or other mobile communication devices by farmers to access information has given improvements in social relationships. Chhachhar and Hasan (2013) reiterate the importance of mobile phone use in bridging communication gaps, for increasing social cohesion and improving social relationships among farmers. Since pest control information is among some very important information that is needed by farmers (Mbagwu *et al*., 2018), access to timely and relevant information for FAW control through the use of mobile phones will contribute significantly to food production and aid agricultural development in Nigeria. This paper thus evaluates the suitability of mobile phone use for e-alert messages and recorded voice calls to farmers in Ogun and Oyo States.

Objectives of the study

This study focused on determining the suitability of FAW e-messages through mobile phones to local farmers. Electronic information use for agricultural messages is a relative discovery. However, the use becomes very important considering the urgency attached to some agricultural information and increased knowledge in mobile phone use. The FAW infestation in maize farms can be devastating leaving most farmers confused about its appropriate control method. Specifically, the objectives of the study include:

1. Examine the personal characteristics of maize farmers in the study area,

2. Determine the perception of farmers to e-messages on FAW,
3. Determine the suitability of e-messages to maize farmers; and
4. Identify constraints in accessing e-message information through mobile phones.

The study hypothesized the inter-relationship between the suitability, constraints and the perception to e-message use by local farmers.

2. Methodology

The study was carried out in Ogun and Oyo States located in South-West Nigeria. The states constitute 30% of the total states in the region. Ogun State is between 7^0 00N and $3^0$35E. Oyo State is located between $8^0$00 N $4^0$00 E. Yoruba language is mostly spoken and understood by people in the states. The multi-stage sampling procedure was used for the study. The first stage involved the random selection of 30% of the six states in South-West Nigeria giving Oyo and Ogun States. In the second stage, a random selection of 10% of the Local Government Areas (LGAs) in the states was carried out, thus, four out of the 33 LGAs in Oyo State and two out of the 20 LGAs in Ogun State were selected. The LGAs sampled are Oriire, Kajola, Saki West, Ido (Oyo State); Ado Odo and Abeokuta (Ogun State). The third stage involved the purposive selection of two communities from each of the selected LGAs with more maize farmers registered under the Maize Improvement Programme of the Institute of Agricultural Research and Training. A total population size of 457 maize farmers was registered under the programme across the twelve purposively sampled communities in Oyo and Ogun states. From the list of the registered farmers, 205 farmers were sampled for this study using a simple random sampling technique. The Krejcie and Morgan (1970) table was used to determine the adequate sample size for the study.

The ex-post facto research design was used for the study. Electronic information on Fall Armyworm was broadcast to farmers through e-formats such as voice calls and text messages. Each of the respondents received five batches of voice calls and text messages in English and Yoruba Languages for 2 – 3 weeks. The intervention was implemented a few weeks after most farmers have planted their maize to coincide with the time the FAW pest is usually noticed in maize farms. The messages detailed the aetiology and different control measures of FAW infestation, emphasizing Integrated Pest Management control measures. This provided the basis employed to assess how suitable the methods were. Each of the respondents received one voice call and two messages in Yoruba and English Languages daily through their mobile phones for three weeks. The same set of farmers were interviewed 2 weeks after the last batch of messages were delivered to gauge the perception of the methods used. The farmers were interviewed on their perception of the medium utilized, major constraints to receiving messages from each medium and how suitable they perceived the medium for receiving FAW pest control messages.

Primary data collection with the use of the interview schedule was employed for the study. The interview schedule elicited information on the respondents' characteristics, perception of the e-messages broadcast, perceived suitability of the e-message for maize FAW pest management and constraints identified in its use. Suitability of the medium used was measured by listing fourteen statements peculiar to the medium used for the message broadcast and responses were obtained on a 4-point scale of very suitable, suitable, not suitable and undecided. Scores of 4, 3, 2 and 1 were awarded to the response options, respectively. Statements were ranked by their mean score to show which application is more suitable and which is not suitable for farmers. Scores of 4, 3, 2 and 1 were awarded to positive responses on the perception scale while the reverse was awarded to negative statements. Scores obtained were pooled and used to categorize the respondents into the favourable and unfavourable perception of the medium utilized using the mean score as a benchmark.

Data were summarized and described using means and percentages while Pearson Product Moment Correlation (PPMC) and linear regression analysis were used to determine the relationship between the independent variables and the suitability of the medium by farmers for FAW use.

3. Results and discussion

3.1 Personal characteristics

The mean age of the respondents as shown in Table 1 is 40 ± 8.6 years. A sizeable proportion (75.6%) were male with an average household size of 6 ± 2.3 persons. Only 10.2% of the respondents had no formal education. The majority (63.9%) could communicate in Yoruba and 39.9% could read and write in the English language. This results further confirms the dominance of male over female in farm agricultural activities. It disagrees with the general opinion that the active participators of agricultural sectors are old farmers. However, this result shows that most of the people that engage in maize farming could neither express their opinion nor decode agricultural information disseminated in the English language. This result implies that the version of Fall Armyworm information disseminated through e-messages expressed in the English language could not be well understood by the majority of the recipients. Although formal information is more appreciated in the English language in Nigeria, Popoola, (2014) explains the importance of the local language in defining peoples' reality. In line with this, FAW information disseminated and expressed in the Yoruba language could have made more meaning and impact than the English language version.

Table 1. Personal characteristics of respondents

Variables	Frequencies (percentages)	Variables	Frequencies (percentage)
Age	Mean - 40 ± 8.6	Household size	Mean-6 ± 2.3
≤ 30	30 (14.6)	1-4	72 (35.1)
31 – 40	93 (45.4)	5-8	108 (52.7)
41 – 50	65 (31.7)	9 – 12	23 (11.2)
51 -60	14 (6.8)	12 and above	2 (1.0)
≥ 61	3 (1.5)	Ability to read and understand Yoruba	
Sex		Yes	131 (63.9)
Female	50 (24.4)	No	74 (36.1)
Male	155 (75.6)	Ability to read and understand English	
Educational level		Yes	81 (39.5)
No formal education	21 (10.2)	No	124 (60.5)
Primary Education	62 (30.2)		
Secondary Education	64(31.2)		
Post-Secondary education	58(28.3)		

3.2 Perception of farmers to e-message use on FAW information dissemination

Farmers' perception of the voice calls and text messages disseminated in both Yoruba and English languages as expressed in short statements are shown in Figure 1. The figure shows that farmers favourably perceived that recorded voice calls ($\bar{x}$=4.2) and e-text messages ($\bar{x}$=4.0) used in the dissemination project is an advancement in technology that should be embraced by all farmers. The figure further shows that not all farmers agreed that literal ability is a major factor in decoding the information disseminated through voice calls and e-text messages. Statements such as "text messages cannot be useful because it is not all farmers that can read" ($\bar{x}$=2.2) and that "voice calls do not need any literal ability which makes it the best for farmers" ($\bar{x}$= 4.0), were both expressed in positive and negative words to ascertain the relevance of the e-messages to non-literate farmers. On the other hand, statements expressing agricultural e-text message as a form of unwanted messages shows transferred displeasure of experiences with mobile network providers. This could pose a threat to the effectiveness of text message use for agricultural information.

The categorization of respondents based on the expression of perception to e-alert use for FAW messages in Figure 2 gives a mean perception of $\bar{x}$=38.10. A little above average (54.0%) of the respondents had perception scores below the meanwhile only 46.0% had scores above the mean. This result suggests that almost half of the respondent had the unfavourable perception of the use of e-alert messages for Fall Armyworm information dissemination. Electronic message dissemination is an advancement in farmers' use of ICTs (Zahedi and Zahedi, 2017). This is because, over the years, farmers' use of modern communication for agricultural information has been limited to the traditional ICTs which include the radio, television and probably phone calls. Thus, baseline understanding of communication used for agricultural information in the past could have dissuaded most of the farmers from accepting electronic information as most suitable for control of FAW.

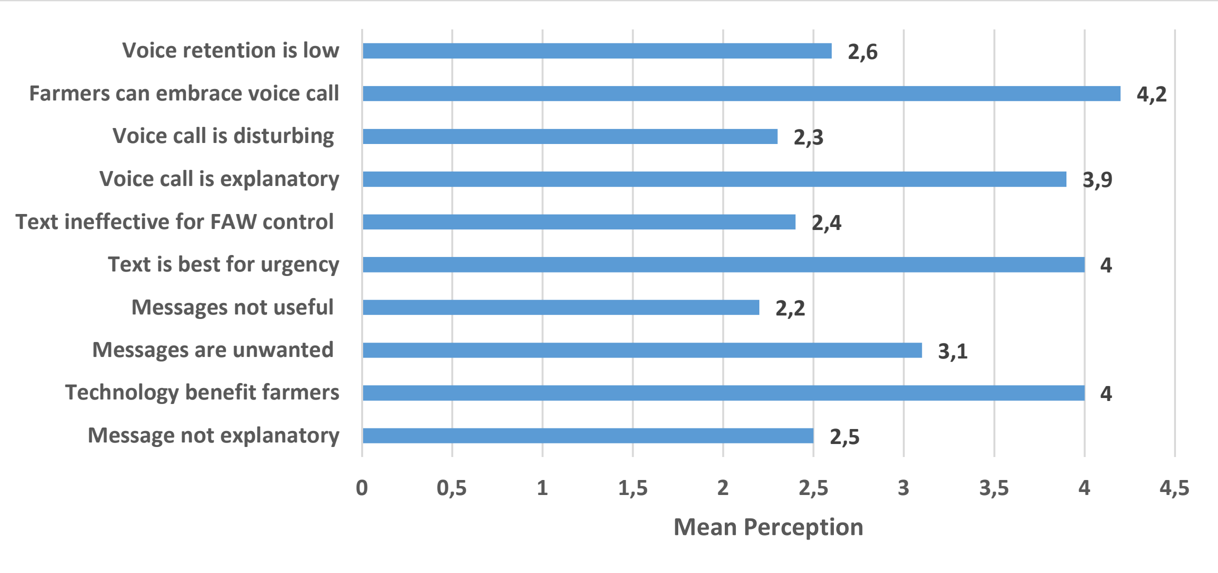

Figure 1. Farmer's perception of e-message use for FAW information dissemination

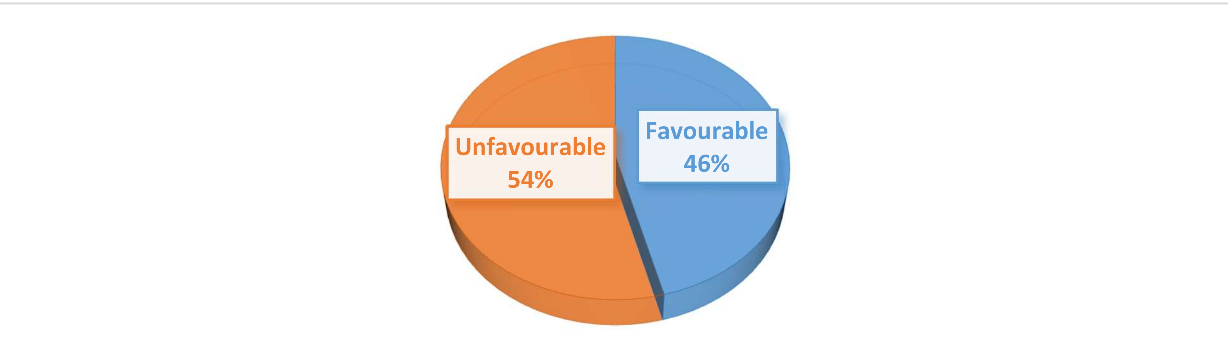

Figure 2. Farmers level of perception of e-message use for FAW information dissemination

3.3 Constraints associated with E-Alert use among farmers in South-West Nigeria

Table 2 shows the constraints identified by respondents. The constraints are grouped accordingly under the two methods used for the dissemination. The first three ranked constraints: "no room for conversation in voice call thereby making it a one-way communication", "inability to retain the message for use after the call" and "the fear of picking calls from an unknown number" having mean scores of

2.81, 2.78 and 2.78, respectively, are under the recorded voice calls. The least constraint for the voice call related to the time wasted in picking the call ($\bar{x}$ = 2.01). The identified highly ranked constraint shows indications of the need for interaction either with the message or disseminator. It can also be inferred from the result that farmers need better opportunity to interact with the source of the FAW information probably to express the grief of loss caused by the pest, or to ask further questions about the pest. This indicates that poor interactivity of the voice calls was a challenge to receiving information using the method. This result implies that the impact expected with the use of recorded voice calls for FAW information dissemination is limited by poor interactivity of the method. On the other hand, the highest constraint associated with the use of e-alert (text messages) was the poor literacy challenge of the respondents ($\bar{x}$=2.71) which was closely followed by the inability of the text message to contain all the FAW information required ($\bar{x}$=2.58). The least constraint associated with the use of text is the inability of farmers phone to receive the message ($\bar{x}$= 2.11). Corroborating this finding, Etwire *et al* (2017) found that text messages are sometimes not self-explanatory or elaborate; hence, farmers, especially, those not literate are unable to process and use the information provided. Also, Ogbeide and Ele (2015) posited that the use of text messages is impacted by the level of literacy and specific knowledge of the technology. The less dissatisfaction expressed for the timing of the call implies the high relevance of the FAW information at the beginning of the maize planting season.

In overall, only 49.3% of the respondents expressed severe constraints in the use of mobile phones for e-alert messages. This implies that at least, an average number of the farmers received and understood the voice call and also received, read and understood the message sent on Fall Armyworm.

Table 2. Distribution of respondents based on their expression of constraints to e-alert message use for FAW information

S/NO	Constraints		Mean	Rank
	Voice calls			
1.		Fear of picking calls from an unknown number	2.78	2
2.		It's a waste of time	2.01	13
3.		It's a one-way information process.	2.81	1
4.		The expression is unclear	2.37	11
5.		The calls always come during busy hours	2.45	9
6.		Lack of trust in the message	2.50	7
7.		Inability to retain the message for use after the call	2.78	2
8.		It contains too many terminologies and careless words	2.51	6
	Text			
9.		The message is too short	2.48	8
10.		Non-literate challenge	2.71	4
11.		Application is not fit for my phone	2.41	10
12.		FAW information not complete in a text	2.58	5
13.		My phone application cannot receive such a message.	2.11	12

Category	***Scores***	***Frequencies***	***Percentages***
Less constraints	15.0 – 35.0	104	50.7
More Constraints	35.1 – 52.0	101	49.3

$\bar{x}$**= 35.1±8.3**

3.4 Suitability of E-Messages Use to maize farmers

Table 3 shows the distribution of maize farmers according to the suitability of the electronic methods used for the dissemination of Fall Armyworm information. The relevance of the message to maize production was very satisfactory to 48.3% of the respondents and length of the text message was suitable for 49.3% while the English version of the voice call, receiving calls from an unknown number and inability to retain the message in recorded voice call was not suitable for 41.1%, 40.5% and 38.0% of the respondents, respectively. This result suggests that the use of recorded voice call for the agricultural message was not suitable to most of the respondents, unlike text message. The result implies that despite the relevance of the Fall Armyworm message to the farmers, disseminating the information in the English language made the whole process not suitable to some farmers. A higher percentage of the recipient, who was satisfied with most features in recorded voice call is expected. This is because the method of dissemination is relatively newer than the text message method and thus still begging for wide acceptability. The non-suitability of English language used for the voice call might not imply an inability to understand English but may indicate non-acceptance of the language for disseminating the important agricultural message to farmers.

Categorization of respondents on how suitable the e-messages were to them shows that 55.6% of the respondents found the method as very suitable for use for agricultural messages. Based on the result, about an average of maize farmers would accept e-messages in subsequent information dissemination. According to Mbagwu *et al*. (2018), farmers desire more use of information communication tools because it helps to provide timely agricultural information needed for better farm productivity. Emphasizing the level of acceptability of mobile phone applications among rural dwellers, Uduji et al, (2018) found that mobile phones in Africa have evolved from simple communication tools to service delivery platforms. In line with these findings, the advancement in the features of mobile phones which makes it relevant to provide important agricultural messages would have spurred the indication of its suitability for use among farmers.

Table 3. Suitability of e-message use by maize farmers

Statements	Very suitable	Suitable	Undecided	Not Suitable
Length of message for each text	43(21.0)	101(49.3)	39(19.0)	22(10.7)
Speed of the text	56(27.3)	90(43.9)	44(21.5)	15(7.3)
Language used for dissemination	53(25.9)	98(47.8)	33(16.1)	21(10.2)
Inability to see the disseminator	35(17.1)	52(25.4)	54(26.3)	64(31.2)
Message				
The relevance of the message	99(48.3)	68(33.2)	28(13.7)	10(4.9)
The simplicity of expression for understanding	53(25.9)	89(43.4)	51(24.9)	12(5.9)
Time of dissemination	73(35.6)	68(33.2)	50(24.4)	14(6.8)
Presenting the information in bits	56(27.3)	67(32.7)	47(22.9)	35(17.1)
Voice call				
Calling with an unknown number	35(17.1)	59(28.8)	28(13.7)	83(40.5)
English version of the message	48(23.4)	49(23.9)	23(11.2)	85(41.5)
Yoruba version of the message	88(42.9)	71(34.6)	24(11.7)	22(10.7)
Voice used for the call	54(26.3)	95(46.3)	30(14.6)	26(12.7)
Inability to retain the call message	35(17.1)	61(29.8)	31(15.1)	78(38.0)
Time of call	49(23.9)	45(22.0)	51(24.9)	60(29.3)
Suitability level using mean score	***Scores***	***F***	***%***	
Not suitable	16.0 – 37. 89	91	44.4	
Suitable	37.90 – 56.0	114	55.6	

$\bar{x}$ **= 37.9±7.6**

3.5 Hypothesis: There is inter-relationship between constraints, perceptions expressed and suitability of e-messages among maize farmers

Table 4 shows the result of the bivariate correlation between constraints, perception to e-message use in mobile phone and suitability of the process to farmers. Perception of farmers to e-message use was significantly related to the suitability of use at 1% although negatively correlated. This implies that the stronger the farmer's perception, the lower the suitability expressed. The relationship between constraints and suitability was not significant. The constraints encountered were not strong enough to deter farmers from future use of e-message for agricultural information. However, the negative correlation between farmers' perception of e-message use and suitability of the method indicate that lower suitability was associated with favourable perception. This could be related to dissatisfaction with the functionalities of individual phones which was an intervening variable in the study. Ryan and Ascigil (2001) report that perception improves with the knowledge thus, repeated use of e-message for FAW control could have a low impact as perception becomes more favourable. The findings could also imply the need for a more sophisticated mobile phone that can allow for message processing in subsequent dissemination effort.

Table 4. Relationship between constraints, perception and suitability to e-message by maize farmers

Variable	r-value	p-value	
Perception	-0.33	0.00	Significant @ 0.01 level
Constraints	-0.08	0.29	Not significant

3.6 Determinants of Suitability of e –Messages among maize farmers

Table 5 shows the variables that determined the level of suitability of e-messages to farmers use. The table shows that out of the nine variables that directly correlate with suitability, only educational level ($\beta = 0.22$; sig < 0.05) and perception ($\beta = -0.31$; sig < 0.05) were best determinants of the suitability of e-message dissemination through mobile phone to farmers. It further shows that all the variables regressed on suitability gave a coefficient of the determinant (R^2) of 0.55, indicating that all the variables influenced suitability up to 55.0% of the chances available. Likewise, the perception of e-alert message use for information dissemination by farmers had a higher (31.0%) magnitude of influence than farmers' level of education (22.0%). This result affirms the importance of education in accessing electronic information among farmers (Aldosari et al, 2019). The implication of this finding is critical. Khapayi and Celliers (2019) reported that low educational level is among the key factors that challenge farmers from adopting innovations and expansion. In line with this finding, the continuous use of e-message for maize farmers sensitisation and information dissemination might lower the quick response expected in the control of FAW. On the other hand, the result emphasized the need for positive perception towards e-message use in mobile phones. Perception plays a strong role in the decision-making process and it is informed by many factors including culture and education (Ryan and Ascigil, 2001). It also contributes a lot to the success or failure achieved in the adoption of any intervention. The intervention using e-messages is relatively new among farmers in Nigeria, thus, an unfavourable perception might not be too far from expectation (Ryan and Ascigil, 2001). This situation is expected to improve after several subsequent uses.

Table 5. Contributions of variables to the level of suitability of e-message for FAW control

Variables	Beta	T	sig
Age	0.005	-0.062	0.95
Sex	0.018	0.255	0.79
Major source of income	0.59	0.766	0.44
Educational level	0.22	2.887	0.004*
Ability to read and write English	0.13	1.90	0.06
Ability to read and write Yoruba	0.07	1.06	0.29
Household size	0.03	0.32	0.74
Perception	-0.31	4.23	0.00*
Constrains	0.02	0.31	0.75
Variables	Beta	T	sig
Age	0.005	-0.062	0.95
Sex	0.018	0.255	0.79

R=0.39(a), R^2 = 0.55; adjusted R^2 = 0.31; standard error = 7.16: *significant @ 5%

4. Conclusion and Recommendations

The use of e-messages in mobile phone for FAW information was suitable for most maize farmers. Receptivity and use of e-messages in voice call attracted more constraints than in text messages. Level of literacy was a major challenge to using text message information. Most farmers were not favourably persuaded to use e-messages for agricultural information because of their previous experiences of disturbances associated with such use by mobile communication service providers. The correlation between maize farmers perception to e-message use and suitability of its use was significant. The study concludes that the applicability of e-messages for FAW information was dependent on the level of education and the perception expressed by the recipients. Thus, the study recommends that:

- E-alert messages are employed by agricultural institutions and development agencies to disseminate agricultural information to farmers owing to the urgency and high importance of agricultural information.
- New modalities are introduced into the recorded voice calls to make it more interactive by giving room for feedback from farmers.
- Most maize farmers are not sufficiently skilled in education to transcribe e-information. It is therefore important to complement e-messages with other communication tools such as radio and pictorials for enhanced effectiveness.

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Hungarian Association of Agricultural Informatics
European Federation for Information Technology in Agriculture, Food and the Environment

Journal of Agricultural Informatics. Vol. 11, No. 2
journal.magisz.org

Impacts of Land Cover Changes on Soil Erosion for Agricultural Sustainability in Maragua Sub-Watershed: Case Study in Murang'a County, Kenya.

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I N F O
Received 10.11.2020
Accepted 07.12.2020
Available on-line 09.02.2021
Responsible Editor: L. Varallyai

Keywords:
Watershed, Watershed Management, RUSLE, Soil Erosion, Land Cover Change, Agricultural Sustainability

A B S T R A C T

Soil erosion affects the yield production becoming a major constraint to agriculture and environmental sustainability. In the last decade, Maragua watershed has undergone major environmental changes. This study explicates the detection of land cover change and how this has affected the amount of soil loss. Three epochs each spanning ten years from 1987 all though to 2017 was selected for this study. To prioritize conservation of predisposed areas, climatic conditions and topography factors that accelerate soil erosion were used in the RUSLE model to generate erosion risk maps and change analysis was carried out to show the trend in soil erosion. Land cover classification, was performed and a trend in the change was examined. To achieve the main objective; randomly created point sampled within the study area were used to demonstrate consistent trends in land cover changes that resulted in high erosion areas. The results of this study shows that bare land and cropland land covers were the major causes of increased soil erosion over the period of the study. The spatial and quantitative information on soil erosion this research provides can be used in managing resources and help implement practical approaches for agricultural sustainability.

1. Introduction

Land degradation is the temporary or permanent decline in the productive capacity of the land, and its value as an economic resource. It is a global problem but more specifically in developing countries in Africa with adverse effects on the functionality of the ecosystem (Kieti et al., 2016). In Kenya, the situation is intensified by rapid population growth, high poverty levels, land-use changes, poor land-use systems and deforestation leading to watershed degradation (Wani & Garg, 2009). Chen et al., (2011) indicates that watershed degradation decreases land productivity resulting in major downstream or off-site damage.

When caused by soil erosion and sedimentation, it poses major challenges in food security, water resources, biodiversity and environmental sustainability (Dabral et al., 2008). Sustainable agriculture majorly depends on how efficiently soil and water are utilized. In the quest to meet the rising food demand; land and water need to be conserved in order to maintain or increase crop yields. Although agricultural management, such as improved crop varieties or mineral fertilizer, has increased crop yields erosion rates have increased accordingly (Vanwalleghem et al.,2017). In developing countries with high poverty rates, access to these management practices is limited and as such, the most viable alternative would be to carry out soil management. Chen et al., (2011) maintain that to preserve the ecosystem, watershed management needs to be employed.

Watershed management is the development of appropriate land-use planning and management for rain-fed and irrigated lands to prevent soil erosion, increase biomass production, and improve the ecological balance (Bhuchar et al., 2011). It can be achieved through the implementation of water management and land-use practices (Wani & Garg, 2009).

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Shinde et al. (2010) points out that soil erosion depletes rich fertile soils, reduces reservoir capacity and degrades downstream water quality. In this case, soil conservation can be achieved through controlling erosion and maintaining soil fertility while focusing on the central role the soil resources play in ensuring sustainable agriculture.

To assess an erosion scenario, modelling is a useful tool that enables the adequate selection of erosion control measures. A wide range of models exists for use and the choice of a suitable model structure relies heavily on the scale of their intended use and the types of output information they provide (Merritt et al., 2003).

According to Merrit et al. (2003), depending on the physical processes simulated by the model and the data dependence, the model is classified as either empirical, conceptual or physically based models. Empirical models are the simplest of all models as they can be implemented in situations with limited data and parameter inputs, and are particularly useful as a first step in identifying sources of sediment. Examples of empirical models include the Universal Soil Loss Equation (USLE) and its derivate Revised Universal Soil Loss Equation (RUSLE) and the Modified Universal Soil Loss Equation (MUSLE) (Igwe, Onuigbo, Chinedu, Ezeaku & Muoneke 2017). The spatial and quantitative information of erosion on a sub-watershed scale contributes significantly to the planning for soil conservation, erosion control, and management of the watershed environment (Prasannakumar et al., 2012)..

In Kenya, the Tana Basin is one of the most important natural resource and plays a vital role in the country's economy. It is divided into two distinct ecosystems. The first is the Upper Tana Basin which receives more rainfall articulates as the main source of water (Braslow & Cordingley, 2016). The other is the drier and flatter lower Tana which is completely dependent on the Upper Tana basin.

The basins resources are used to produce hydroelectricity and supply irrigation water to some of the largest public schemes in Kenya. Intensive commercial and subsistence farming together with deforestation has caused the unpredictable flow of water despite the rising water demand (Hunink & Droogers 2015). Sediments and siltation have threatened the ecosystem resulting in reduced water supply, poor water quality, reduced hydropower generation and reduced agricultural yield.

The main causes of poverty within the area has a strong linkage to the environment. Change in environmental conditions has led to reduced agricultural production which supports a majority of the population in the catchment. This has in turn led to reduced incomes and as well as un-certainties in food security. The Upper Tana Natural Resources Management Project (UTaNRMP) was formed to help in conservation measures. It's main objectives, based on the challenges identified, is to increase sustainable food production and incomes for poor rural households living in the upper Tana and the sustainable management of natural resources for provision of environmental services.

In Maragua watershed, the hilly topography, soil disturbance through the removal of vegetation, deforestation on steep slopes and poorly executed terracing has significantly contributed to water controlled erosion and consequently to low agricultural returns. Due to these challenges, there is a need for watershed management to help to conserve the environment. This can only be achieved by monitoring soil erosion and reducing the effect of sediment yield.

The study aims at assessing soil erosion severity and identifying critical areas that need immediate and appropriate conservation measures for sustainable agriculture. The objective of the research is to evaluate how the changes in land cover impacts soil loss.

2. Research Objectives

The main objective of the study is to assess the impact of land cover changes on soil erosion to help in managing manmade and natural resources and assets, plan conservation measures and prioritize the erosion predisposed areas for agricultural sustainability in Maragua watershed, Murang'a County.

The specific objectives are;

- To perform watershed analysis for watershed delineation and stream feature extraction.
- To generate soil erosion risk map and land cover map for the year 1987, 1999, 2007 and 2017.
- Assessment of land cover changes on soil erosion.

3. Area of study

Murang'a County lies within the Upper Tana River Basin, which has three priority sub-watersheds namely Sagana-Gura, Maragua, and Thika-Chania (Water Resources Authority, 2018). Maragua sub-watershed covers an area of approximately 47000 Ha. The altitude ranges from 1191m to 3769m above sea level. Murang’a area has a bimodal rainfall pattern that includes long rains and short rains. The long rains occur between March and June while the short rains occur between October and December with an average annual rainfall of 700mm-1300mm (Muema, Kaluli, Gatheny018). Part of the watershed is covered by coffee plantations, subsistence farms and Aberdare forest. Study area map is in (Figure 1).

4. Materials and Methodology

To fulfil the objectives of the study, the data type, source and characteristics were required. To get the extent of the watershed, elevation data was required, the Shuttle Radar Topographical Mapper (SRTM) 30m digital elevation model was used. Rainfall data was sourced from CHIRPS website for monthly and annual precipitation data from the year 1982 to 2017. SOTER dataset from Food and Agriculture Organization of the United Nations was used to derive erodibility factors for the different soil types within the area. For temporal data on land covers, Landsat satellite imagery was obtained from the United States Geological Survey (USGS) website. The conceptual framework used to perform the study is as shown below (Figure 2):

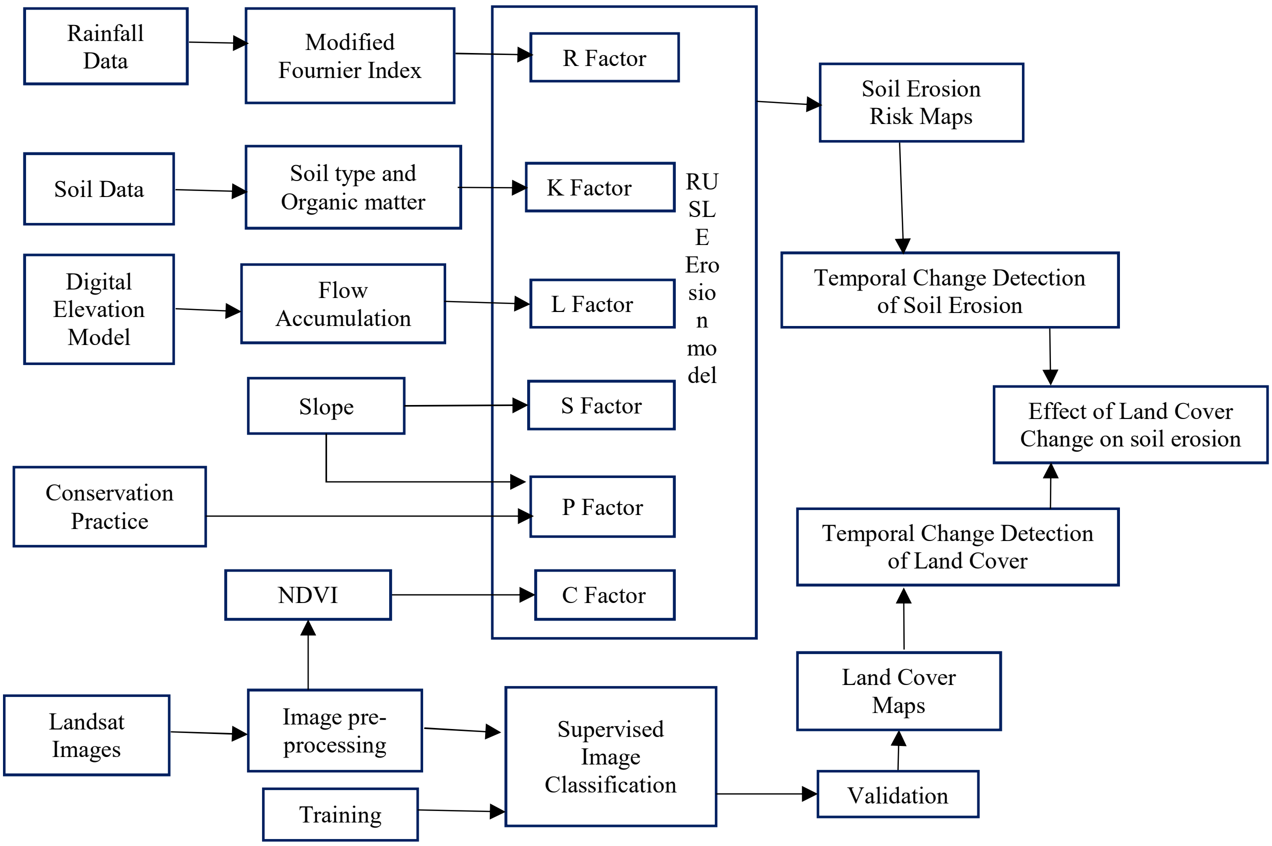

Figure 2: Conceptual Framework

Image Processing

Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) 1 arc-second, with a spatial resolution of 30 meters, were used to get the digital elevation model. The images were mosaicked, projection changed and clipped in ERDAS Imagine. The processed image was then used as an input, in ArcGIS, for watershed analysis to delineate Maragua watershed extent, slope and stream features as inputs for the study. See (Figure 3).

For the study, Landsat Mission images were selected for the period of February and March just before the heavy rains and with a cloud cover of less than 10%. The available images obtained from the USGS explorer for the year 1987 and 1999 was Landsat 5, 2007 was Landsat 7 and for 2017 was Landsat 8.

Image enhancement was carried out for all the images during pre-processing. For Landsat 7, de-stripping was done using the gap fill file available when the image is downloaded. Supervised classification, maximum likelihood classifier was used to classify the images into four major land cover classes. The classes identified were Forest, Crop Land, Bare land and Water. They were identified as being consistent in all the epoch and could be used in comparison during analysis

Accuracy assessment, for the 2017 image, was performed by comparing the classified image to reference data collected from the ground using GPS, 300 point were collected. As there was no ground data for the preceding years of 1987, 1999 and 2007, an image with a discernible features was used to extract the reference data for accuracy assessment. For each image consumers' accuracy, producers' accuracy, overall accuracy and the kappa coefficient were determined and proved to be sufficient for the study. This is to permit quantitative comparisons of different interpretations to determine the usefulness of the information. Post classification thematic change detection tool in ENVI was used to determine land cover changes and soil erosion changes over the years. Change detection was done for the years 1987-1999, 1999 – 2007 and 2007- 2017.

Soil Erosion model

They soil loss model applied for this study is the RUSLE model. The model estimates the value of soil erosion is derived from the production of six major soil erosion factors which are expressed numerically as follows (Bash, 2015):

$$(1)\quad A=R\times K\times LS\times C\times P$$

Where:

A is the Average soil loss per unit of area (t/ha/y)

R is the Rainfall erosivity factor (MJ mm/ha/h/y)

K is the Soil erodibility factor (t h/MJ/mm)

LS is the Topographic factor (dimensionless) including slope length (L) and steepness (S) factors

C is the Cover management factor (dimensionless)

P is the Support (or conservation) practice factor (dimensionless).

The rainfall erosivity factor was derived using the Fournier index due to the lack of detailed datasets on rainfall intensity. Rainfall data was acquired from CHIRPS and it constituted of monthly and annual precipitation from the year 1982 to 2017. The Modified Fournier Index for five years was then calculated using the formula (Hernando & Romana, 2016);

$$(2)\quad F_f = \frac{1}{N}\sum_{n=1}^{5}\left[\sum_{i=1}^{12}\frac{{p_i}^2}{p}\right]$$

Where:

F_f – Is the modified Fournier Index for N years, N is the five, for five years of precipitation used for this study. From the Modified Fournier Index the R factor was determined using (Benavidez, Jackson, Maxwell & Norton 2018):

$$(3)\quad R = 4.79 * F_f - 142$$

The soil erodibility factor that represents the ability of soil to detach, the potential of the soil to runoff and the capability of the eroded sediments to be transported was derived from the soil factors derived from the Food and Agriculture Organization of the United Nations (SOTER) dataset. The analytical relationship for the factor by Wischmeier is used expressed as (Ashiagbor 2012);

$$(4)\quad K = \frac{2.1*10^{-4}(12-OM)M^{1.14}+3.25(S-2)+2.5(P-3)}{7.59*100}$$

Where;

K is the erodibility (t ha h/ha/MJ/mm^{-1}); OM is the percentage of organic matter. The organic matter derived from the SOTER dataset using the expression;

$$(5)\quad OM = 1.72 * \%OC$$

S is the soil structure code; P is the soil permeability code; M is a function of particle size fraction of silt percentage and clay percentage given by;

$$(6)\quad M=(\%silt)*(100-\%clay)$$

Fine-textured soils have low K values of about 0.05 to 0.15 (Kim and David, 2014). Coarse textured soils have low K values of about 0.05 to 0.2. Medium textured soils have moderate K values of about 0.25 to 0.45. Silt size particles have high K values, which can exceed 0.45 and can be as large as 0.65 (Khare et al., 2017). From the SOTER data the following soil structures very fine, fine, medium fine, medium, and coarse was assigned indexes 1, 2,3,4,5 respectively. The permeability Indices and characteristics assigned to each soil drainage according to FAO and ISRIC is as shown in Table 1 below;

Table 1: Soil Drainage, Permeability Characteristic and Index

Soil Drainage	Permeability Characteristics	Permeability Index
Excessively drained (E)	Very rapid	1
Somewhat excessively (S)	Rapid	2
Well-drained (W)	Moderate to rapid	3
Moderately well-drained (M)	Moderate	4
Imperfectly drained (I)	Slow to moderate	5
Poorly drained (P)	Slow	6
Very poorly drained (V)	Very slow	7

The Slope length factor (L) was derived from the DEM to represents the effect of slope steepness on erosion. The formula used according to (Ghosh et al., 2013) is given as:

$$(7)\quad L = (\frac{\lambda}{22.13})^{m}$$

Where; L is the slope length factor; λ is the actual slope length in metres given by multiplying the Flow accumulation to the cell resolution of the Digital Elevation Model as 30m. The flow accumulation is derived from watershed analysis

$$(8)\quad \lambda = flow\ accumulation \times cell\ resolution$$

m is the slope length exponent that is the ratio of rill to interill erosion. It was derived by using the equation;

$$(9)\quad m = \frac{\beta}{\beta+1}$$

Where: β is given by;

$$(10)\ \beta = \frac{(\sin\theta/0.0896)}{0.56+3(\sin\theta)^{0.8}}$$

$\boldsymbol{\theta}$ is the slope in degrees

The Slope steepness factor is the ratio of soil loss relative to a standard slope of 9%, which is the standard slope that modelled the RUSLE. The factor is calculated as (Kim & David, 2014);

$$(11)\ S = 10.8 \sin\theta + 0.03, \textit{for a slope gradient less than or equal to 9\%}$$

$$(12)\ S = 16.8 \sin\theta - 0.5, \textit{for slope gradient of more than 9\%}$$

Where; S is the slope factor; $\boldsymbol{\theta}$ is the slope gradient in radians

The cover management factor (C) represents the effect of plant cover on soil erosion. This factor was determined by use of Normalized Difference Vegetation Index (NDVI) using the Landsat satellite images. The equation used is expressed as:

$$(13)\ NDVI = \frac{NIR+RED}{NIR-RED}$$

Following the extracted NDVI the C factor was determined using the following equation (Kumar et al., 2014):

$$(14)\ C = e^{-\propto\left(\frac{NDVI}{\beta-ND}\right)}$$

Where; $\propto$ and β are unit parameters whose value are 2 and 1 respectively.

The support practice factor (P) is used to determine the effect of conservation practices on soil erosion. Within the region, the widely used soil conservation practice by the farmers is terrace Farming. In terracing, wide steps are cut around the slope to alter the shape of the slope to produce flat areas that provide a catchment for water and preventing soil erosion.

The P factor was estimated based on the slope and cultivation method. The table below was used to give the estimated values based on the relation between terracing and slope (Karamage et al., 2017).

Table 2: P Factor Values Based on Slope and Terracing

Slope	P Factor by Terracing
0.0 – 7.0	0.10
7.01 – 11.30	0.12
11.31 – 17.60	0.16
17.61 – 26.80	0.18
26.81 >	0.20

To get the soil erosion risk for the year 1987, 1999, 2007 and 2017, the product of the already generated model factors as expressed in the equation (1) above.

For the purpose of this study erosion values were classified into five main classes as shown in the table below;

Table 3: Soil Erosion Classification

Erosion Classification	Erosion Value (T/Ha/Year)
Very low erosion	0 - 50
Low erosion	51 - 100
Medium erosion	101 - 150
High erosion	151 - 300
Very high erosion	Above 300

Change detection was carried out to show how the land cover changes have affected the rate of soil erosion over the years. To show the trend, about 7000 random points within the area of study were created. The points were then populated with the land cover changes and their respective erosion changes. The points were then analysed to determine the prevailing land cover changes that had an effect of causing high and very high erosion.

5. Results and Discussion

Land Cover Change Analysis

The land-cover maps were classified into four classes, Forest, Cropland, bareland and water. The accuracy for the classified images was as follows; 1987 classified image had an overall accuracy of 87.50% and a kappa coefficient of 0.8102; 1999 classified image had an overall accuracy of 90.00% and a kappa coefficient of 0.8461; 2007 classified image had an overall accuracy of 94.01% and a kappa coefficient of 0.8980; 2017 classified image had an overall accuracy of 90.04% and a kappa coefficient of 0.8341.

(Figure 4 to 7) show the spatial distribution of the land covers over the years and the Table 4 below shows the area coverage of the land cover.

Table 4: Area Coverage and Percentage of Land Cover

Land Cover	***1987***		***1999***		***2007***		***2017***	
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)
Forest	9362.52	19.62%	14069.16	29.48%	10435.05	21.87%	9560.34	20.03%
Cropland	19143.27	40.11%	17193.69	36.03%	9233.28	19.35%	12497.04	26.19%
Bareland	19188.63	40.21%	16347.6	34.26%	28045.35	58.77%	25665.03	53.78%
Water	27.99	0.06%	111.96	0.23%	8.73	0.02%	0.00	0.00%

Maps showing the land cover changes is shown in (Figure 8, 10 and 12) shows. Graphs as shown in (Figure 9, 11 and 13) show how the land cover changed. Water decreased continually from 8% to 2% and 0% with the area changing to bareland. Forest cover decreased form 89% to 65% and later increased to 76%. For the period 1987 to 1999, 5% of forest changed to cropland and bareland. Period of 1999 to 2007, 24% changed to cropland and 12% to bareland. The period 2007 to 2017, 16% changed to cropland and 8% into bareland. Cropland decreased drastically from 51% to 27% and increased to 80% from 2007 to 2017. In the period of 1987 to 1999, 25% and 23% changed to Forest and Bareland respectively. The period of 1999 to 2007, 5% changed to Forest and 67% into Bareland. 12% and 7% changed to Forest and Bareland respectively from 2007 to 2017. In the period of 1987 to 1999, 5% and 36% of bareland changed from forest and cropland respectively. 2% and 8% changed to forest and cropland respectively from 1999 to 2007. The period of 2007 to 2017, 2% of bareland changed to Forest and 12% into Bareland. It is predominantly noted that most part of bareland remained as bareland.

Soil Erosion Factors

The estimated R factor value ranges from 100.29 to 187.69 MJ mm/ha/h/year for the year 1987, 179.75 to 295.62 MJ mm/ha/h/year for the year 1999, 85.21 to 156.39 MJ mm/ha/h/year for the year 2007 and 183.04 to 324.69 MJ mm/ha/h/year for the year 2017. It is observed that the R factor was high for the years between 1987 and 1999 and there was a drop in the year 2007 as shown in (Figure 14 to 17). The factor then became very high for the period leading to 2017. The results are indicative of the results in the amount of rainfall within the region.

C factor was derived from land cover NDVI values and RUSLE model parameters. The values ranged from 0.00011 - 1 in 1987, 0.008 - 1 in 1999, 0.003 -1 in 2007 and 0.889- 1 in 2017 as shown in (Figure 18 to 21). The areas with high values are more susceptible to soil erosion than the areas with low values. In 2017 the area was highly susceptible to erosion mostly due to very little vegetation cover within the area.

The conservation practice factor represents the positive impacts any support practice has in preventing soil erosion. It accounts for the control practices that reduce the erosion potential of the runoff by their influence on drainage patterns, runoff concentration, runoff velocity, and hydraulic forces exerted by a runoff on the soil. The value of P factor ranges from 0 to 1, the value approaching 0 indicates good conservation practice and the value approaching 1 indicates poor conservation practice. For this study, the P-value is a factor of slope and terracing as a conservation practice the factor values is as shown in (Figure 22 to 25).

From the digital elevation model, the watershed analysis was carried out to get the flow accumulation and slope. The L factor which is the slope length was calculated from the flow accumulation and the slope steepness, the S factor, was determined from slope percentage as an input. The LS factor values ranged from 0 to 4.2588 refer to (Figure 26). With most of the area within the region having very low values it shows that the topography had very little impact on the erosion process.

The K factor lower value is associated with the soils having low permeability and higher values with soils having higher permeability. (Figure 27) show the factor values ranging from 0.001 to 0.046 ton/ha/MJ/mm.

The predicted annual soil loss for the year 1987 loss ranged from 9.521 - 662.753 t/ha/year with the mean annual soil loss for the entire watershed was estimated at 336.137 t/ha/year. For the year 1999, annual soil loss ranged from 1.259 - 446.068 t/ha/year with the mean annual soil loss for the entire watershed was estimated at 223.664 t/ha/year. For the year 2007, annual soil loss ranged from 7.571 - 420.038 t/ha/year with the mean annual soil loss for the entire watershed was estimated at 213.8045 t/ha/year. For the year 2007, annual soil loss ranged from 32.605 - 835.587 t/ha/year with the mean annual soil loss for the entire watershed was estimated at 434.096 t/ha/year. The erosion risk areas were classified into 5 classes; very low erosion, low erosion, medium erosion, high erosion and very high erosion. (Figure 28 to 31) show the erosion distribution on the watershed.

The results show decreased soil loss between the period of 1987 and 1999 this can be attributed to increased land cover even though there was a higher amount of rainfall. The amount of soil loss continues to drop for 2007 although there is a decrease in the amount of land cover, this can be attributed to the fact that there was less amount of precipitation around that period. There was a tremendous increase in soil loss to the period leading to the year 2017, this can be attributed to the fact that there was a complete increased amount of rainfall and tremendous decrease in the amount of land cover.

Soil Erosion Change Analysis

The results in (Figure 32, 34 and 36) illustrates the spatial distribution of erosion change and (Figure 33, 35 and 37) illustrates in percentages the temporal aspect of erosion change. Very low erosion continuously remained as areas of very low erosion with 95%, 53% and 85% over the three epochs. 45% and 46% of low erosion remained as low erosion in the period of 1987 – 1999 and 2007 – 2017 respectively.

Low erosion remained low at 45%, 38% very low, 13% medium and 4% high in the first epoch. In the second epoch it changed to medium at 58%, 28% remained low, 10% high and 2% very low and very high. The third epoch saw 46% remain low, 24% change to very low and 8% high erosion.

Areas of medium erosion changed 39% low, 33% remained medium, 16% high, 9%very low and 4% very high for the first epoch. The second epoch saw medium remain medium at 67%, change to high at 19%, low at 9% and 4% very high. 52% remained medium, 28% low and 19% at high erosion in the third epoch.

In the first epoch, 30% of high erosion remained high, 28% changed to medium, 24% changed to very high, 16% to low and 2% changed to very low. The second epoch, 57% changed to medium, 29% remained high, 12% changed to very high and 2% changed to low. In the period 2007 to 2017, 69% remained as high, 25% changed to medium, 4% to low and 3% to very high erosion.

Area of very high erosion changed mainly into 38% to high, 34% remained very high, 22% and 6% changed to medium and low erosion respectively in the period 1987 to 1999. 62% change to high erosion 24% remained as very high, 14% change to medium erosion for the second epoch of 1999 to 2007. The period of 2007 to 2017, 59% changed to high erosion and 33% remained as very high erosion.

Erosion trends illustrated by land cover variations are shown in (Figure 38, 40 and 42). During the all the epochs explored when bare land areas remained as bare land and cropland areas changed to bare land, it resulted in high and very high erosion scenarios. From change analysis maps shown in (Figure 39, 41 and 43), it is observed that the central and the eastern region were majorly covered by regions of high and very high erosion. With this information, conservation practices can be directed to areas that require urgent measures and ensure sustainable use of resources for this purpose.

6. Conclusion and Recommendation

The average amount of soil loss is 336.137 t/ha/year for 1987, there was a significant drop in erosion value to 223.664 t/ha/year in the year 1999. This can be attributed to the fact that there was increased amount of land cover around that period. In 2007, the value was 213.8045 t/ha/year this could be as a result of decreased amount of rainfall leading to that period. The value increased considerably to 434.096 t/ha/year in 2017 even though there was no significance increase in the amount of rainfall, this was attributed to the fact that there was significant decrease in the amount of land cover. The spatial information, in form of maps, display the critical areas where conservation measures should be directed with a lot of urgency. When cropland changed to bare land and bare land remained as bare land, there resulted in instances of high and very high erosion. Assessment of the impacts of land cover on soil loss showed that major changes that resulted in most of the soil loss were reflected in the loss of vegetation cover, poor conservation on agricultural land, and lack of rehabilitation of degraded lands. The improvement in vegetation cover could be attributed to better conservation practices.

To improve the accuracy of the results, the parameters can better be estimated by the use of detailed datasets. For instance, the R factor can be determined by using storm energy and 30 minutes of intensity, the use of high-resolution imagery for better mapping of the land cover. The model can also be improved by carrying out intensive research for areas with limited datasets

As soil erosion remains a challenge on watershed management, conservation practices are the only methodologies of mitigating the challenges. The practices include Contour ploughing, terrace farming, Keyline ploughing, perimeter runoff control, agroforestry and crop rotation (Bhuchar *et al.*, no date). Additionally, management of soil erosion should be concentrated to the affected areas and could be encouraged through grants and community education in developing adaptive measures that are desirable to the indigenous people (Wani & Garg, 2009). In order to protect and improve the soil's productivity and environment, there is need for commitment in all sectors of society. Understanding soil erosion is an essential step toward developing effective soil conservation strategies. By decreasing soil loss through conservation practices, the soil's fertility will allow for land to sustain higher crop yields that will have a positive impact on the economy.

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Hungarian Association of Agricultural Informatics
European Federation for Information Technology in Agriculture, Food and the Environment

Journal of Agricultural Informatics. Vol. 11, No. 2
journal.magisz.org

Engaging agriculture in e-government, E- agriculture potentials and its contribution in economy

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INFO
Received 12.08.2020
Accepted 21.07.2020
Available on-line 09.02.2021
Responsible Editor: L.Varallyai

Keywords:
E- agriculture, E-government, ICT, WSIS action line C7, Sustainable Development Goals.

ABSTRACT

The rapid development in Information Communication Technologies accompanied with digital transformation of governments toward e-government reveals of great opportunity to engage this development in the agriculture sector in what called e- agriculture which introduces a revolution in this sector and gives innovative solutions to the anticipated problem of world hunger in future.
This paper aims to reveal of the potentials of e- agriculture, strategies of its implementation and the practical initiatives in this regard, also, the paper estimates the degree of implementing ICTs in agriculture sector worldwide compared to other economic sectors.
This study finds that there is a negative relation between E-government Development Index, ICTs use, Government on-line Services Index and e-Participation Index in a country and agriculture sector contribution in economy, Also, it finds that engagement of ICTs in agriculture section is still far away behind other economic sectors as the increasing development of ICTs adoption in a country has been related with a declining of agriculture contribution in economy whereas other economic sectors have increased their contributions.

1. Introduction

Agriculture which has been neglected for decades, it is now coming-back to take first attention globally as a key vehicle to reduce poverty and as an economic growth leverage (Timmer 2005, Hailu n. d).

In near future, as population of the world are increasing rapidly, agriculture is stands for a big challenge to feed the anticipated ten billion inhabitant and have to increase its production of food about 50%, more specifically, by 2050 global production of agriculture should be increased by 60% to meet the anticipated needs, 80% of this increasing would come from crop yields production raise (Alexandratos & Bruinsma 2012, FAO website), but this is not an easy mission if we know that the increasing in agriculture yields are slowing (Alston & Pardey 2014), and "conventional" way in enhancing effective and efficient agriculture is going to reach its limits. This new situation need a new way of thinking and take every opportunity to go out of the box, here, the new development in ICT and its applications of huge potentials, give a real opportunity to agriculture to have a new revolutionary raise by using the great potentials of new technology

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since it provides a wide range of applications and tools that can be easy to use by farmers and in the same time affordable with a reasonable cost, suiting agriculture sector that have a modest financial possibilities especially in developing countries, this novel perspective of agriculture called e- agriculture.

Taking in regards the significant jump of developed countries in transforming its government toward e-government, these e-governments is promising for a high chance of development especially among less developed countries to leapfrog over obstacles (UN 2016(and build a modern e-government provides its e-services for a sustainable development, here, for those developing countries- witch most of their economies depends on agriculture and have a high population growth rate especially in rural areas (Fuglie 2018) are threatening their future with possible hunger (FAO 2018)- developing agriculture sector considers a solution, So, directing e-governments and ICTs applications in enhancing agriculture is a high priority for those countries particularly and to the world in general for starting a new age of revolutionary e-agriculture (Awuor 2016) which is more than a collection services of e-government for farmers and rural regions but it covers a comprehensive range infrastructure, services, relations, knowledge and products supplied by government (FAO 2017, Maumbe 2009).

The main objective of this study is to shade the light on engaging ICT in agriculture and the anticipated potentials of e-agriculture in enhancing agriculture production and solving the anticipated future world hunger.

Also, this study is involved in estimating the degree of integrating ICT in agriculture sector compared to other economic sectors and its effect on agriculture sector contribution in economy.

2. Background

2.1 E-agriculture concept

E-agriculture is a new domain or discipline concerns in optimizing the development of agriculture and rural areas by improved engaging of information and communication technologies. In other words, e-agriculture concerns in finding innovative solutions using information and communication technologies (ICT) for developing agriculture and rural areas by framing concepts, designing, developing and evaluating a new application.

This concept has been adopted by World Summit on the Information Society (WSIS) and has been set in its Declaration and Plan of Action as an action line, The Food and Agriculture Organization of the United Nations (FAO) was set to facilitate e- agriculture action lines and to facilitate the initiating e-Agriculture Community initiatives (FAO n. d).

In 2007, one of the most important initiatives set up by FAO with 13 partners to support e-agriculture notion in practical applications is e-Agriculture Community of Practice (ACP) which is an open global platform for exchanging the knowledge, data, thoughts and sharing resources about engaging ICTs for developing sustainability in agriculture, this community is open for individuals interested in e- agriculture who belong to different disciplines as ICTs experts, farmers, researchers, politicians, businessmen and any other stakeholder, 170 countries with more 14 thousand members are involved in this society to improve policies and find practical applications of ICTs to develop agriculture and enable the rural regions environment to be a more convenient place to live and work, this in turn effects on agricultural process (Ntaliania 2009), some examples of such enhancements is starting Family Farming Knowledge Platform and Farmer Field Schools.

Also, the ACP conducted international forums concerning food security and agriculture solutions those mentioned initiatives are designed carefully to reach wide diversity of targeted groups over the world (WSIS 2019a).

2.2 Practical perspectives of e- agriculture in e-governments plans

As much as it looks easy to talk about integrating ICTs in agriculture as it hard to be implemented, especially in those countries which depends on agriculture in its economy as they are generally poor countries and have a sever lack in potentials to implement e- agriculture, taking in regards, that the lake of knowledge and expertise are great barriers to practice e- agriculture (EU SCAR 2015, Herbold 2014(.

Here, it is important to breakdown the role of e-governments and its ICT tools in initiating e-agriculture, this breakdown is important to enhance the understanding of the concept of e- agriculture and interpret the resulted ideas into practical directions and projects.

The following directions have been discussed by FAO (2017) as steps for building national e-agriculture strategies:

E- agriculture as a framework for regulating policies: engaging ICT gives a powerful tool to set, evaluate and spread new relevant policies and monitors its implementations (Singh et al 2017).

E- agriculture as empowerment tool and capacity developer: engaging ICT enables more vulnerable people to engage locally, creating by that new opportunities for new business in rural areas and making those areas a better place for working and living (Yonazi et al 2012).

E- agriculture as a platform for providing insurance and access to financial services*:* engaging ICT enables inhabitants of rural areas from reaching financial services easily, providing a secure way for saving, and bringing enhanced instruments for risk management and insurance that can rural inhabitant afford (Singh et al 2017, Kloeppinger-Todd and Sharma 2010).

E- agriculture as platform for tracing food safety: engaging ICT provides a huge pool of accountable and updated data, this data accompanied with developed application can efficiently trace the food and nutrition issues complying the international standards.

E- agriculture as an innovation system**:** engaging ICT shorten the distance among various stakeholder of agriculture as farmers, researchers, academic institutions, agents, marketplace, business players and policy makers, making it is easier to communicate and exchange their needs and directions (Rudgard et al 2011).

E- agriculture supports sustainability in agriculture: engaging ICT provides the suitable knowledge, information and accessible applications for applying innovative and sustainable agricultural methods like protecting plants, health-care of animals and using applications as climate smart solutions (Syiem 2015).

E- agriculture as a tool for risks, early warning and disaster risks management**:** engaging ICT supplies on-line and real time anticipated risk information- like agro-meto information system- with ongoing advice for dealing with risks before and during their happenings and provide the suitable directions to deal with disasters' consequences, all that offered in real time and on-line observation (Zyl et al 2014).

E- agriculture as a platform for enhancing access to marketplace*:* engaging ICT makes it easier for farmers and small business in rural area to access marketplace for better knowledge of new inputs, market conditions, prices and best time for trading a specific product (Cleene, S 2014, Warren 2004).

2.3 E-agriculture strategies

From previous paragraph where the importance of e- agriculture was breakdown into different perspectives of e- agriculture implementation aspects, e- agriculture national strategies can be derived to put an comprehensive plan for increasing agricultural productions especially in food within a timeframe to meet the increasing needs of food and anticipated national population growth, and providing new incentives with facilitating new innovative technologies for exporting Agri-products, also, these strategies aims to create new markets, promoting social protection, de-centralizing the trading and driving innovation in agriculture, besides, strategies should have the capacities to monitor and correct the implementation of its plans to ensure farmers' accessibility to the market, transparency and efficiency of savings and loan processes and other financial services (Jainzik & Pospielovsky 2014), , optimum decease monitor and mitigation for corps and animals, best applying of disaster prediction and weather forecasting, and right execution of many other remote services supplied by e-governments to the agriculture communities especially those in far rural areas.

Developing countries have started in implementing and adopting serious strategies at national level for implementing e-government services especially in e-learning, e-commerce and e-health but there were no developing country except four out of all has adopted an e- agriculture strategy on national level in the year 2012 (ICT 2103).

This lagging in adopting e-agriculture strategies may come from the current potentials of the agriculture sector, that agriculture is still behind the other economic sector in development and have a deficit in financial support from private sector especially in developing countries, also, the role of multinational enterprises in supporting researches and developments in agriculture sector is still modest comparing to other economic sectors as they considered more profitable and have a faster capital turnover, besides, investment in agriculture is a high risk investment (Miller et al 2010).

The mentioned weak investment in agriculture will cause lagging of implementing e- agriculture which in turn keeps the private investment in agricultural projects modest, and this will keep agriculture lagged-off once again and so on , here, governments over the world have the responsibility to break this repeated circle of lagging and low investment in agriculture, by global collaboration to provide suitable financial support for an evolutionary implement of e-agriculture which enables a real jump in agriculture sector development to be a modern and profitable sector in a way attracts investments, those investments in turn get involved in developing the sector and new circle of interactive mutual benefits starts.

Figure1. illustrates the declining in agricultural sector contribution in economy in the vast majority of world regions.

Figure 2. is showing the continuous declining of agricultural sector contribution in economy in favor of increasing other economic sectors.

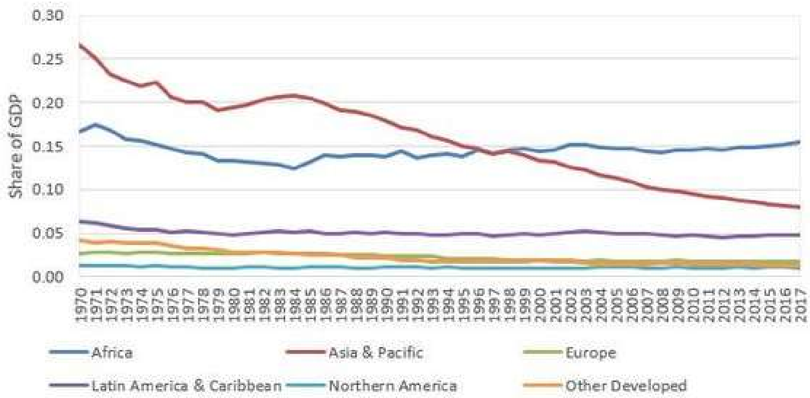

Figure 1. Agriculture contribution in economy as % GDP by region. (Source: United Nations Statistics Division and Food and Agriculture Organization http://www.fao.org/economic/ess/ess-economic/gdpagriculture/en/)

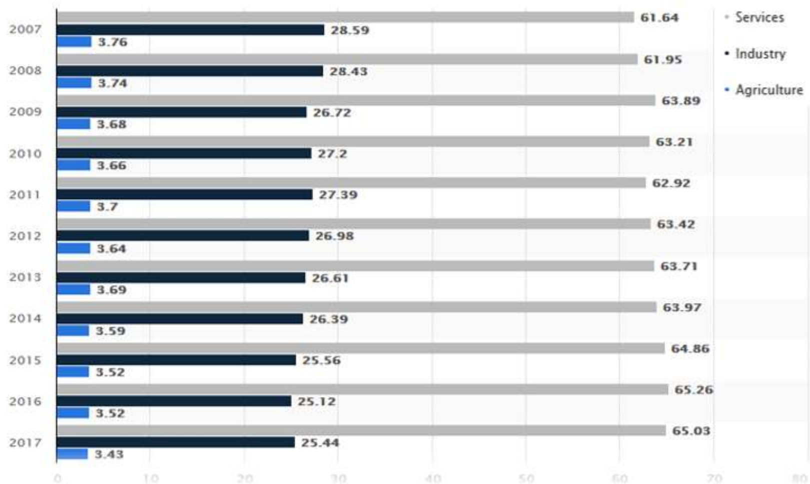

Figure 2. World economic sectors contribution in economy as percent of GDP between 2007- 2017. (Source: Statista website, https://www.statista.com/statistics/256563/share-of-economic-sectors-in-the-global-gross-domestic-product/)

3. Applying innovation for SDGs in agriculture

3.1 Innovation for SDGs in agriculture

Broadband Commission for Sustainable Development Goals 2025 has setup international joint strategy to come over digital divide created by the rapid developments in ICTs, this strategy will give a drive forward digital transformation and implementing e-governments, SDGs 2025 have ambitious targets summarized by Sharma (2019) as the achieving all countries worldwide by 2025 national plans or strategies for implementing broad-band coupled with the a proper allocated financial resources, this broad-band should be accessible and affordable in developing countries at no more than 2% of monthly GNI per capita, also by 2025 internet should by accessible by 75% of people globally, 65% of developing countries', and 35% of poorest countries' population, taking in regards gender equity, and the important thing is enabling minimum 40% of people worldwide to use financial e-services.

These SDGs in technologies is a leverage for e-government implementation and optimizing its services in all sectors. So, applying SDGs in agriculture sector enables to transform ideas to actions, builds multiple relations among various stakeholders and affords accessible networks, continuous applying and testing new technologies, on-line monitoring and correcting plans executing and increasing potentials of the agricultural and the food system. The precise and effective execution of these SDGs in agriculture will decrease poverty, enhance rural areas livelihood, provide more food security, sustainable solutions, optimized dealing with risks and disaster and engaging most vulnerable groups in the process, finally SDGs create more productive communities.

An example of integrating ICTs in agriculture for sustainable agriculture is the joint initiative of FAO and Google, that enables google earth to analyze geospatial data for farming reasons, another example led by FAO in collaboration of telecommunication company Telefonca is applying Internet of things with using remote sensing to increase agricultural water productivity (WSIS 2019b), applying these goals in serve of agriculture sector for providing sustainable agriculture and national and global food security, needs to address obstacles that faces executing these goals and draw strategies and plans for practical implementations, this drove World Summit on the Information Society WSIS to adopt action lines C7 and C3 for enabling e- agriculture, the subject of next paragraph.

3.2 World Summit on the Information Society WSIS action lines C7 and C3 for enabling e-agriculture:

Discussing the opportunities of enabling e- agriculture drives this paper to highlight two of action lines adopted by World Summit on the Information Society WSIS, C3 and C4, the first concerns in accessing to information and knowledge, which is very important determinant of spreading e- agriculture especially in developing countries even in some rural area of developed countries, the second; C7 concerns in engaging ICTs apps in governmental services in a shape of e-government also this action is very important in enabling e- agriculture since governments has the key role in supporting agriculture, at the same time it has the major responsibility in enabling such strategic development projects such as e-government and its various directions like e- agriculture initiatives, So, C7 action line have specific targets can be summarized in distributing needed information systemically in means of ICT for issues concerns food, forestry, fishing, husbandry of animals and agriculture, providing by that for all stakeholder- particularly in rural areas- an easy access information, updated and ready to use (WSIS 2019a).

3.3 E-agriculture policies in developing countries

As discussed in the paragraph 2.3 that most of developing countries haven’t defined comprehensive strategies nor policies to integrate ICTs in agriculture to build their national e-agriculture, for instance, in 2012 only those countries; Côte d’Ivoire, Ghana, Mali and Rwanda of all developing countries have adopted governmental national strategies and put defined policies for e-agriculture, the vast majority of these policies have been evolved with the collaboration of international organizations like ‘United Nations Development Program’, ‘International Telecommunication Union’, ‘United Nations Economic Commission for Africa’ and ‘Food and Agriculture Organization’ and put terms on agricultural strategies on sectorial basis, those policies differs according the conditions of the targeted country or region, for instant FAO and ITU have unleashed common program in 2013 called e- agriculture strategy guide for assisting countries to build national inclusive e- agriculture strategies by setting up documents of guidance polices depending on-demand basis (Kolshus et al 2015).

This role of international organization is very important for developing countries in setting up their e-agriculture policies to leapfrog over access and achieve the aimed agricultural revolution especially that those countries have a lack of expertise, facilities and knowledge in policy making regards (EU SCAR 2015(.

4. Study hypotheses and Methodology

This paper tries to find the relation between agriculture sector change and the development in applying ICTs in countries over the world, more specifically, does the level of applying ICTs and e-government implementation in a country have a significant relation with agriculture contribution in economy.

Hypotheses of this study are:

H1: Is there a relation between the development of ICTs engagement in a country and agriculture sector contribution in economy.

H2: Is there a relation between e-government development in a country and agriculture sector contribution in economy.

***Measuring the variables*:**

To measure agriculture sector contribution in an economy this study has chosen agriculture, forestry, and fishing, value added (% of GDP) to interpret the agriculture contribution in economy.

For measuring the development of ICTs engagement in a country this study has chosen the ICT access index, ICT use index, overall ICT index, on-line participation index, government on-line services index, On-line Service Index, telecommunication infrastructure index, that indicis are the main scales used by United Nations different researches to evaluate the development of ICTs in a country.

For measuring e-government development in a country this study has chosen E-government Development Index (EGDI) level and E-government Development Index (EGDI) score, those indicis are the main scales United Nations different researches to evaluate the e-government development in a country.

***Testing hypotheses*:**

For testing the relations and hypotheses of the study, correlation test will be applied to test the relation between agriculture, forestry, and fishing, value added (% of GDP) in the year 2018 from one side and development of ICTs engagement in a country in the year 2018 on the other sides. The selected year (2018) for collecting data of the sample is providing the most recent data that needed for conducting the test.

The data for analysis gathered from World Bank data website and from UN government knowledgebase. The sample covered most of the world countries that have available data for analysis.

Correlation test splits into two tests, the first one applied on a sample of 120 countries, the second applied on a sample of 169 countries, the difference in samples depends on the availability of information provided by countries needed for analyzing.

Limitation of the study:

The test conducted depending on only one year; 2018, which is provides most recent data that needed for conducting the test, this limitation can be a subject of future research that can observe relation change of study variables over the years.

5. Results and Discussion

The collected data about agriculture, forestry, and fishing, value added (% of GDP) from ("World Bank data website", n. d) and development of ICTs engagement indices in a country were gathered from ("UN government knowledgebase website" n. d) and (" World Bank TCdata360 website" n. d).

Those data analyzed using SPSS program by conducting correlation analysis, the results showed in the following table1. and table.2

Table 1. Correlations EGDI score, E-Participation Index, On-line Service Index, Telecommunication Infrastructure Index and Agriculture, forestry, and fishing Value Added (% of GDP) in 2018

		EGDI Score 2018	E-Participation Index	On-line Service Index	Telecommunication Infrastructure Index
Agriculture, forestry, and fishing Value Added (% of GDP) 2018	Pearson Correlation	-.610**	-.388**	-.423**	-.640**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	169	169	169	169
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 2. Correlations between EGDI level, ICT access Index, ICT use Index, Government on-line services Index, On line e participation Index, Overall ICTs Index and Agriculture, forestry, and fishing, value added (% of GDP) in 2018

		EGDI level 2018	ICT access Index	ICT use Index	Government on-line services Index	On line e participation Index	Overall ICTs Index
Agriculture, forestry, and fishing, value added (% of GDP)	Pearson Correlation	.735**	-.262**	-.262**	-.664**	-.622**	-.218*
	Sig. (2-tailed)	.000	.004	.004	.000	.000	.017
	N	120	120	120	120	120	120
**. Correlation is significant at the 0.01 level (2-tailed).							

From table. 1 It can be noticed that there is a strong negative relation between Agriculture, forestry, and fishing, value added (% of GDP) from one side with each of EGDI number and Telecommunication Infrastructure available in a country (Pearson factor is -.610, -.640 respectively).

Also, the relation between Agriculture, forestry, and fishing, value added (% of GDP) with each of E-Participation and On-line Services available in a country are negative relation with medium strength.

Table. 2 returns almost the same result of the existence of a negative relationship between agriculture sector contribution in economy presented by value added (% of GDP) with ICTs development in a country presented by ICT access index, ICT use index and overall ICT index (weak relation), and by Government on-line services Index, on-line participation index and e-government development level (strong relation).

As a result, the two hypotheses of research are accepted and there is a moderate negative relationship between the development of ICTs engagement in a country and agriculture sector contribution in economy.

Also, there is there a strong negative relationship between e-government development in a country and agriculture sector contribution in economy.

The relations strength estimated from the average of relations strength of components of ICTs development and e-government development in a country from one side and agriculture contribution in economy on the other side, they are r = -0.435, -0.672 respectively.

Explaining results: The previous results for a superficial analysis may have no information to provide or no interpretation on the reality, but a deep look can tell us that whenever ICTs application and e-government implementation rise in a country the less of agriculture sector contribution in economy, this can be explained in two approaches:

First approach is the leaders countries in ICTs and e-government development- who showed high ICTs and e-government development indices- are not concentrating on applying this development in agriculture sector as they are not an agriculture economies and the benefit of this development goes in enhancements in other sectors that their economies depends on especially if we know that the top 10 countries in EGDI level in the year 2018 due to UN e-government survey (2018) are industrial countries besides to their advancement in tourism and research and development sectors.

So, the new technology enabled an expansion of other sectors contribution in economy on the expense of agriculture contribution, this is affirmed by the discussion in the paragraph 2.3 about the declining of the agriculture sector contribution in economy in favor of increasing other sectors' contribution, see figure 2.

Second approach looks to the matter from this study's objectives point of view that shows there is no enough engagement of ICTs in agriculture which affirms the notion discussed about the slack in adopting e-agriculture strategies, the necessity to integrate ICTs in agriculture and the importance for e-governments to adopt e-agriculture as an important service for agri-development.

This lagging in adopting e- agriculture is demonstrated especially in private sector, because ICTs engagement in agriculture needs a lot of support for research and development with a little opportunity of feasible revenues that private sector seeks, in this regards, there are a modest initiatives for integrating technology in agriculture in shape of e- agriculture such as FAO initiatives but if the world want to face the anticipated world hunger in future and increase agriculture production, governments over the world with collaborations of global organization should focus on finding serious supporting for engaging new technology in agriculture.

Conclusion

The negative relation between e-government developing level, ICTs development indices, e-participation, Government on-line Services from one side with agriculture sector contribution in economy of a country on the other side, led the study to conclude that the adoption of e-agriculture as strategic solution for anticipated food deficit in the future is still modest, and the engagement of ICTs in agriculture section is still far away behind other economic sectors which benefits from these new technologies and increased their contributions in economy in expense of agriculture sector, this situation drives to another conclusion that governments over the world have the responsibility with the collaboration of global organizations to provide suitable financial support for an evolutionary e-agriculture projects which would enable a real jump in developing agriculture sector to be a modern and profitable sector in a way attracts private investments which in turn get involved in developing this sector again, and new circle of interactive mutual benefits starts.

Also, this paper concluded that countries who have a highest engagement of ICTs and highest e-government development are not concentrating on applying this development in agriculture sector as they aren't agriculture economies, and the benefit of this development goes to enhance other sectors that their economies depends on.

Also, browsing the international collaboration initiatives to exploit the great potentials in developing agriculture revealed of real opportunities in optimizing agriculture sector to find innovative solutions for future anticipated world hunger and reaching a sustainable e- agriculture.

This study recommends to extend this study and perform tests on a repetitive basis to be an observe tool of e-agriculture development, this tool helps in estimating the degree of success in e- agriculture strategies and plans implementation, in addition to that, this article recommends that international organizations put more efforts in finding financial support to develop e-agriculture which in turn raise agricultural process productivity and efficiency to the level enables agriculture sector from attracting business and international enterprises to invest in this sector as much as other economic sectors.

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Hungarian Association of Agricultural Informatics
European Federation for Information Technology in Agriculture, Food and the Environment

Journal of Agricultural Informatics. Vol. 11, No. 2
journal.magisz.org

Is it essential the digitization in agriculture? Experiences in Curriculum Development for Agri-digitalization engineer at BSc level

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INFO
Received 26.01.2021
Accepted 02.02.2021
Available on-line 09.02.2021
Responsible Editor: L.Varallyai

Keywords:
digitization, agriculture, business, education, BSc level.

A B S T R A C T

The paper examines the role and tasks of agricultural digitalization education. The major challenges and possibilities of agricultural digitization are inevitable. With the help of modern technology, agriculture has great benefits. This article has been based on a qualitative review of the literature to prove why digitization is necessary for agriculture, and also created a proposal for Curriculum for agriditization at BSc level. There are five suggested subjects groups: Basics of economics, Agronomy basics, Agricultural economics and entrepreneurship, Agricultural digitization and the Differentiated professional knowledge. We also suggest subjects for the knowledge groups and also propose credits to each one. We summarize the Training and Output Requirements (TOR) for the suggested course. We think that new education programmes and new approaches to extension would be also needed to accelerate the transition to digitized agriculture.

1. Introduction

The development of information and communication technologies (ICT), the growth of database systems and digitization is a current topic nowadays: It is true in the corporate and also in the academic sphere. Automation and robots have been around for a long time, but the Internet revolutionizes the process management connected to network them. Thanks to increasing digitalization, enterprise devices and machines can connect and collaborate, implementing Industry 4.0. Devices such as sensors, RFID chips, 3D scanners, cameras, and robots generate data that the literature describes Big Data. It is a huge challenge to store, process, and interpret this data (Hermann et al., 2016; Ilie-Zudor et al., 2011). Digitization is not only an ICT development, but it is also widely used in corporate processes and also has an impact on the organization (Horváth & Szabó, 2019). The most published articles deal with digitization only from a technological point of view (Dworschak & Zasier, 2014; Hermann et al., 2016) or a theoretical point of view (Fettig et al., 2018; Dalenogare et al., 2018). The most published studies deal with digitization only from a technological point of view (Dworschak & Zasier, 2014; Hermann et al., 2016) or from a theoretical point of view (Fettig et al., 2018; Dalenogare et al., 2018). The development of digital technologies is embedded in all sectors of the economy and can contribute to improving productivity, accessing new markets, reducing costs, changing businesses, creating processes, new business opportunities, and new jobs. The impact of digitization is perhaps most significant in the mechanical engineering and electronics industries (Demeter et al., 2020; Nagy, 2018; Horváth and Szabó, 2019; Gauger et al., 2017). We often encounter digitization in agriculture, especially in the manufacturing and food industries, in various studies.

2. Agricultural and business digitization course and international history

Before planning or founding a new course, the question is which foreign higher education institutions have similar courses. The following list contains the most important foreign higher

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education institutions where agricultural digitization course takes place at a basic level, independently or combined with business training:

Cranfield University, Agricultural University of Athens, University of Natural Resources and Life Sciences (BOKU), University of Southampton, Ivey Business School, Rotterdam School of Management Erasmus University, University of Edinburgh Business School, University of Bath School of Management, University of Liverpool Lancaster University, University of London, Shobhit University.

All of the BSc-level agricultural digitization courses examined at the international level focus on applied IT or IT knowledge related to the agricultural sector. It is difficult to find training where agricultural and business digitization would occur together. Based on the above and using our information, we can say that the agricultural and business digitization course is widespread worldwide, the need for it is not questioned anywhere. In almost all the mentioned institutions, an institute or department manages the course and researches in this field. The course related to Agricultural and Business Digitization does not currently exist in the field of economics. The former course can be considered the informatics and administrative agricultural engineering, which ran in the field of agriculture but does not currently have a valid accreditation. The informatics and administrative agricultural engineering course have great popularity across the country. Several successful and middle-level colleagues with such qualifications work in the agricultural sector, but also in small and medium-sized agricultural enterprises, as well as in agricultural professions and administrations, a large number of people have such a degree or qualification. The Agricultural and Business Digitization course has a modern structure with a practical view, which meets the needs of the individual company managers of the Hungarian agrarian sector. In our opinion, the course is also needed because a so-called non-agrarian general manager, who does not know the basic processes/conditions of agricultural production, is not or only to a limited extent suitable for the performance of agricultural economic and IT tasks. The field of agricultural and business digitization can be interpreted by the agriculture (thanks in part to its former course) and the whole Hungarian agricultural economy, in addition to the strong need for professionals with such qualifications who have practical agricultural and information technology knowledge. On the one hand, this is also supported by the fact that job advertisements appear regularly, where they are looking for a specialist who understands business digitization and has agricultural knowledge too. On the other hand, they are looking for answers nowadays to issues such as ensuring food supply, increasing productivity, tracking agricultural products. Drone technology, or the application of pesticides with this technique, which can increase efficiency and reduce costs, can all be supported by digitization. Ensuring equal opportunities is particularly important for digital investments, but the return rate is quite different for large-scale agricultural enterprises and small farms. Also important that the development of agricultural digitalization is also included in the new CAP plans, so supporting this area may be a priority in the 2021-27 EU budget cycle, which is not realizable in Hungary without specialists with such knowledge. We must also highlight the Hungarian digital agricultural strategy, which can create the conditions for the necessary technical-technological modernizations, as a result of which the annual performance of domestic agriculture can increase by hundreds of billions. The fields of knowledge that represent the specific pillar of the basic education of agricultural and business digitization (about 40-45% of the available credits) are not part of the curriculum network in any other basic course which has valid accreditation in Hungary.

2.1. Agricultural and business digitization course

The main parts of the curriculum: digitization, agricultural economics knowledge supplemented with general knowledge (human, social, linguistic, etc.). The course aims to train professionals who can easily navigate on the field of digitization and can explore and solve the arising problems. Digitization is closely linked to the field of agriculture as well as economic, business, which is an important aspect nowadays in the knowledge-based information society. Graduates with a BSc degree must be able to understand the real production, operation and business model, and be able to create digitization models and recognize the digitization technique they wish to use solve the problems. It is necessary to be able to apply suitable digitization techniques in both the agricultural and business fields. Nowadays, it is almost inconceivable for anyone without this knowledge to be successful, whether in agriculture or business. It is an important goal for professionals to understand agricultural and business processes and to be able to support them with IT and digitization tools and to be able to act as experts in these areas. This BSc-level training keeps for 7 semesters, where is the 7th semester is the so-called practical semester, which the students spend at an external (agricultural or economic) company. The required total study time is nearly 2000 contact hours and the required credit is 210.

The rate of subjects group can be shown in Figure 1.

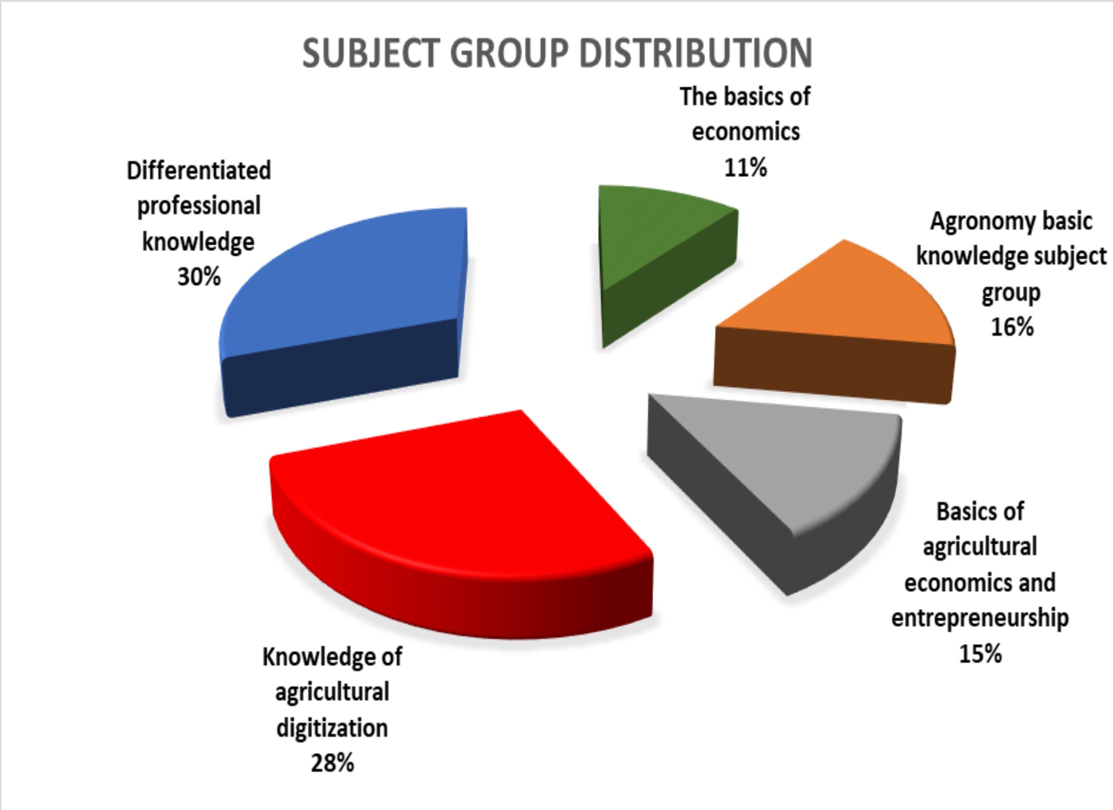

Figure 1. The rate of subjects group, own source

The proposed subject groups

a. **Basic knowledge of economics:** Gives general knowledge of the field of economics (Table 1.).
b. **Agronomy basic knowledge subject group:** The characteristics of the training determine the required knowledge in the field of agriculture. These subjects are aimed at acquiring knowledge related to agriculture (Table 2.)
c. **Basics of agricultural economics and entrepreneurship subject group:** This knowledge underpins the application of digitization in agriculture and business (Table 3.).
d. **Knowledge of agricultural digitization subject group:** These objects underpin the use of digitization tools and methods used in agriculture and business. The differentiated professional knowledge subject group is based on this (Table 4.).
e. **Differentiated professional knowledge subject group:** Students can get specialized knowledge based on previously acquired basic knowledge (Table 5.).
f. **Free choice of the subject group:** Students can choose 3 subjects from courses of other faculties: The 3 faculties, which also participated in in the training, are the Faculty of Economics, Faculty of Agriculture, Food Science and Environmental Management, and the Faculty of Informatics.

According to our plans, in the initial period, the new training can start at about 20-40 people, which according to the Ministry has a serious future. With the training and agriculture ICT, practice-oriented training can start at the University of Debrecen. The possible

Table 1. Basic of Economy group subjects, hours, credits

ID	No.	Subject name	Hours	Credit
A	1	Economic mathematics	60	**4**
A	2	Economics	60	**5**
A	3	Statistics	60	**5**
A	4	Economic law	30	**3**
Basic of Economy total credit				**17**

Table 2. Agronomy basic knowledge group subjects, hours, credits

ID	No.	Subject name	Hours	Credit
B	5	Basics of agricultural production I.	45	**4**
B	6	Agricultural technical knowledge	60	**5**
B	7	Basic knowledge of horticulture	60	**4**
B	8	Basics of agricultural production II. (Crop production)	45	**4**
B	9	Basics of agricultural production III. (Animal husbandry)	45	**4**
B	10	Environmental management	30	**3**
Agronomy basic knowledge total credit				**24**

Table 3. Basics of agricultural economics and entrepreneurship knowledge group subjects, hours, credits

ID	No.	Subject name	Hours	Credit
C	11	Financial basics	60	**4**
C	12	Basics of accounting	60	**4**
C	13	Agricultural and rural economics	45	**4**
C	14	Agronomy management I	45	**3**
C	15	Agronomy management II	45	**3**
C	16	Business planning and analysis	45	**4**
Basics of agricultural economics and entrepreneurship total credit				**22**

Table 4. Knowledge of agricultural digitization group subjects, hours, credits

ID	No.	Subject name	Hours	Credit
D	17	Basic of agricultural digitization I.	60	**5**
D	18	Basic of agricultural digitization II.	60	**5**
D	19	Data processing and visualization	45	**4**
D	20	Agricultural database systems	45	**4**
D	21	Agricultural management systems	45	**4**
D	22	Livestock farm management systems	45	**4**
D	23	E-commerce and marketing	45	**4**
D	24	TQM in agribusiness	45	**4**
D	25	Supply chain management and logistics	45	**4**
D	26	IT project management	45	**4**
Knowledge of agricultural digitization total credit				**42**

Table 5. Differentiated professional knowledge group subjects, hours, credits

ID	No.	Subject name	Hours	Credit
E	27	Sector information systems	60	**5**
E	28	Agricultural management systems	45	**4**
E	29	ICT support for food safety	45	**4**
E	30	Basics of supply chain management	45	**4**

E	31	Environmental monitoring and IT background	45	**4**
E	32	Specialized sector information systems	45	**4**
E	33	ICT support for agricultural knowledge management	45	**4**
E	34	GIS and remote sensing	45	**4**
E	35	SME adaptation of integrated corporate governance systems	45	**4**
E	36	Precision agriculture	45	**4**
E	37	Management of value creation processes	45	**4**
Differentiated professional knowledge total credit				**45**

Training and Output Requirements (TOR)of the Agri-digitalization engineer

The Training and Output Requirements are an important part of a new degree because the subjects must meet this. In the following sections we summarize it:

- Learns in detail the concepts, laws, processes and contexts of economics and the micro and macro levels of organization of the economy/agriculture, as well as the terminology of related fields. He is well acquainted with agricultural economics vocabulary, the peculiarities of written and spoken language communication.
- Understands the structure, operation and cross-border of national and national relations, information and motivation factors of economic organizations, especially concerning the institutional environment. Knows the general and specific characteristics of the agricultural economy, its borders, the most important development directions, the connection of agriculture to the economic and business sphere.
- Is aware of the operation and development, administrative, accounting and financial background of the agribusiness sector. Has a comprehensive knowledge of the most important agricultural digitization tools, administration, planning, analysis and site management software used in agriculture.
- Knows the process of European integration and the policies of the European Union related to its activities. Has a comprehensive knowledge of the domestic and European Union legal regulations related to the agricultural economy.
- Knows the planning and management rules, professional and ethical norms of projects managed by agricultural enterprises and other economic organizations. Has the knowledge required to prepare project plans and EU and/or domestic funded applications individually or in groups.
- Knows and understands the system of domestic and EU administration related to the operation of the Hungarian agricultural economy, as well as the processes taking place in his field and the connections between them.
- Knows the peculiarities of the operation of rural and regional development (the role of agriculture in maintaining and developing the countryside) and the reasons for the peculiarities. Knows the relationship between human well-being and the agricultural sector, the cultural relations of the agricultural sector, its cross-cultural role and traditions. Knows the relationship between the rural economy, society and the agricultural sector, the social necessity of community development, the related environmental policy contexts.
- Is aware of land use, ecological and integrated production technologies, especially precision farming. Knows the professional and financial conditions and principles of the feasibility of innovative developments in a sustainable food economy in economic/social/ecological terms. Knows the evaluation of the financing sources required for the implementation of developments/investments and the methodology of financial return analyzes.
- Is aware of the modern, theoretically demanding mathematical-statistical, econometric and modelling methods of problem recognition, formulation and solution, information collection and processing, as well as their limitations. Knows and uses quantitative and qualitative analysis and software-supported methods of agroeconomic research. Knows the specific research methods of agricultural economics, abstraction techniques, the ways of elaborating the practical aspects of the theoretical issues, the methods of planning, measuring and analyzing the sub-areas. It has the range of knowledge required to enter a master's degree in economics.

3. Further study opportunities after completing the BSc course

Students can choose from several master's programs based on the basic course of agricultural and business digitalization. Perhaps the most recommended master's program for students graduating in this major is the Master in Supply Chain Management, which is also related to our institute. Besides, of course, students can choose from several master's programs of the Faculty of Agriculture, Food Science and Environmental Management.

Our previous students regularly participated in the applications of the Hungarian Agricultural Informatics Association's dissertation and diploma thesis with their dissertations of an agricultural informatics nature and achieved valuable places, as well as presented lectures at the annual agricultural informatics summer university and conference organized by the professional organization and our faculty. We intend to continue to encourage and assist this in the future after the launch of the new program.

During the training, an important task is to recognize and embrace the quality educational needs of students who show outstanding professional skills and interest in listening to core subjects as well as differentiated professional knowledge. Further widening the interest of students with excellent progress in departmental and institute workshops, participation in demonstration tasks, Scientific Student Associations activities, and the preparation of diploma theses. As a result of talent management, these students become eligible to pursue their PhD studies upon completion of an MSc program at a Faculty or Fellow Faculty. One important outcome of talent management can be to obtain a PhD degree. During their PhD studies, these students become involved in university BSc, education, and can pass on the approach developed during their training. Among them, the young and agricultural and business digitization teachers and researchers can be selected from among the young people.

Summary

The scope and direction of digitization in agriculture need a reaction to higher education. The main contribution of this paper is to highlight the importance of digitization and also suggest a BSc level curriculum. With the suggested BSc course the benefits of ICT can be approved in agriculture. As has been shown, data-driven innovations in agriculture have become unavoidable and a modern entrepreneur have to know about it and also try to apply it. The digital communication and massive volumes of data from the farmers and rural economies have possibilities to improve the level of production. It can be expected that the implementation of ICT in agriculture will vary depending on local capacities and strategies, but those farms that will turn into fully networked and digitized businesses will be better economic position. Without enhanced education, the digitization opportunities in agriculture might not be fully realized. It would be therefore important to communicate all opportunities and challenges related to the use of digitization in agriculture. Farmers exchanging information and data through internet support the establishment of digital agriculture.

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Hungarian Association of Agricultural Informatics
European Federation for Information Technology in Agriculture, Food and the Environment

Journal of Agricultural Informatics. Vol. 11, No. 2
journal.magisz.org

Utilisation of Web2.0 technologies among undergraduate agricultural students of higher educational institutions in Osun State, Nigeria

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INFO
Received 04.02.2021
Accepted 14.01.2021
Available on-line: 09.02.2021
Responsible Editor: L. Varaallyai

Keywords:
Utilization, Web2.0 Technologies, Agricultural Students,

A B S T R A C T

This study interrogated agricultural students' usage of Web2.0 technologies in higher educational institutions in Osun State, Nigeria.A validated interview schedule was used to collect data from 360 respondents who were selected through a multi-stage sampling procedure while descriptive satistics like mean and inferential like Pearson Correlation were used to sumarise and make inference from the data respectively. The mean age of the respondents was 22.7±2.8 years and the majority (91.7%) were single. Also, the mean years of schooling were 18.07± 2.25 years while their mean monthly income was $40.06±$23.11. Also, more than half (55.80%) of the respondents had a high level of awareness about Web 2.0 technologies while about 62 percent of the respondents had a moderate level of Web 2.0 technologies usage. The findings revealed that at p<0.01, awareness level (r = 0.727) and monthly income (r = 0.124 *had a significant relationship with agricultural students' level of usage of Web2.0 technologies. The study concludes that respondents had a moderate level of usage of Web 2.0 technologies.*

1. Introduction

Agricultural information dissemination is an important function carried out in agricultural extension to connect agricultural stakeholders with the latest technologies needed for optimum performance that would result in the development of the community at large. Information and Communication Technologies (ICT's) have revolutionized every aspect of life thus making it easier to overcome time and distance impediments in the dissemination of agricultural information (Collence, 2012). Worthy of note among the communication technologies used for agricultural information dissemination purposes is the *Web2.0* technologies. The *Web 2.0* technology is variously defined. These defintions however converge arround issues of attributes, functionlity, and agencement. For instance, O'Reilly (2005), while acknowledging that the technology is of the second generation of the "World Wide Web" and web design, indicated that its aims are to enable creativity, faciliatate information sharing, and boost collaboration among users. Barsky (2006) in Mohammad (2011), on the other hand, explored the human experience dimension of the *Web 2.0* and suggested that the technology somewhat allows for equitable agencement as depicted by its chacteristics such as "open communication, decentralization of authority, and increased freedom for users to share and reuse content". Similarily, Richardson (2006) and Ikenwe *et al.* (2019) underscored the enhancement of agency of the users . The authors, at different times, noted not only the easy accessibility or usability of the technology by the users but also the increased latitude it gives to the users in terms of modifying or adding to its contents through reading/writing, among others. Hence, *Web 2.0* is concerned with many different things at the same time: ideas, technologies, behavioural patterns,

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ideals, goals and cultures (Anderson, 2007). It encompases creating, manipulating and sharing information as well as enabling collaboration and interaction among information service users (Burke, 2009).

Various organizations have utilized the *Web2.0* technologies in training, seminars and conferences aimed at introducing and sustaining agricultural and rural development globally. Ashley, Corbett, Garside, Jones and Rambaldi, (2009) noted that *Web2forDev* was "a term used at the Web2forDev International Conference organized by the Technical Centre for Agricultural and Rural Cooperation (CTA) and other development partners in Rome at Food and Agricultural Organization in September 2007." *Web2forDev* is about encouraging the active use of these tools in development (Ashley *et al.*, 2009). These tools which include blogs (political Blog), Social networks (Facebook, Twitter, WhatsApp, to mention a few.), video sharing (YouTube), audio sharing (Podcast), mobile sites (2go, WhatsApp), image or picture sharing (flicker), Voice over Internet Protocols (VoIP services) among others, have the capacity of boosting participation in the communication process because of their open, conversational nature, connectedness and textual and audio-visual characteristic appeals Abubakar (2011). The ability of *Web 2.0* technologies to transform education landscape is not in doubt. Hartshorne & Ajjan (2009) and Rogers-Estable (2014) posited that the technologies have the capacity to improve teching-learning process through effective d sharing of information among various groups of scholars such as techers and students, mentors and mentees. According to Bonk, (2009), *Web2.0 technologies* have revolutionized education to the extent of emerging as platforms to encourage users to be collaboratively creating and sharing their insights into current and emerging themes within their environment.

Studies of the potentials of Web 2.0 technologies for agricultural development conducted in Nigeria revealed that "the web2.0 tools were used for the purposes of leisurely entertainment, to watch films, discuss serious national issues like politics, economy, and religious matters. The use of this technology for agricultural discuss was very minimal" (Ezeah, Euphemia, Asogwa and Obiorah, 2013). Mtega, Dulle, Malekani, & Chailla (2014) noted from their study that the *Web2.0* technologies were very useful for agricultural knowledge creation and information sharing in Tanzania. The *Web2.0* tools were used to send information from the extension agents to farmers on the latest technologies while feedbacks were sent from the farmers to the extension agent. YouTube and other video tools were used to teach them new techniques for planting and harvesting. Collence (2012) noted that farmers in Zimbabwe have begun to exploit the numerous opportunities that *Web 2.0* technologies provide such as using social media to share information on the cultivation of crops. Furthermore, a survey of higher learning institutions across five countries (Australia, the Netherlands, South Africa, the United Kingdom and the United States of America) revealed that *Web 2.0* technologies were deployed across all areas in higher education including academic, administrative and support areas for disseminating information (Kelly, 2008). The UK and Netherlands lead the way in enabling use, through supporting national infrastructure developments. In the United States, *Web2.0* tools (such as blogs, Facebook, LinkedIn, Twitter, YouTube) are "emerging for more two-way (or even multi-directional) collaboration and learning between extension experts, entrepreneurs and farmers that creates new space for relationship building and innovation" (Cornelisse, Hyde, Raines, Kelley, Ollendyke, & Remcheck, 2011; Fisher, 2011; Gilbert, Karahalios, & Sandvig, 2010). Agricultural videos and audio scripts from around the world are being collected in searchable web portals such as YouTube (Chowdhury *et al.,* 2013) which are being used for training purposes.

In spite of these promising prospects of the *Web 2.0* technologies in agricultural information generation and transfer among various users globally, little fact is known about the usage of this technology for agricultural information dissemination among agricultural students in Osun State, Nigerian hence this study.

1.1. Objectives of the study

The main objective of this study is to assess agricultural students' usage of *Web2.0* technologies in higher educational institutions in Osun State, Nigeria. The specific objectives of the study were to

1. describe the socio-economic characteristics of Web2.0 technology users in higher educational institutions in Osun State;
2. determine the level of awareness of Web2.0 technology users in higher educational institutions in Osun State; and
3. determine the level of usage of Web2.0 technology in higher educational institutions in Osun State.

Hypothesis of the study

There is no significant relationship between some selected variables and agricultural students' and their level of usage of *Web2.0* technologies in the study area.

2. Material and methods

Osun State is the six States of South west geopolitical zones of Nigeria, The study area was located within longitude 2.750 and 6.750 Greenwich meridian and latitude 70 and 90. Osun State has one Federal, one State, six Private Universities and two State Colleges of Education. They are one Federal University (Obafemi Awolowo University, Ile-Ife), one State University (Osun State University, Osogbo), Seven private University (Joseph Ayo Babalola University, Ikeji-Arakeji, Bowen university, Iwo; Kings University, Ode-omu; Fountain University, Osobgo, Oduduwa University, Ipetu-Modu, Adeleke University Ede; and Redeemer University, Ede), and two State College of Education (Osun State College of Education, Ilesa and Osun State College of Education, Ila). The population of the study comprised of 3556 agricultural students across the selected institutions. A two-stage sampling procedure was adopted for the study. At the first stage, four higher institutions, that is, one Federal University (Obafemi Awolowo University), one State University (Osun State University), one private University (Joseph Ayo Babalola University), and one State College of Education (Osun State College of Education, Ilesa) were purposively selected based on their offering of the agricultural courses and for equal representation. At the second stage, 10 percent of all the agricultural students in the selected institutions were randomly selected based on their numerical strength, making a total of 360 respondents which translate to 185 respondents from Obafemi Awolowo University, 152 respondents from Osun State University, 13 respondents from Joseph Ayo Babalola University (JABU), and 10 respondents from Osun State College of Education (COE) were interviewed. Data collected were analyzed using descriptive statistical tools such as frequency counts, percentage, mean and standard deviation while inferential statistics such as Chi-Square and Pearson Product Moment Correlation (PPMC) were used to test the hypotheses.

2.1. Measurement of variables

The dependent variable for the study is usage of the *Web2.0* technologies. It conceptualized as the extent to which the agricultural students were using *Web2.0* technologies. This was measured using a utilization score which was calculated following the pattern used by Ayodele (2015). The score was obtained from the summary of the students' responses to selected questions on the frequency of utilization of *Web2.0* technologies. Respondents were asked to indicate the extent of utilizing *Web2.0* technologies using a-8 point scale ranging from Never (0), Annually (1), Biannually (2), Quarterly (3), Monthly (4), Fortnightly (5), Weekly (6), and Daily (7). The maximum usage score was therefore 98 while the minimum usage score was 0. Equal interval approach was used to divide the scores and group the respondents into low (≤36.7), moderate (36.7-65.2) and high (≥65.2) usage level categories. The mean score and standard deviation were also calculated. On awareness, the respondents were asked if they are aware of each of the technologies. Their responses were rated on a four point scale as "not aware" (0), "heard about" (1), "seen" (2), and "experienced" (3). Since it requires progressive responses, the maximum obtainable score was 3 multiplied by the 14 *Web 2.0* tools listed which gave 42. The mean score and standard deviation for the respondents were calculated and the tools were arranged in descending order of their mean to determine the level of awareness of each tool. The aggregate score was used to calculate the overall mean score of the respondents and this was used to categorize the respondents into overall level of web 2 tools awareness. Respondents with overall mean score of ≤ 1.44 were categorized as having low awareness (heard); 1.45 – 2.44 were categorized as having moderate awareness (seen); while ≥ 2.45 were categorized as having high level of awareness (experienced). This was based on the approach used by Mtega *et al*. (2014) to identify the level of awareness among respondents in the use of *Web 2.0* technologies in sharing agricultural knowledge in Tanzania.

3. Results and discussions

3.1. Socio-Economic Characteristics of Respondents

The results in Table 1 showed that the mean age of the respondents in the study area was 22.67±2.76 years. This was expected given the fact that most young people of this age category were expected to be in the higher educational institutions as undergraduate students. This agrees with the submission of Adesoji *et al,* (2018) the mean age of undergraduate agricultural students was 23 years. This implies that young people with their characteristic traits of innovativeness and creativity would be keen to acquire new knowledge and skills on the use of *Web 2.0* technologies for agricultural purposes. This finding is similar to the findings of Tapscot (2006) and Procter *et al.* (2010) who observed that the usage of *Web 2.0* technologies is often associated with urban, younger and more technological savvy users who are eager to learn and make use of these new technologies. A huge proportion of (91.7%) of the respondents were single. These results indicate that as undergraduate students, majority of the respondents were single, still very young and may not have the means to support a family yet as a result of their educational pursuit. The implication is that the high proportion of the respondents who were singles were more likely to acquire knowledge on the use of Web2.0 technologies to promote agricultural information dissemination to the end-users. This validates the findings of Moro (2013) that the majority (77.7%) of the students using *Web 2.0* technologies in the Kenya School of Computing and Informatics were single. The majority (79.4%) of the respondents were Christians. The results showed that all the respondents had one religious affiliation or the other. This implies that religious affiliations did not constitute a hindrance to the use of *Web 2.0* technologies by the agricultural students in the study area and the various religions had no prejudice against the use of *Web 2.0* technologies. Besides, the mean household size of the respondents was 7±3 persons. This shows that a large proportionof the agricultural students in the study area belonged to households whose sizes were larger than the national average household size of 5 persons (National Bureau of Statistics, 2016). This implies that more than half of the agricultural students belong to a family with large household sizes having a large number of dependent relatives. This could affect the number of resources available to each agricultural student to purchase internet data for surfing the web, hence limit the use of *Web 2.0* technologies by these agricultural students. Also, the majority (86.9%) of respondents were from the monogamous family. This shows that the majority of the agricultural students were from the monogamous family, thereby making it possible for them to enjoy good attention from their parents and possibly get more funds, and other resources needed for their use of these *Web 2.0* technologies. Besides, the mean monthly income of the respondents was \$40.06±\$23.11. This implies that the majority (91.7%) of the respondents earned, at most, \$75.87 monthly as allowance or income from stipends, salary and/or gift. The implication of this is that the agricultural students are most likely to have some funds to be used on the acquisition and maintenance of gadgets that support the use of *Web 2.0* technologies for various uses. Also, the mean years of schooling experience were 18.07± 2.25 years. This implies that most of the agricultural students were literates and most likely able to determine the type of *Web 2.0* technologies needed to meet their communication needs. Also, they were most likely able to use the *Web 2.0* tools as prescribed by their manufacturers, especially because they are literates. The findings were in line with the submissions of Stutzman (2006) and Yoo *et al.* (2011) which indicated that users' literacy is capable of influencing the effective use of *Web 2.0* applications because college students have been found to use these applications more recently than ever both in and out of their classrooms.

Table 1. Distribution of agricultural students by socio-economics characteristics

Variables	Frequency (f)	Percentage (%)	(n = 360)
Age (years)			
≤20	81	22.5	
21-30	273	75.8	Mean = 22.67
≥31	6	1.7	SD = 2.76
Sex			
Male	162	45.0	
Female	198	55.0	
Religion			
Christianity	286	79.4	
Islam	71	19.7	
Traditional religion	3	0.8	
Marital Status			
Single	330	91.7	
Married	30	8.3	
Household size			
≤ 5	121	33.6	
6 – 10	208	57.8	Mean = 6.74
≥ 11	31	8.6	SD = 3.30
Family type			
Monogamy	313	86.9	
Polygamy	47	13.1	
Income ($)			
≤25.29	156	43.9	
25.29- 50.58	144	40.0	Mean = 15,839.03
50.59- 75.87	37	10.3	SD = 40.06
≥75.88	21	5.8	
Years of schooling			
≤ 12	3	0.8	
13 – 16	94	26.1	
17 – 20	222	61.7	
≥ 21	41	11.4	

Source: Field survey, 2018
SD = Standard deviation. *Multiple choice

3.2. Level of awareness of respondents on the *Web 2.0* technologies

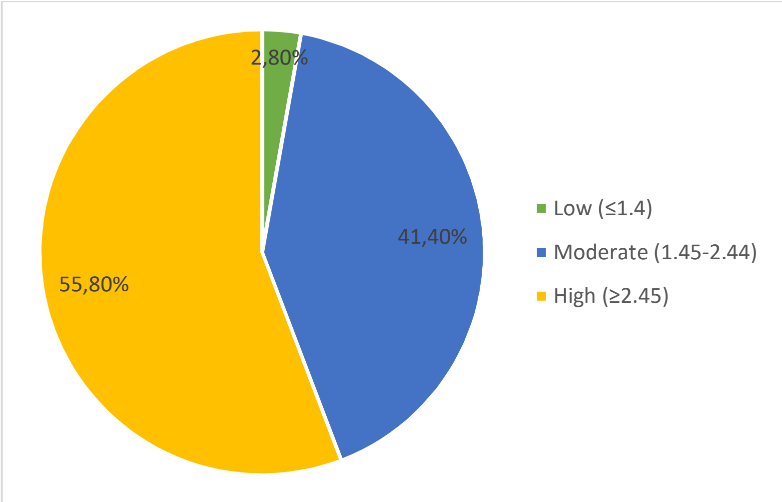
Results in Table 2 showed the mean score of the respondents which was used to categorize their levels of awareness into three, i.e., high, moderate and low. The result indicated that the respondents had high awareness of Facebook (Mean = 2.97), WhatsApp (Mean = 2.95), YouTube (Mean = 2.77), BBM (Mean = 2.72), Instagram (Mean = 2.59) and Google Plus (Mean = 2.57), while respondents had moderate awareness of Twitter (Mean = 2.38), Blogs (Mean = 2.19), Skype (Mean = 2.10), Wikis (Mean = 1.52) and Google Sheets (Mean = 1.45). The result also indicated that the respondents had low awareness of Dropbox (Mean

= 1.17), ResearchGate (Mean = 0.82), and Soundation (Mean = 0.39). The overall results indicated that the respondents were more aware of Facebook, WhatsApp, YouTube, BBM, Instagram and Google Plus. The implication of these findings is that agricultural students were likely to have more knowledge of Facebook, WhatsApp, YouTube, BBM, Instagram and Google Plus in relation to agricultural information dissemination than other *Web 2.0* technologies whose awareness level were low, such as Dropbox, ResearchGate, and Soundation.
Further analysis revealed the general levels of awareness of the respondents about the *Web 2.0* technologies as shown in Figure 1. This finding reveals that more than half (55.80%) of the respondents had high awareness about *Web 2.0* technologies, 41.40 percent of the respondents had moderate awareness while the rest (2.80%) had low level of awareness about the *Web 2.0* technologies. This result indicate that more than half of the respondents had heard, seen and experienced the *Web 2.0* technologies. The aggregate mean was 28.59±6.30. The implication of this high level of awareness about *Web 2.0* technologies like Facebook, WhatsApp and YouTube is that agricultural information or messages can be easily prepared and packaged by the students and delivered to the farmers using these technologies upon graduation. These findings are in consonance with the submission of Mohammad (2011) that students of higher educational institutions in Kuwait were highly aware of *Web 2.0* technologies such as YouTube, Facebook, Wikis and Twitter.

Table 2. Mean score and standard deviation for level of awareness of *Web 2.0* technologies

***Web 2.0* Technologies**	**Mean**	**SD**	**Remark**
Facebook	2.97	0.27	High
WhatsApp	2.95	0.30	High
YouTube	2.77	0.60	High
BBM	2.72	0.59	High
Instagram	2.59	0.71	High
Google Plus	2.57	0.83	High
Twitter	2.38	0.82	Moderate
Blogs	2.19	1.02	Moderate
Skype	2.10	1.00	Moderate
Wikis	1.52	1.27	Moderate
Google Sheets	1.45	1.18	Moderate
Dropbox	1.17	1.09	Low
ResearchGate	0.82	1.06	Low
Soundation	0.39	0.82	Low

Source: Field survey, 2018



Aggregate mean = 28.59 ± 6.30
Figure 1. General levels of awareness of the respondents about *Web 2.0* technologies
Source: Field survey, 2018

3.3. Level of usage of web2.0 technology

Results in Table 3 showed the mean scores for the frequency of use of the *Web 2.0* technologies by the respondents. It was observed that Whatsapp was used daily (Mean = 7.89) while Facebook was used weekly (Mean = 7.36). The respondents used BBM (Mean = 6.32), Google plus (Mean = 6.29) and Instagram (Mean = 5.90) fortnightly, while Wikis (Mean = 5.38), YouTube (Mean = 5.22), Blogs (Mean = 5.10) and Twitter (Mean = 4.87) were used monthly. It was also observed that Dropbox (Mean = 4.41), Research gate (Mean = 3.84) and Skype (Mean = 3.55) were used quarterly, while Soundation (Mean = 2.80) and Google Sheets (Mean = 2.52) were used biannually.

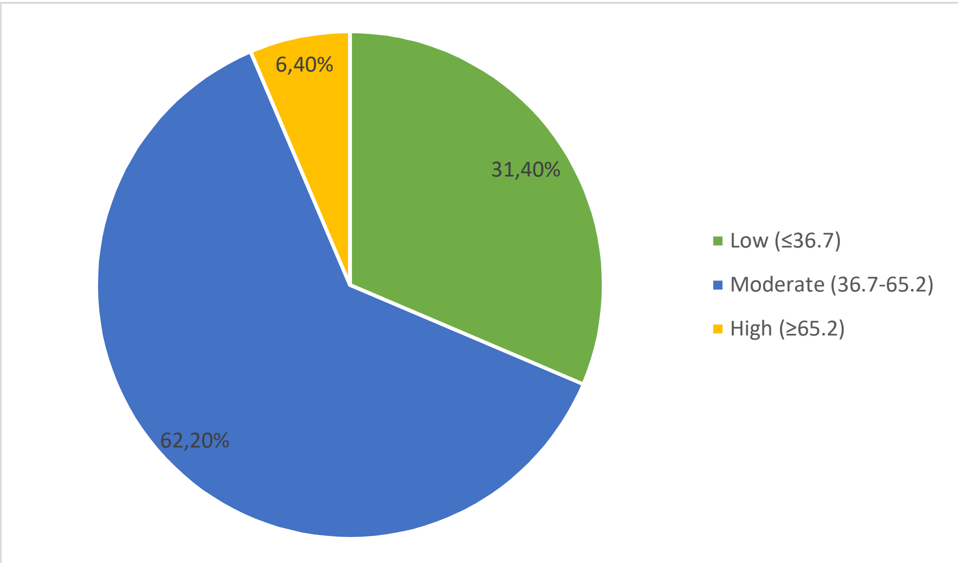
These results imply that Whatsapp and Facebook were the most frequently used *Web 2.0* technologies on daily basis by these agricultural students. This might be due to the social and easy-to-use nature of the tools, coupled with the low cost involved in accessing them, considering the low level of income of the agricultural students. This is in line with the finding of Nesta and Mi (2011) and Baro *et al.* (2013) which observed that Whatsapp and Facebook were among the *Web 2.0* technologies most frequently used by students in Nigerian Universities. This imply that if agricultural information are channeled through these tools, it will be easier for them to disseminate such information to the end-users especially among young agriculturist.

Furthermore, the results in Figure 2 showed the distribution of the respondents based on their total *Web 2.0* technologies usage score. Results show that 62.2 percent of the respondents had a *Web 2.0* technologies usage score of between 36.7 and 65.2 (moderate level), 31.4 percent had a usage score of ≤ 36.7 (low level), while 6.4 percent of the respondents had a usage score of ≥ 65.3 (high level). The mean score was 77.12 ±28.16. This implies that many of the respondents (62.2%) used *Web 2.0* technologies on a moderate level. A probable reason for the moderate use of these *Web 2.0* technologies by the respondents could be the level of resources available to acquire and maintain the tools. This finding corroborates the conclusion of Yakubu *et al.* (2013) from the study of ICT usage among Extension Agents in Kano State that the respondents used *Web 2.0* technologies on a moderate level. This finding is in tandem with the conclusion of Ward *et al.* (2009), which noted that students of higher educational institutions in the United Kingdom were moderate in their use of *Web 2.0* technologies.

Table 3. Frequency of usage of *Web 2.0* technologies

***Web 2.0* technologies**	**Mean**	**Std. Deviation**
WhatsApp	7.89	0.747
Facebook	7.36	1.656
BBM	6.32	2.665
Google plus	6.29	2.069
Instagram	5.90	2.702
Wikis	5.38	2.140
YouTube	5.22	2.500
Blogs	5.10	2.473
Twitter	4.87	2.850
Dropbox	4.41	2.399
Research Gate	3.84	2.517
Skype	3.55	2.624
Soundation	2.80	2.533
Google sheets	2.52	2.508

Source: Field survey, 2018



Grand mean = 77.12±28.163

Figure 2. Overall usage level of *Web 2.0* technologies by the respondents **Source:** Field survey, 2018

3.4. Relationship between selected variables and agricultural students' level of usage of *Web2.0* technologies

The results in Table 4 showed that only religious affiliation (χ^2 = 21.891, C = 0.239) had significant association with agricultural students' level of usage of *Web2.0* technologies at 0.01 level of significance. This implies that only religious affiliation could influence agricultural students' level of usage of *Web2.0* technologies in the study area. Furthermore, results in Table 5 showed that awareness level (r = 0.727) and monthly income (r = 0.124) had positive and significant relationship with student's usage of *Web2.0* technologies. The result also showed that the higher levels of awareness of the respondents to *Web 2.0* technologies, the higher their level of usage of the tools. This is also not surprising because a good level of awareness would encourage them to use the tools. Most people would use what they have been aware of. This is in line with the findings of Adesoji *et al.* (2020) that high level of awareness of innovation/technologies influence usage of that technologies. Also, the higher the monthly income of the respondents, the higher their level of usage of *Web 2.0* technologies. This is not surprising because most of the tools require financial resources to acquire and maintain them, which could be difficult to do if the income of the users were low.

Table 4. Results of Chi-Square analysis between socio-economic characteristics of respondents and respondents' level of usage of *Web2.0* technologies

Variables	χ^2 Value	Contingency coefficience (C)	Sig.
Sex	1.096	0.055	0.578
Religion	21.891*	0.239	0.000
Marital status	2.890	0.089	0.236
Family type	0.427	0.034	0.808

* - Significant at P ≤ 0.01 level **Source:** Field survey, 2018

Table 5. Results of Correlation analysis between some selected variables of agricultural students and their level of usage of *Web 2.0* technologies

Variables	r – value	Sig. Level
Age of respondent	0.038	0.470
Household size	0.040	0.453
Number of years of formal schooling	0.017	0.752
Monthly income	0.124*	0.020
Awareness score	0.727**	0.000

** - Significant at P ≤ 0.01 level * - Significant at P ≤ 0.05 level
Source: Field survey, 2018

Conclusion

Based on the findings of the study, it was concluded that the majority of the respondents were male and single, in their early twenties and from low income earning background. The majority of the respondents had a high level of awareness of Web 2.0 technologies such as Facebook, WhatsApp, YouTube, BBM, Instagram, and Google Plus. While awareness was low in Dropbox, Researchgate and Soundation. Also, the majority of the respondents rated Whatapps as daily used Web 2.0 technology while Soundation and Google Sheets were used less frequently. Besides, they had a moderate level of utilization of these technologies. Monthly income and awareness level had a significant influence on student's utilization of Web 2.0 tools. The income relationship with utilization implies that inequality exists in the utilisation of the technology which would widen the gap between the haves and have nots. It is therefore recommended that government and other stakeholders should put in place an adequate interventionist programme that would subsidize the data cost of accessing the technology among students of the higher educational institutions in Nigeria.

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