ADOPTION OF PRECISION AGRICULTURE TECHNOLOGIES IN ETHIOPIAN AGRICULTURAL CONTEXTS: A REVIEW
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ABSTRACT

In the coming decades, world agriculture will need to under-go a major transformation to meet the future demands of a growing population. Adoption of precision agriculture by smallholder farmers is still at a nascent stage and is limited by several factors. Smallholder farmers suffer from low farm productivity and yields as well as lack of access to inputs, credit, and markets; the lack of digital infrastructure like Internet and electricity; lack of awareness and digital skills among farmers; and societal barriers like gender. Thus, the main objective of this study is to determinants of adoption of PAT and to build a conceptual framework that consolidates the determinants of adoption of PAT by Ethiopian farmers. It can help to precisely level land, correct seeding, and application of the right amount of fertilizer, irrigation water, and pesticide based on the plant need. Digital technologies are making precision agriculture solutions increasingly affordable and accessible to even smallholder farmers in developing countries. These include mobile phones, remote sensing using satellites and unmanned aerial vehicles (UAVs), and sensors and the Internet of things (IoT) - all enabled by advances data processing and analytics.

Keywords: Artificial Intelligence, Digital Agriculture, Precision Agriculture

INTRODUCTION

Over the past few decades, agricultural production has progressed from the machinery age to the information age with the growing use of precision agriculture (Reichardt and Jürgens, 2009). FAO (2018) by 2050, the food industry will have to face the daunting challenge of feeding about 10 billion people by almost doubling its food supply in a sustainable way.

The Ethiopian land holding is less than one hectare in the highlands and a bit more in Afar, Gambelia, and Somali Regions. Hence, adoption of precision farming may be difficult, as the technology requires large farms of at least 60 hectares. However, the current system of cluster-based farming for a single commodity (several hundred farmers clustered to grow a single crop variety) may open the possibility of adoption for site-specific input application (Berhanu M., 2019)

Ethiopia Is Importing 30% of Wheat, 70% of Sugar and Rice, and 85% of the Vegetable Oil annual Demand from Abroad. This has brought a Huge Burden for the Economy Which Otherwise Would Have Been Used for Development. Hence The Government of Ethiopia has A Project to Intensify the Productivity of Wheat in the Highlands and Increase the Area of Wheat Production in the Lowlands of Afar, Wabe Shebelle and Omo Valleys Using Irrigation (Agegnehu et al., 2017).

In Ethiopia, since large- and small-scale farmers are using furrow (Agegnehu et al., 2016) and flood irrigation that resulted (Zeleke et al., 2010) Ethiopia has been one of the countries affected by soil sanity in the world (IFPRI, 2010). Adoption of precision agriculture by smallholder farmers in Ethiopia is still at a nascent stage and is limited by several factors. In addition to high costs, other key barriers include the lack of digital infrastructure like Internet and electricity, lack of awareness and digital skills among farmers, and societal barriers like gender. Finally, lack of digital skills and literacy among smallholder farmers remains a major barrier in leveraging the potential of digital technologies. Shortage of land per household is severe and land degradation is widespread in the highlands of Ethiopia. The fertilizer rate and type used for many crops is based on blanket recommendation with limited site-specific information (Agegnehu et al., 2016; Zeleke et al., 2010). This paper provides a synthesis of the level, practice, and future perspective of precision agriculture as well as the need and benefit of introducing the technology into the Ethiopian agriculture production system.

MATERIALS AND METHODS

Study area and the data

The study was conducted in the Haramaya University; & Adama science and Technology University, Oromia Regional state, Ethiopia. Haramaya, and Adama district and data on precision and non-precision farming's were collected Using structured interview schedule, both qualitative and quantitative primary data were gathered from FRG participant farmers and nonparticipant farmers. Interview schedule and group discussions have been conducted to gather information of demographic characteristics, socioeconomic, institutional dimensions to find out the determinant factors of adoption of precision Agriculture during the year 2020/21.

A secondary Data Search was conducted through the Web of Science (Apps. web of knowledge.com), Google Scholar (scholar.google.com), AGRIS (agris.fao.org), Research Gate (https://www.researchgate.net), Ethiopian Journal of Agricultural Sciences, The Ethiopian Society of Soil Science (www.esss.org.net), and Libraries of the Ethiopian Institute of Agricultural Research and National Soils Research Center. Several Publications that Provide Empirical Evidence on Precision Agriculture were reviewed in this paper.

Data Analysis

Collected data was analyses with the help of ANOVA, & SWOT Analysis.

Table 1. Determinants of Precision Agricultural Technology Adoption.

Categories	Variables
Socioeconomic Factors	Age, Education, Family Size, Activity Experience, Ability to obtain and process information, network, credit, risk aversion, producer organization level, farm management
Agro-Ecological factors	Land domination, farm specialization, total area, revenue, variable rate fertilizer application, livestock sales, asset / liability ratio, value of production, yield, corporate structure, income, and farm profitability, quality of soil, % of primary crop of the total area, % of the total area harvested area, % of the farm area divided by municipal area, activity / non-agricultural employment, and others.
Institutional Factors	Distance from the fertilizer distributors, Region, using of future contracts, development pressure and distance to the main market.

RESULTS AND DISCUSSION

Table 2. Distribution of non-FRG member's respondents by adoption Category of precision technologies.

Adoption Category	N	percent	Adoption index score	Mean	SD	F	P
Non-Adopter	50	65.8	0.00-0.000	0.00000			
Low-Adopter	22	28.9	0.01-0.30	0.4670	0.06858		
High-Adopter	4	5.2	0.31-1	0.0956	0.00762		
Total	76	100	0.00-1	0.2212	0.22124	34.47***	0.000

Table 3. Distribution of FRG member's respondents by adoption Category precision technologies.

Adoption Category	N	percent	Adoption index score
High	54	100	1
Total	54	100	

Table 4. Education statuses of sampled respondent.

Adoption Category	Illiterate	Read & write	1-4	5-8	9-10	>10	Total	χ^2	P
Non-Adopter	18	12	10	3	6	1	50		
Low-Adopter	2	2	8	5	2	3	22		
High-Adopter	3	6	9	16	10	14	58		
Total	23	20	27	24	18	18	130	17.25a	0.004

Table 5. Non-FRG Land holding of sampled respondents.

Land in hectare	Adoption Category	N	Mean	SD	t	P
	Non-Adopter	50	0.36	0.351		
	Low –Adopter	22	0.66	0.182		
	High-Adopter	4	1.0	0.204		
	Total	76	0.480	0.237	17.65***	0.000

***, significant at 1% probability level.

Table 6. FRG members Land holding of sampled respondents.

Land in Categories hectare	Adoption	N	Mean	SD	t	P
Total land holding	High-Adopter	54	0.86	0.246		
	Total	54	0.86	0.246	26.09***	0.000

***, significant at 1% probability level.

Table 7. Variable Coefficient.

Variable Coefficient	Estimated	Standard error	T	P=value
AGE	- 0.0013105	0.9966604	- 0.03	0.897
EDU	0.185146	0.0857708	1.88**	0.040
LANHO	0.1023712	0.0271121	2.81***	0.000
LIVSTO	0.0002305	0.0268286	0.01	0.881
ACESSAGRES	3257437	.0772683	3.38***	0.000
ACESSEXT	2543525	- 0.543362	4.12***	0.000
FRGM.	292717	0.428348	3.05***	0.000
Constant	-215274	1224055	-1.56	0.064
sigma	.3226762	.0316416	-	-
Log likelihood function=21.045534				
ANOVA best fit measure =0.4244				
P=0.000				

Source: Model output, ***, **,* represents 1%, 5% and 10% level of significant.

Table 8. Respondents' opinion on precision agriculture adoption @ Haramaya University.

Challenges of precision adoption	Total number of respondents	No. of respondent's Face challenges	% of respondent's Face challenges
Behavioural factors	200		
Lack of technology awareness /knowledge		158	79.31
Rigidity to adopt new technology /believe in old traditional factors		184	92.11
Reference group influence		120	60.09
Lack of awareness of government/ institutional support		127	64.03
Economic factors	200		
Higher initial cost		186	93.10
Higher operational cost		133	66.99
Lack of institutional and government assistance		151	75.86
Technology factors	200		
Complexity of technology usage		155	77.83
Limitation of technology use		164	82.75
Lack of installation/ training assistance		173	86.69
Availability and accessibility in sale		160	80.29

Table 1. Reasons for adoption and constraints to adoption of precision farming.

Reasons	Mean Garrett's score	Rank
Lack of finance and credit facilities	73	1
Drip installation and water-soluble fertilizers are expensive	65	2
Lack of knowledge about precision farming technologies	54	3
Labour scarcity	53	4
Farmers' perception on yield impact of low quantity of inputs	51	5
Lack of water availability and pumping efficiency	44	6
Lack of technical skill to follow precision farming recommendations	42	7
Market tie-ups lead to low price fixation for the produce / unprofitable negotiations	41	8
Inadequate training and demonstrations and weak research – extension – farmer relationship	41	9
Inadequate size of landholdings for adoption of precision farming	27	10

Table 10. Crosstab for land size versus age of sample respondents.

land size * age of respondents * I think I would adopt PA Cross tabulation					
I think I would adopt PA		Age of respondents			Total
	land size - acres/ha	26-35	36-50	Above 50	
Neutral	6-9		1		1
	Total		1		
Agree	less than 1			1	1
	2-5		11	11	22
	6-9	2	10	12	24
	10-12			5	5
	13 and above	1		1	2
	Total	3	21	30	54
Strongly Agree	2-5	2	14	13	29
	6-9	8	29	35	72
	10-12	1	9	25	35
	13 and above	0	2	7	9
	Total	11	54	80	145
Total	less than 1	0	0	1	1
	2-5	2	25	24	51
	6-9	10	40	47	97
	10-12	1	9	33	43
	13 and above	1	2	8	11
	Total	14	76	110	200

DISCUSSION

These are varieties, fertilizer application rate, chemical spraying, cultivation frequency, the sample respondent's adoption index scores were categorized in to three adopter groups namely non-adopter, low and high adopter the actual adoption index score ranges from 0 to 1. Adoption index score of 0 point implies non-adoption of the overall improved technologies production package. Statistical analysis of ANOVA indicated that there was significant variation (F= 34.47, P=0.000) among the adoption index score between the three categories at 1% level of significant which indicates difference of adoption of precision technology packages among sampled non- FRG (Table 1). As indicated in Table 3, non-adopter accounts for 65.8% with the mean adoption index of 0.0000. This indicated that non adopter was not practicing any of the recommended package and the technologies in the production year of 2020. Next to non-adopters, low adopters constituted about 28.9 %. They have mean adoption index of 0.4670 while high adopters constituted about 5.2% with mean adoption index were 0.0956.

CONCLUSIONS

Agriculture being the socio-economic backbone of the nation necessitates the implementation of Precision Agriculture to accelerate food productivity at a reduced cost, achieve food security, safety, and sustainability, and conserve the environment. It is still only a concept in Ethiopia and requires strategic assistance from both public as well as private sectors for successful adoption. Precision agriculture a way of research for revolutionizing agriculture and is a systematic implementation of the best management practices into a site-specific system. The concept of 'doing the right thing, at the right time and the right place' is an intuitive appeal. It is a technically sophisticated system of farming and requires technical manpower with the know-how of modern-day machines. Furthermore, we analyzed the influence over factors as socioeconomic, agro ecological, behavioral, information sources, perception by the farmer and technological in the adoption of PAT. The framework built is purely conceptual and it can be tested through application of field research with farmers. Based on the studies analyzed we were able to build up some propositions relating the determinants identified in the studies analyzed with the probability of farmers adopt or not PAT, which may indicate pathways for development of future studies.

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