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Towards Implementing the Integrated Technology of Precision Agriculture in Sudan

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Abstract

This study reviews the agricultural development perspective in the light of a rapid space technology development. In other words, precision agriculture as part of geoinformatics. The aim is to quantify whether the adopted technology can improve the efficiency of agricultural fields management and production to attain food security. Therefore, views of targeted groups from different States of Sudan were investigated, using stratified sampling method. Where quantitative statistics (descriptive/inductive techniques) was applied. About 800 questionnaires were distributed. The outcomes of data analysis reflected that the majority of interviewed groups 357 (82.1%) do not know the principles and application of integrated technology in the field of agricultural management. 85.3% of respondents know nothing about computer program related to precision agriculture. The majority of the respondents (84.6 %), did not get courses on precision agriculture during the under graduate study. The result also revealed that only 11.8% of the respondents use modern techniques in land preparation, 16.1 % in soil analysis, 12.5 % in the field of seed technology, and 11.4% in crop harvesting. However, 53.9% of the respondents reported that their Departments did not care about training on agricultural precision. Nevertheless, 24.3 % of the respondents got trained on precision agriculture through personal efforts, while about 19% got trained by their respective Departments. In regard to education, 16% of the respondents got trained on precision agriculture at undergraduate and only 9% after graduation. The study concludes that despite the rapid technological development, agriculture in Sudan remained lagging, and the productivity is below the expectation. It recommends that the Ministries of Agriculture in different States in Sudan should take the issue of introduction of new technology seriously to boost the agricultural development to attain food security.

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Introduction

Most of the small scale farmers in Sudan, under both rain-fed and irrigation system use simple technology like hand tools in land preparation and cultural practices such as planting, weeding, manual application of chemicals and harvest which is very tedious, inaccurate and time consuming. So if precision agriculture is applied, farmers will optimize and efficiently utilize the agricultural resources. Moreover, they can safe time, get accurate and reliable information which help in policy formulation and decision making. Finally they can get profound and economic yield which can improve their livelihoods.

However, the continuous growth of the world population has exerted high pressure on the limited agricultural resources. Thus, profound, sustainable food production as well as the need to halt the environmental degradation became inevitable. This fact has drawn the attention for improving the efficient use of the available agricultural resources through precision agriculture [1].

Today, every farmer seeks to improve his farm management, productivity, and environmental benefits. This can only be achieved by application of modern technology which is known as a precision agriculture. It is an approach that incorporates variable technologies such as automated steering, intelligent guidance, assisted steering, and integrated electronic communications systems utilizing remote sensing (RS), Geographic Information Systems (GIS), and Global Positioning Systems (GPS) [2].

Precision agriculture is a general term that has several definitions, among these: A method that capable of helping farmers to apply the right amounts of inputs, on right place, and at right time [3]. (Daniel, et al., 2009). It also defined as a modern farming practice which can improve management and production efficiency, increase overall yield, accumulation of farmers' knowledge for better management with time, better decision-making in agricultural management, reduce production costs, as well as the negative environmental impacts on socio-economic status [3].

Nowadays, farmers are lucky, because new farming system is emerging, providing an effective solutions to the farming and the related activities. A good example is the developing countries which use 70% of the fertilizers of the whole world, yet the farmers do not realize the exact nutrient status of their soils.

In fact, this technology has brought a new agricultural world with unprecedented yield increase. The use of GPS allows the farmers to map their fields in a more comprehensive and can apply input in the exact location and amounts. Recently, detectors are created to directly get the nutrient levels in grounds and plants, while the application of Geographical Information System technology (GIS) enable farmers to divide a field into small areas so they can look at the field in greater detail [4].

Studies revealed that adoption of advance technology facilitated the development of farming equipment and management systems which designed to apply agricultural inputs with greater precision, depending on site-specific soil and crop plant conditions [5.]

In a comparative field study; between precision and conventional agricultural systems related to determination of the effects of groups of weed species, soil variability and herbicide application on grain yield, the result reflected high significant effect on grain yield differences between treatments for the precision agriculture, but non-significant differences for conventional treatment plots [6].

Despite the great advantages of precision agriculture, unfortunately, many farmers in different parts of the world unable to acquire it. It is reported[7]. that non adoption of precision agriculture in many developing countries because of high costs of this technology, while a researcher [8]explained the reasons as lack of information, high labor requirements, complexity of the system. He added that the planning horizon for the technology to be profitable seem too far in the future, due to the lack of accessibility of supporting resources, and inadequate managerial skills.

Generally, the development of proper decision-support systems for implementing precision agriculture remains a major stumbling block to adoption [9]. This is due to several reasons, among these the lack of favorable attitude, insufficient information, and lack of economic to acquire the technology [10].

Materials and Methods

Sudan is one of the largest countries in the world area wise. It has a huge potentiality. It has about 200 million Hectares of arable cultivable land. It enjoys good amount of rainfall beside the Blue Nile White Nile, River Nile, seasonal streams and ground water, along with diverse climatic zones. For this potentiality, Sudan is assumed to feed the world and therefore it is call the "World Bread basket"

During 2012, frequent field visits were paid to different States in the country (Map 1). Based on the population census data 2008, stratified sampling method was applied to collect the primary data. Where, about 800 questionnaires were distributed to the targeted groups, including agricultural inspectors; administrative, technicians; agricultural labors; and universities' students in different states of Sudan. Moreover, personal interviews were conducted. Furthermore, secondary data were collected from universities, ministries, Non-Governmental Organizations (NGOs), and internet. Descriptive statistics, including statistical inferences, measure of central tendency and Chi-square ($\chi 2$), were used for data arrangement and analysis. The results of data analysis were presented in tables and bar charts.

Results and Discussion

From Table 1, Agricultural Inspectors were the dominant occupation (29.5%), followed by students, (27.6%), labor (8.8%), Agricultural workers (8.5%), Agricultural experts (7.1%) Administrative (6.3%), and Teachers (4.8%).

Table 2; reflected the highest percentage (61.8%) of BSc. holders among the respondents, followed by MSc. holders (13.7%.). These two groups represent the planners and decision makers in the field of agriculture. Those of Post Graduate Diploma represented by 6.5%, followed by 5%, 4.8%, 4.3%, 3.5,% and 0.4% for Secondary schools, PhD, Primary Schools, and the literates respectively.

Table 3, showed significant differences ($P<0.05$) between the states in regard to application of computer programs in managing agricultural fields. However, Khartoum state is the pioneer in adopting this technology, while Red Sea and Western Darfur States are in the tail of the list.

Table 4, displayed that Khartoum State is in the top (30.8%) in using precision agriculture in crop growth monitoring, while the Red Sea and Western Darfur States are the least in utilizing precision agriculture.

The above Table 5; reflected significant ($P<0.05$) difference between education levels and application of modern technology in managing agricultural fields. It revealed that the 61.9% of the respondents who widely use computer programs are the graduates (BSc.), while literates, the lower educated group represented by 0.4%.

Table 6, showed that the majority of the people (60.3%) engaged in the field of agriculture do not know how to operate computer.

Table 7, revealed that the majority of the respondents (82.1%) do not know how to operate computer.

Table 8, reflected that few people (14.8%) are acquaintance with the application of computer program in precision agriculture.

Table 9, showed that only few people (15.4%) got trained on agricultural projects management by modern integrated technologies (precision agriculture).

From Table 10, it is obvious that training is not a priority in agricultural development, particularly on precision agriculture.

From the above Table 11,the majority of the respondents (77.8%) believe that application of precision agriculture is efficient in time management, reduce production cost and increase productivity.

Considering the Table 12; the application of modern technologies in the field of agriculture is very limited (16.1%). Laser is highly cost, and therefore; its application is limited to the large scale projects. For filed survey, data and information collection by GPS and GIS are not widely used, this may be due to lack of training, and accessibility to this technology. Moreover, many people in the third world who engaged in agricultural activities do not have the access to modern geospatial technology or the skills to apply these technologies in effective way. Therefore, farmers are pressurized with uncertainties, particularly under rain-fed farming system.

Table 13, demonstrates that the arithmetic means are greater than the mean of Null hypothesis

Map 1. Shows the different States in Sudan
Source:http://ontheworldmap.com/sudan/administrative-divisions-map-of-sudan.html111.

Table 1. Reflects the occupation of the respondents in different States in–Sudan (2012)

No	Occupation	Frequency	(%)
1	Agricultural Expert	57	7.1
2	Agricultural Inspector	236	29.5
3	Extension worker	68	8.5
4	Administrative	50	6.3
6	Technician	27	7.5
7	Labor	70	8.8
8	Teachers	38	4.8
9	Student	221	27.6
	Total	800	100.0

Table 2. Frequency distribution of educational levels in different States in Sudan (2012)

No.	Education level	Frequency	%
1	PhD.	034	04.30
2	MSc.	109	13.70
3	PGD	039	04.80
4	BSc	495	61.80
5	Diploma	052	06.50
6	Secondary School	040	05.00
7	Literate	003	00.40
8	Primary School	028	03.50
	Total	800	100

Table 3. Relationship between Computer Programs Skills and agricultural fields management in different States in Sudan (2012)

State	Application of computer programs in agricultural field management					Total
	Keeping Documents	Precision agricultural operations	Other	Collectively	Do not use Precision agric.	
Northern State	32 (4.0 %)	1 (0.1%)	5 (0.6%)	4 (0.5%)	41 (5.1%)	83 (10.4)
River Nile State	19 (2.4%)	3 (0.4%)	4 (o.5%)	4 (o.5%)	21 (2.6%)	50 (6.3%)
Kassala	22 (2.6%)	1 (0.1%)	2 (0.3%)	4 (o.5%)	13 (1.6%)	42 (5.3%)
Gedarif	15 (1.9%)	0	5 (0.6%)	2 (0.3%)	7 (0.9%)	29 (3.6%)
Gezeira	35 (4.4%)	1 (0.1%)	6 (0.8%)	12 (1.5%)	19 (2.4%)	73 (9.1%)
Sennar	22 (2.8%)	3 (0.4%)	-	4 (0.5%)	8 (0.1%)	37 (4.6%)
Blue Nile	33 (4.4%)	1 (0.1%)	1 (0.1%)	6 (0.8%)	4 (o.4%)	45 (5.6%)
White Nile	75 (9.4%)	3 (0.4%)	1 (0.1%)	2 (0.3%)	11 (1.4%)	92 (11.5%)
N. Kurdofan	30 (3.8%)	1 (0.1%)	3 (0.4%)	5 (0.6%)	27 (3.4%)	66 (11.5%)
S. Kordofan	3 (0.4%)	1 (0.1%)	0	0	3 (0.4%)	7 (0.9%)
W. Kordofan	4 (0.5%)	0	0	1 (0.1%)	1 (0.1%)	6 (0.8%)
N. Darfur	2 (0.3%)-	0	0	2 (0.3%)	2 (0.3%)	6 (0.8%)
S. Darfur	3 (0.4%)	0	0	1 (0.1%)	3 (0.4%)	7 (0.9%)
W. Darfur	1 (0.1%)	0	0	0	0	1 (0.1%)
Red Sea State	1 (0.1%)-	0	0	0	0	1 (0.1%)
Khartoum	183 (22.9%)	3 (0.4%)	3 (0.4%)	11 (1.4%)	46 (5.8%)	246 (30.08%)
Others	3 (0.1%)	1 (0.1%)	3 (0.4%)	-	-2 (0.3%)	9 (1.1%)
Total	482 (60.3%)	20 (2.5%)	32 (4.0%)	58 (7.3%)	208 (26.0%)	800 (100%)

Table 4. Application of precision agriculture in crop monitor in different States in Sudan (2012)

State	Application of computer programs agricultural field management					Total
	Keeping Documents	Precision agricultural operations	Other	Collectively	Do not use computer	
Northern State	14 (1.8 %)	1 (0.1%)	8 (1.0%)	29 (3.6%)	31 (3.9%)	83 (10.4)
Nile State	15 (1.9%)	7 (0.9%)	9 (1.1%)	11 (1.4%)	8 (1.0%)	50 (6.3%)
Kassala	8 (1.0%)	4 (0.5%)	6 (0.8%)	7(o.9%)	17 (2.1%)	42 (5.3%)
Gedarif	6 (0.8%)	0	6(0.8%)	11 (1,4%)	13 (0.6%)	29 (3.6%)
Gezeira	13 (1.6%)	7 (0.9%)	14 (1.8%)	19 (2.4%)	20 (2.1%)	73 (9.1%)
Sennar	9 (1.1%)	4 (0.5%)	8 (1.0%)	8 (1.0%)	8 (0.1%)	37 (4.6%)
Blue Nile	14 (1.8%)	4 (0.5%)	11 (10.4%)	9 (1.1%)	7(o.9%)	45 (5.6%)
White Nile	10 (1.3%)	14 (1.8%)	22 (2.8%)	22 (2.8%)	24 (3.0%)	92 (11.5%)
N Kordofan	12(1.5%)	1 (0.1%)	10 (1.3%)	18 (2.3%)	25 (3.1%)	66 (11.5%)
S Kordofan	2 (0.3%)	0	2 (0.3%)	2 (0.3%)	1 (0.1%)	7 (0.9%)
W Kordofan	1 (0.1%)	0	1 (0.1%)	3 (0.4%)	1 (0.1%)	6 (0.8%)
N Darfur	4 (0.5%)-	1 (0.1%)	1 (0.1%)	0	6 (0.8%)	6 (0.8%)
S Darfur	5 (.05%)	0	1 (0.1%)	0	1 (0.1%)	7 (0.9%)
W Darfur	0	0	0	0	1 (0.1%)	1 (0.1%)
Red Sea	0	0	0	1 (0.1%)	0	1 (0.1%)
Khartoum	15 (1.9%)	29 (3.6%)	50 (6.3%)	58 (7.0%)	94 (11.8%)	246 (30.8%)
Others	1 (0.1%)	1 (0.1%)	3 (0.4%)	2 (0.3%)	2 (0.3%)	129 (16.1%)
Total	129 (16.1%)	72 (9.0%)	152 (1.9%)	194 (24.3%)	253 (31.6%)	800 (100%)

Table 5. Relationship between Educational levels and application of Computer Programs in agricultural fields management in different States in Sudan (2012)

Educational level	Application of computer programs agricultural field management					Total
	Keeping Documents	Precision Agricultural operations	Other	Collectively	Do not Use	
PhD	21 (2.6 %)	0	4 (0.5%)	4 (0.5%)	5 (0.06%)	34 (4.3%)
MSc.	73 (9.1%)	11 (0.4%)	7 (o.9%)	9 (1.1%)	9 (1.1%)	109 (13.6%)
PGD	29 (3.6%)	1 (0.1%)		2 (0.3%)	7 (0.9%)	39 (61.9%)
BSc	313 (39.1%)	5 (0.6%)	14 (1, 8%)	39 (4.9%)	124 (15.5%)	459 (3.6%)
Diploma	35 (4.4%)	1 (0.1%)	-	12 (1.5%)	19 (2.4%)	73 (9.1%)
Secondary	8 (1.0%)	2 (0.3%)	2 (0.3%)	1 (0.1%)	27 (3.4%)	40 (5.0%)
Literacy	0	0	2 (0.3%)	0	1 (0.1%)	3 (0.4%)
Elementary	1 (0.1%)	0	1 (0.1%)	0	26 (3.3%)	28 (3.5%)
Total	482 (6.3%)	20 (2.5%)	32 (4.0 %)	58 (7.3%)	208 (26.0%)	800 (100%)

Table 6. Frequency distribution of Computer uses in managing agricultural fields in different States in Sudan (2012)

No	Particular	Frequency	%
1	keeping Documents	482	60.3
2	Precision agriculture	20	2.5
3	Other agricultural activities	3	4
4	Collectively	58	7.3
5	Do not use at all	208	26
Total		800	100

Table 7. Application of Computer in Managing Agricultural Projects in different States in Sudan (2012)

No	Respondents	Yes/No	%
1	143	Yes	17.9
2	657	No	82.1
Total			100

Table 8. Application of Computer Programs in precision Agriculture in different States in Sudan (2012)

No	Respondents	Yes/No	%
1	118	Yes	14.8
2	682	No	85.2
Total	800		100

Table 9. Training on agricultural projects management using computer in different States in Sudan (2012)

No	Respondents	Yes/No	%
1	123	Yes	15.4
2	766	No	84.6
Total	800		100

Table 10. Skills to enter agricultural data and information in computer in different States in Sudan (2012)

NO	Answer	Frequency	%
1	Excellent	52	6.5
2	Very good	58	7.3
3	Good	113	14.1
4	Average	205	25.6
5	Week	211	26.4
6	Very week	161	20.1
Total		800	100

Table 11. Impacts of precision agriculture on crop production and time management in different States in Sudan (2012)

No	Impact on	No of respondents	%
1	Time management	29	3.6
2	Save effort	46	5.8
3	Reduce cost	21	2.6
4	Increase production	40	5.0
5	All collectively	622	77.8
6	Others	42	5.3
Total		800	100

Table 12. Modem technological tools used in field survey in different States in Sudan (2012)

No.	Equipment	Respondents	%
1	Laser	181	22.6
2	Geographical Information System (GIS)	73	9.1
3	Global positioning System (GPS)	129	16.1
4	Office Integrated Operator	19	2.4
5	Others	398	39.8
Total		800	100

Table 13. Presents the values of statistical analysis –Sudan (2012)

Phrases	Arithmetic mean	Standard deviation	Chi-square (χ2)	Degree of freedom	Probability
Skills of acquiring and processing data of precision agriculture through computer programs	4.18	1.43	73.06	5	0.00
Precision agriculture increases water use efficiency	4.59	1.65	184.78	5	0.00
Effect of new technologies improve production processes	4.22	1.61	509.11	5	0.00
Efficiency of modern technologies on I mproving agricultural fields management	4.67	1.66	390.74	4	0.00
Modern technologies are desired in agricultural projects.	3.97	1.65	430.92	5	0.00
Impacts of modern technologies on crop production	4.42	0.98	745.9	4	0.00
Availability and accessibility of modern technology	3.54	1.38	224.96	4	0.00
Modern technologies have high precision and accuracy	4.49	1.54	419.0	5	0.00
Response to adopt computer in agricultural projects	4.19	1.38	197.26	5	0.00
The usefulness of computer in agricultural projects	4.88	1.47	790.01	5	0.00
Efficiency of computer in agricultural fields management	4.97	1.39	836.41	5	0.00
Computers are capable to store data and information about precision agriculture	5.16	1.20	1074.95	5	0.00
It is simple and easy to apply precision agriculture in agricultural projects	4.42	1.63	281.65	5	0.00
How far the data and information pertaining precision agricultural are accepted?	4.52	1.33	299.53	5	0.00
How it is difficult to manage agricultural projects through precision agriculture?	2.99	1.27	112.36	4	0.00

(3.5). This indicates that the response of investigated samples tends to the positive direction. This complies with the standard measure of farm management through integrated modern technologies.

The standard deviation ranges between (0.98-1.66). It is a good indicator for homogeneous answers on agricultural fields' management through modern technologies. In the same table, the value of (χ2) is less than (0.o5) significant. And this also confirms that the answers are good and tend to the positive direction.

Conclusion and Recommendations

Conclusion

The study reflected the efficiency and usefulness of precision agricultural in managing agricultural projects is not fully utilized, due to many constraints hindering the adoption of this technology.

The study also dominstrated that the majority of the respondents lacking the technical knowhow to acquire and process the data about agricultural operations such as crop production, irrigation, seed broadcasting, fertilization and harvest by precision agriculture. Nevertheless, the majority of the respondents lack the skills to use RS, GIS and GPS to collect field data, analyze, relate and interpret the results of different phenomena. Even those who got trained, they just concentrated on the theory rather than practical part.

Furthermore, most of the respondents know nothing about the databases, which is essential in planning, decision making and taking.

Recommendations

It is clear that the new technology is inevitable. It is crucial for agriculture. Therefore; the study recommends the introduction of integrate modern technology in the curricula at all levels of education in Sudan. It also recommends; continuous intensive courses to all people engaged in the field of agricultural activities.

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