Prospects and Challenges to Precision Agriculture Technologies Development in Ghana: Scientists' and Extension Agents' Perspectives

Martin Bosompem (Ph.D)

Department of Agricultural Economics and Extension, University of Cape Coast, Cape Coast, Ghana

A paper from the Proceedings of the
14th International Conference on Precision Agriculture
June 24 – June 27, 2018
Montreal, Quebec, Canada

Abstract. The main objective of the research was to examine the prospects and challenges of developing and implementing precision agriculture (PA) in cocoa production in Ghana. A census of cocoa research scientists and a survey of cocoa extension agents (CEAs) in Ghana were taken. Five major challenges they perceived to pose serious challenges to the development and implementation of future Precision Agriculture Technologies (PATs), in their decreasing order of importance, were (a) farmer-demographic characteristics, (b) environmental, (c) educational, (d) economic, and (e) technical challenges. Major farmer-demographic characteristics expected to pose serious challenges to precision agriculture development and adoption in Ghana were age of farmers, farmers' low level of education, farmers' lack of computer knowledge, and subsistence farmers with low income. The most important environmental challenges expected to pose substantial challenge to PAT development and adoption were lack of accessible road to farms, vegetation (mostly forest/trees) posing a challenge to the movement of PA tools, and undulating nature of topography of cocoa fields. Scientists' and CEAs' perceived that the overall challenges to PATs development and implementation would be substantial and there were no significant difference between their perceived challenges anticipated in the development and implementation of PATs in cocoa industry in Ghana. This means that the overall prospect of developing and implementing PA in cocoa production in Ghana was perceived to be rather low. The study recommended, among others, the need for stakeholders to set up research unit purposely to develop PA tools, technologies and methods taking into consideration the environmental factors such as soil type, vegetation and topography of arable cocoa lands in Ghana. On-station trials of PATs should begin with these units and later on-farm trials replicated on farmers' farm. Moreover, initial targets and training of farmers should focus on those with higher level of education who can fully comprehend and apply features of PA since PA is highly knowledge-based.

Keywords. Challenges and Prospects, ICT and Precision Agriculture, Cocoa Production, Ghana.
Challenges and prospects anticipated in PATs development in cocoa industry in Ghana

Introduction.

Precision Agriculture (PA) has made phenomenal changes and improvement in increased agricultural productivity and sustainability in most developed countries. However, its application is limited in Sub Saharan Africa. Some experts of PA are even skeptical about the feasibility of PA in Africa because of the challenges they anticipate in PA implementation in Africa (Shibusawa, 1999). But PA technologies are very essential to increase food security and at the same time mitigate some of the effects of climate change anticipated in Africa.

Challenges are difficult tasks that test the ability, capacity and skills of a person, organization or community (Wehmeier, 2008). Hence, problems of implementing PA were viewed as challenges not necessarily as barriers to PA development. Studies have identified several challenges when dealing with PA systems (e.g. Daberkow & McBride, 2003; Hudson & Hite, 2001; Kutter, Tiemann, Siebert, & Fountas, 2009; Reichardt, Jurgens, Klobe, Huter, & Moser, 2009). These challenges have contributed significantly to the slow rate of adoption of PA by farmers (Kutter et al., 2009). A careful review of literature of challenges on PA has resulted in categorizing these challenges into eight. (Najafabadi et al., 2011; Mcbratney, Whelan & Ancev, 2005; Tey & Brindal, 2012).

These challenges are:

1. **Economic:** Economic challenges reviewed were;

   i. High Initial cost of Investment;
   ii. Very Expensive equipment;
   iii. High Consultancy and Rental fees;
   iv. High Training and learning costs to use equipment ;
   v. Obsolesce Potential of hardware;
   vi. Uncertainty of PA's return on investment .

2. Time: Time challenges include;

   i. time taken to introduce the PA Technologies
   ii. time taken to learn how to use the PA equipment
   iii. time taken to get any return on the producer's investment.

3. **Educational/Training:** Educational challenges comprise of;

   i. lack of effective advisory services;
   ii. low acceptance of PA technologies among the advisors;
   iii. lack of local experts ;
   iv. lack of research and extension personnel who have a good handling of the practical

field applications;

v. lack of PA awareness of farmers and experts;
vi. ineffective PA education;
    a. lack of integrating agronomical knowledge and ecology with PA;
vii. needed skills in the application of PA software and hardware;
viii. inadequate qualified and experienced operators,
ix. lack of technical knowledge and software skills (lack of considering PA topics in universities;
x. lack of considering PA topics in technical and vocational schools.

(Reichardt & Jurgens, 2009; Wiebold et al., 1998; Heiniger et al., 2002; Kitchen et al., 2002; Fami et al., 2005; Fountas et al., 2005; Adrian, 2006).

4. **Technical:** Technical challenges comprise of

i. complexity of PA technologies makes it difficulty of quantifying PA profitability because of its complexity with other benefits such as environmental benefits and food safety and missing computer equipment;
ii. unreliable computers and equipment;
iii. unchangeable machines;
iv. lack of PA research,
v. low mechanization level on the farms;
vi. smaller farms;
vii. poor internet connectivity;
viii. Low level of standardization in the manufacturing of PA tools and software.
(Bongiovanni & Lowenberg-Deboer, 2004; Reichardt & Jurgens, 2009; Mcbratney et al., 2005 Cook et al., 2003; Zarei, 2007).

5**. Data quality**: Data quality challenges include;

i. difficulty in maintaining quality data;
ii. difficulty in storing and retrieving data with different formats;
iii. difficulty in analysing data to understand yield-limiting factors;
iv. difficulty of data transfer to external sources for analysis;
v. difficulty of data interpretation;
vi. lack of appropriate measurement and analysis techniques for agronomical important factors
vii. difficulties in managing such a large amount of data and using them efficiently
viii. incompatibility of software packages
ix. problems related to data ownership and data handling
x. Data accuracy concerns.
(Lavergne, 2004; Reichardt & Jurgens, 2009; Wiebold et al., 1998; NRC, 1997).

6. Farmer/Operator demographics: These refer to the personal background of the farmer's who are main decision makers (Tey & Brindal, 2012).These characteristics include;

i. farmer/operator's age;
ii. years of formal education;

iii. years of farming experience
iv. farm size
v. Other factors includes farmers' lack of computer knowledge and low levels of income.

7. Environmental/Abiotic:

i. Vegetation eg. mostly forest
ii. undulating topography
iii. numerous streams of water and rivers:
iv. lack of roads to the farms.

These hinder the movement of heavy equipment and farm machinery such as tractors, VRA, harvesters and planter

8. **Political/Governmental challenges.** These includes
i. Lack of political will to implement PA even when funds are available
ii. PA technology is not compatible with current government policies in
iii. Agriculture and Cocoa in Ghana (Mcbratney et al., 2005; Lattus, 2014).

No comprehensive research has been done in Ghana on the challenges and potentials of implementing PA.

The main objective of the research was to examine the prospects and challenges of developing and implementing precision agriculture (PA) in cocoa production in Ghana

Methodology

This Paper is Part of a scholarly research to investigate the Prospects and Challenges of Precision Agricultural Development and Implementation in Cocoa Production in Ghana. A census of cocoa research scientists and a survey of cocoa extension agents (CEAs) in cocoa growing regions in Ghana was undertaken. There are 200 Cocoa Extension Agents (CEAs) in the seven (7) cocoa regions in Ghana (COCOBOD, 2015). These extension agents provide extension services to cocoa farmers in Ghana. There are thirty-five (35) Cocoa researchers (scientists) in CRIG (COCOBOD, 2015). CRIG was established at Tafo (Akim) by Department of Agriculture in June 1938 as the Central Cocoa Research Station of the Gold Coast on the recommendation of the Agricultural Adviser to the British Minister of State for the Colonies, Sir Frank Stockdale. Even though their main focus is on cocoa, these scientists also research into coffee, cashew, kola, and sheanut.

A content-validated questionnaires were used to collect primary data for the respondents on their views on 8 main categories of challenges to PAT development and implementation in Ghana mentioned. With the help of IBM Statistical Product and Service Solutions (SPSS) version 22.0, frequencies, percentages, means, standard deviations and independent sample t-test were used to analysis the data.

Summary of Results

Eight (8) main challenges to PAT development and implementation examined were economic,

time, educational/training, technical, data quality, farmer/operator demographics, environmental, and political/governmental challenges. Generally, both scientists and CEAs perceived that five (5) of the challenges (farmer demographic characteristics, economic, educational, environmental and technical) would be substantial in militating against any future development of PATs in cocoa industries in Ghana, whereas three (3) of the challenges (time, data quality, and political) would be moderate. However, the greatest perceived challenge to PAT development and implementation was farmer demographic characteristics. This was followed by environmental, educational, economic and technical challenge. The perceived challenges in these five areas (farmer demographic characteristics, economic, educational, and environmental) being substantial imply that the prospects of developing PA in these areas is low. Conversely, they perceived moderate challenges in these three (3) areas (time, data quality and political) which also implied that the prospects are moderate.

The most important farmer demographic characteristics perceived to pose greatest challenge to PATs development and adoption in cocoa industry were, age of farmers, farmers' low level of education, farmers' lack of computer knowledge, and subsistence farmers with low income.

The most important environmental challenges reported to pose substantial challenge to PAT development and adoption were lack of accessible road to farms, vegetation (mostly forest/trees) posing a challenge to the movement PA tools, and undulating nature of topography of cocoa lands.

Educational challenges perceived to pose substantial challenges to PAT development and implementation in Ghana were: lack of farmers awareness and basic knowledge of PATs, lack of effective advisory service, lack of local experts on PA, lack of extension personnel knowledgeable in PATs, lack of PA topic consideration in educational institution, and lack of adequate training resources.

Economic challenges perceived to pose a challenge to PA were high initial cost of investments, very expensive PA equipment, and accessibility of funds, high consultancy and rental fees, and uncertainty of PA's returns on investments. Moreover, lack of PA research centre in Ghana, low mechniasation level on cocoa farms, and unreliable internet connectivity were the most important technical challenges, perceived to pose substantial challenge to PA development.

Scientists' and CEAs' perceived that the overall challenges to PATs development and implementation would be substantial and there were no significant difference between their perceived challenges anticipated in the development and implementation of PATs in cocoa industry in Ghana. This means that the overall prospect is rather low.

Conclusions or Recommendations

The five (5) most important challenges expected to have significant impact against any future development of PATs in cocoa industry in Ghana are (a) farmer demographic characteristics, (b) economic, (c) educational, (d) environmental, and (e) technical, with farmers' demographic

characteristics expected to be the greatest. The farmers' demographic factors expected to militate against the PATs adoption in cocoa industry are age of cocoa farmers, farmers' low level of education, farmers' lack of computer knowledge, and subsistence nature of farms. Both scientists and CEAs believe that the challenges to future precision agricultural technologies development and implementation in cocoa production in Ghana would be substantial; hence the prospects would be rather low.

Lack of accessible road to farms, undulating nature of topography, and vegetation (mostly forest/trees) of cocoa lands are the most important environmental challenges that must be addressed in the quest to make PA reality. Lack of cocoa farmers' awareness and basic knowledge of PATs, lack of effective advisory service, lack of local experts in PA, lack of extension personnel knowledgeable in PATs, and lack of PA topic consideration in educational institution are significant educational challenges that must be addressed to make PATs development in Ghana a reality. Economic challenges to future PATs development and implementation in cocoa industry in Ghana are high initial cost of investments, very expensive PA equipment, and accessibility of funds, high consultancy and rental fees, and uncertainty of PA's returns on investments. Moreover, lack of PA research centre in Ghana, low mechnisation level on cocoa farms, and unreliable internet connectivity are the technical challenges.

It is recommended that Ghana Cocoa Board *(COCOBOD) should alert the major stakeholders (e.g. Government,* Licensed Buying Companies (*LBCs),* World Cocoa Foundation *(WCF),* International Cocoa Organization *(ICCO) and Banks) on the potentials and challenges of PA development in Ghana. Such collaboration is necessary because of the potentially high cost of investments as a result of very expensive equipment and consultancy fees. Also, Institutions of higher learning (universities and polytechnics) specializing in agricultural and related disciplines (especially in engineering, crop science, soil science, ICT and geographic information systems) should collaborate to introduce precision agriculture topics, courses and subsequently curricula to introduce and teach undergraduates in PA. Alternatively, PA topics can be mainstreamed into the curriculum of aforementioned agriculture and related institutions. These would provide adequate knowledge and practical skills necessary to jumpstart precision farming and research among these young future farmers and researchers.*

Acknowledgements

I acknowledge (1) The University of Cape Coast, Ghana (http//ucc.edu.gh) (2) The Association of African Universities (AAU-www.aau.org) and (3) The Council for the Development of Social Science Research in Africa (CODESRIA-http://www.codesria.org) for their financial support to this research.

References

Adrian, A. M. (2006). *Factors influencing adoption and use of precision agriculture*. *Vasa*. Auburn University. Retrieved from http://medcontent

.metapress.com/index/A65RM03P4874243N.pdf\nhttp://etd.auburn.edu/

etd/handle/10415/267.

COCOBOD (2015). Ghana Cocoa Board subsidiaries. Retrieved from https://cocobod/oursubsidiaries.php.

Cook, S.E., O'Brien, R., Corner, R.J. & Oberthur, T. (2003). Is precision agriculture irrelevant to developing countries? *Proceedings of 4th Biennial European Conference on Precision Agriculture* (pp.115-120). Berlin, German

Daberkow, S. G., & McBride, W. D. (2003). Farm and operator characteristics affecting the awareness and adoption of precision agriculture technologies in the US. *Precision Agriculture*, *4*(2),163–177.

Bongiovanni, R., & Lowenberg-DeBoer, J. (2005). Precision Agriculture in Argentina. *3° Simpósio Internacional de Agricultura de Precisão*, (1),

Fountas, S., Blackmore, S., Ess, D., Hawkins, S., Blumhoff, G., Lowenberg-Deboer, J., et al.

(2005). Farmer experience with precision agriculture in Denmark and the US Eastern Corn Belt. *Precision Agriculture*, 6(2), 121–141.

Heiniger, R. W., Havlin, J. L., Crouse, D. A., Kvien, C., & Knowles, T. (2002). Seeing is believing: The role of field days and tours in precision agriculture education. *Precision Agriculture*, *3*, 309–318.

Hudson, D., & Hite, D. (2001). *Adoption of precision agriculture technology in Mississippi: Preliminary results from a producer survey*. Starkville: Mississippi State University.

Kitchen, N., Snyder, C. , Franzen, D. , & Wiebold, W. (2002). Educational needs of precision agriculture. *Precision Agriculture*, *3*, 341–351.

Kutter, T., Tiemann, S., Siebert, R., & Fountas, S. (2009). The role of communication and co-operation in the adoption of precision farming. *Precision Agriculture*, *12* (1), 2-17.

Lattus, A. (2014). *Lack of "political will" hampering environmental la*ws. Retrived from https://www.mendeley.com/research/lack-political-hampering-environmental-laws/.

Lavergne, C.B. (2004). *Factors determining adoption or non-adoption of precision agriculture by producers across the cotton belt*. Unpublished master's *thesis*. Office of Graduate Studies, Texas A&M University.

Mcbratney, A., Whelan, B., & Ancev, T. (2005). *Future directions of precision agriculture*. Paper presented at 7th International Conference on Precision Agriculture, Minneapolis, USA, July 2004.

Najafabadi, M. O., & Hosseini, S. J. F., & Bahramnejad, S. (2011). A Bayesian confirmatory factor analysis of precision agricultural challenges. *African Journal of Agricultural Research*, *6*(5), 1219–1225.

NRC. (National Research Council) (1997). *Precision agriculture in the 21st century* (Committee on Assessing Crop Yield: Site-Specific Farming, Information Systems, and Research Opportunities). Washington DC : National Academy Press

Reichardt, M., & Jurgens, C. (2009). Adoption and future perspective of precision farming in Germany : Results of several surveys among different agricultural target groups. *Precision Agriculture*, *10*(1), 73–94.

Reichardt, M., Jurgens, C., Hutter, U., & Kloble, U. (2009). *Precision farming education in Germany – obstacles and solutions*. Bochum: Association for Technology and Structures in Agriculture.

Reichardt, M., Jurgens, C., Klobe, U., Huter, J., & Moser, K. (2009). Dissemination of precision farming in Germany : and training activities. *Precision Agriculture*, *10*, 525–545.

Tey, Y. S., & Brindal, M. (2012). Factors influencing the adoption of precision agricultural technologies: A review for policy implications. *Precision Agriculture*, *13*(6), 713–730.

Wehmeier, S. (2008). *Oxford advanced learner's dictionary* (7th ed.). London: Oxford University Press.

Wiebold, W.J., Suduth, K. A, Davis, J.G, Shannon, D.K., & Kitchen, N.R. (1998). *Determining barriers to adoption and research needs of precision agriculture.* (Report to the North Central Soybean Research Program) Retrievedfrom http://www.fse.missouri.edu/mpac/pubs/parpt.pdf.

Zarei, Z. (2008). *Information technology and its effectiveness in field of precision agriculture*. Retrieved from www.aftab.ir.