Precision Agriculture Education in Africa: Perceptions, Opportunities and Challenges, and the way forward

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Abstract

Precision Agriculture is critical for accelerated transformation of the agrifood systems in Africa for shared prosperity and enhanced livelihoods. The paper presents an overview of the perceptions of faculty, undergraduate and postgraduate students from Ghanaian universities about PA education, and its opportunities and challenges. The study involves a case study of two public universities, the University of Cape Coast and the Technical University of Cape Coast, respectively a and a desk review of available literature. The study shows that Precision agriculture education is not widespread in Africa, but the impact of PA on African agriculture will grow as new ideas and opportunities spread. The study also shows that in there is a lack of PA skilled faculty and facilities in most African universities. There is limited financial commitments and regulatory policies towards integrating PA into existing programmes. Moreover, existing extension services in most African countries lack the capacity, skill and competencies to promote PA services. This is exacerbated by the lack of equipment and logistics to stimulate outreach. The existing media is interested and adequately psyched to promote PA education and outreach but there appears to be a disjoint between academic, industry and the media. The study further confirmed that the success of PA in Africa is highly dependent on curriculum re-engineering, outreach and education. Sustainable PA education and outreach requires skilled faculty, appropriate curriculum, and ICT and digital solutions. The study revealed that PA education and outreach are very necessary for the growth of PA in the African agricultural systems for improved agricultural productivity. We propose that existing undergraduate and postgraduate programmes should be redesigned to include courses such as data science, geographic information systems (GIS), remote sensing, artificial intelligence and digital agriculture courses related to specific disciplines. We further suggest that government policies should include training and re-training of faculty, building the

capacity of support staff, and provision of the needed infrastructure and funds for agricultural universities to successfully run PA programmes.

Introduction

Ghana is a trade hub for much of West Africa with agriculture as the mainstay of its economy. There is enormous potential for Ghana's agricultural industry to become more productive and profitable, contributing to sustainable development, poverty reduction and better inclusion of young people in society. Yet in Ghana, few young people see a future for themselves in agriculture. It is therefore, increasingly clear that investments must be made in training and education opportunities so that young people can acquire new knowledge, and upgrade or sharpen their skills so as to have access to highly paid jobs. Agriculture has been offered as a major course in Ghanaian universities for many years, but the number of students interested in or offering agriculture has not seen any significant improvement. Indeed, the number is dwindling. The declining numbers of students pursuing agriculture in Ghanaian higher institutions raises concern about the underlying causes and how these challenges can be addressed. Integration of Precision Agriculture (PA) into existing programmes in Ghanaian universities can provide the needed impetus to increase enrolment in these universities. The International Society for Precision Agriculture (ISPA) defines PA as 'a management strategy that gathers, processes and analyzes temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production'. Romanov et al. (2016) opined that PA allows agriculturalists to observe, evaluate and control farming operations. Studies by Paustian and Theuvsen (2017) and Swinton & Lowenberg-DeBoer (1998) have shown that PA offers a lot of economic and environmental benefits. Thus, PA is critical for accelerated transformation of the agrifood systems in Africa for shared prosperity and enhanced livelihoods. However, adoption of PA is low globally, and particularly in developing nations (Paustian & Theuvsen, 2017). The impact of PA on Ghanaian agriculture is likely to grow as new ideas and opportunities spread, but PA agriculture education is still rudimentary in Ghana. Moreover, most of Ghana's universities and extension services lack the capacity, skill and competencies to promote PA education. It is therefore, imperative that agricultural education in Ghana, especially at the higher education levels, is transformed to integrated PA technologies and skills into existing curriculum. Thus, existing pedagogy should be restructured to include PA aspects that can enhance the knowledge and skills of students pursuing agriculture in Ghanaian institutions of higher learning. The study is underpinned by the hypothesis that a clearer understanding of PA and its integration into existing curriculum of Ghanaian universities will attract greater numbers of students, and the knowledge and skills that the students will acquire can be leveraged to enhance agricultural productivity and profitability in Ghana. However, the success of PA education in Ghana is highly dependent on curriculum re-engineering, outreach and tailored education, which requires skilled faculty, availability of ICT infrastructure and an enabling policy environment. In this regard, this paper presents an overview of the perceptions of faculty, undergraduate and postgraduate students from Ghanaian universities about PA education. The paper further examines opportunities and challenges associated with PA education Ghana.

Methodology

The study involved a desk review of relevant literature, especially FAO and World Bank reports, a focus group discussion (FGD) and a survey involving faculty, postgraduate and undergraduate students randomly selected from two Ghanaian public universities: the

University of Cape Coast and the Technical University of Cape Coast, respectively. The desk review of documents was done to tease out specific information to facilitate triangulation of results. Furthermore, the survey and focus group discussion were used to elicit information from three categories of respondents – undergraduate students, postgraduate students and faculty in agriculture or agriculture-related departments as sources of the qualitative and quantitative data. The total number of respondents were 700 comprising 70 faculty and 630 students (530 males and 170 females) from different levels of education. In the study, the same semi-structured survey instrument was used to elicit information from each category separately. However, the focus group discussions were held separately for each university, involving both students and faculty. The data obtained from the study was analysed and presented mainly as descriptive statistics (frequency, percentage, and mean values). From the FGD we could compare faculty PA needs to those of students, and highlight the most important needs for accelerated PA education in Ghana. Each category of respondents was asked to assess their own perceptions on PA as "strongly agree" to "strongly disagree" based on the 5-point Likert scale (1 = strongly agree, 5 = strongly disgaree).

Results and discussion
Demographics of the respondents

The demographic information of the respondents is summarized in Table 1.

Table 1: Demographic of the respondents

Gender		Designation		Highest level of Education			Number of years of university education university	
Male	Female	Faculty	Students	PhD	MSc	BSc	>5 years	< 5 years
530	170	70	630	30	70	600	60	640

The results showed that an overwhelming majority of the respondents (76%) were males while the remainder were females; 10% of the respondents were faculty compared to 90% students. Regarding their highest level of education, 30%, 10%, and 86% of the respondents had attained PhD, MSc or BSc, respectively. Approximately 91% of the respondents has less than 5 years of university education, with only 9% having had more than 5 years of university education. The survey results suggested that the numbers of women pursuing agriculture in Ghanaian universities is low. This is in good agreement with an IFPRI (International Food Policy Research Institute) study, which showed that women are underrepresented in agricultural research and higher education (Beintema and Di Marcantonio, 2010). The survey report further showed that most of the respondents interviewed has no or very limited knowledge about PA. For the few who knew about PA, an overwhelming majority (76%) of them first learnt about PA from their lecturers. (Figures 1 and 2)
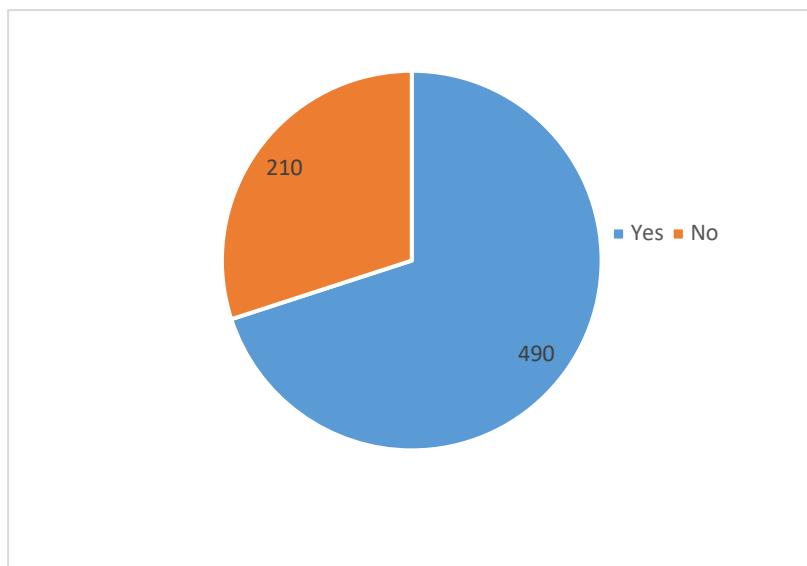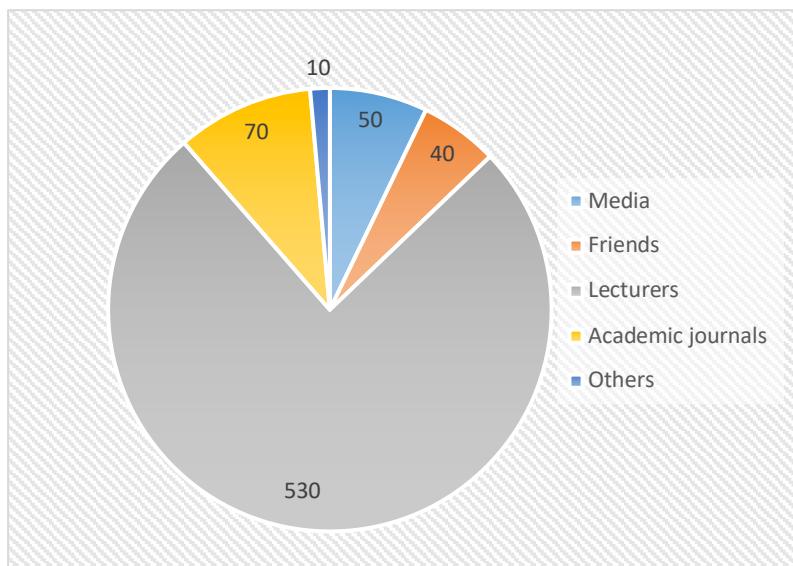
Figure 1: Knowledge about Precision agriculture

Figure 2: Respondents sources of PA information

Although most of the respondents (students and faculty alike) agreed that the impact of PA on Ghana's agricultural industry will grow as new ideas and opportunities spread, an overwhelming majority of the respondents indicated that PA education is not wide spread in Ghana. Out of the 700 respondents, 70% had knowledge about Precision agriculture and 30 % had no knowledge about Precision Agriculture. Probing further, 86% admitted that they did not know the components of PA education, with only 14% claiming to know what they are.
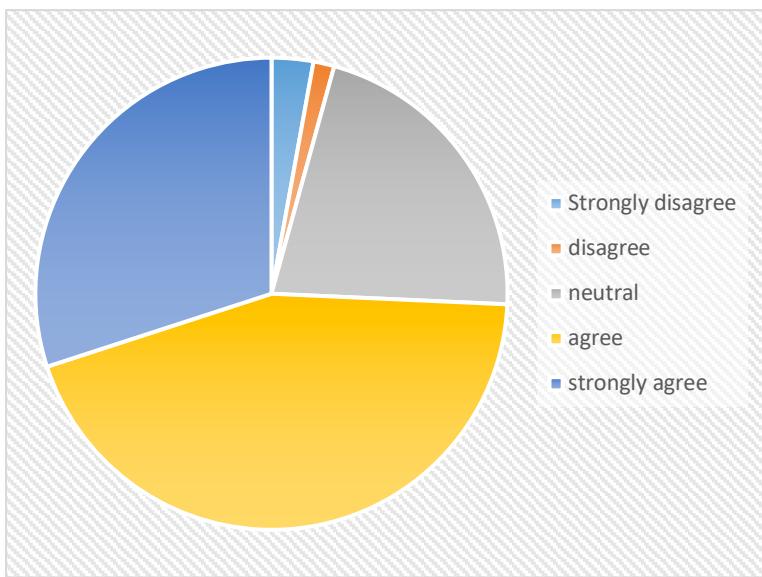
Figure 3: Impacts of PA in agriculture will row as new ideas and opportunities emerge
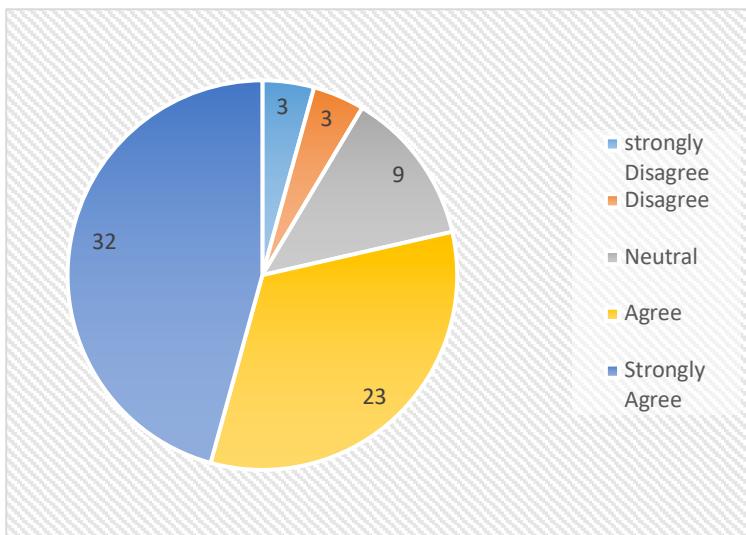

Figure 4: PA education is not widespread in Ghana

In the study, we sought to identify the key perceptions surrounding PA education in Ghana. The respondents showed a high level of consensus on their perceptions and requirement of PA education in Ghana. Responses to specific questions asked during the FGD are summarised in table 2.

Table 2: Perceptions of PA education in Ghana

Perception	Yes	No	Don't Know
Is PA critical for accelerated transformation of the agrifood systems, and shared prosperity and enhanced livelihoods in Africa	83%	17%	-
There is inadequate skilled PA faculty, tools and facilities in Ghanaian universities	87%	13%	-
There is limited financial commitments and regulatory policies towards integrating PA into existing program in universities	86%	14%	-
The extension services in Ghana lacks the capacity, skills and competencies to promote PA services	60%	22%	18%
There is lack of equipment and logistics to stimulate PA Education and outreach in Ghana	70%	9%	21%
The media is interested and adequately psyched to promote PA education and outreach in Ghana	39%	27%	44%
Promotion of PA education and outreach is low because of a disjoint existing between academia, industry and the media	59%	10%	31%
The success of PA education in Ghana is highly dependent on curriculum reengineering to include PA technology and skills training	59%	4%	37%

Majority of the respondents perceived that PA offers the potential to accelerate the development of Ghana's agrifood sector. A large proportion of the respondents also agreed that there is inadequate skilled PA faculty, tools and facilities in Ghanaian universities, and that there is limited financial commitments and regulatory policies towards integrating PA into existing program in universities. Most of the respondents also thought that the extension services in Ghana lack the capacity, skills and competencies to promote PA services. Furthermore, many of the students and faculty interviewed agreed that there is lack of equipment and logistics to stimulate PA education and outreach in Ghana. A fairly large number (59%) of respondents thought that promotion of PA education and outreach was at a low level due to a disjoint existing between academia, industry and the media, and a similar percentage (59%) of the faculty and students interviewed perceived that the success of PA education in Ghana is hinges on curriculum reengineering and integration of PA technology and skills training. However, only a few of the respondents agreed that the Ghanaian media is interested and adequately psyched to promote PA education and outreach in Ghana.

Challenges of PA Education in Ghana
It is widely documented that education is the surest way to overcome Africa's socio-economic development challenges. FAO (2007) pointed out that there a direct link between food security and education of rural youth, and that education can also help to improve farmers' livelihoods. In most parts of Africa, agriculture education is not prioritised and so it is often viewed as the preserve for underachievers. This problem is exacerbated in Africa where agricultural activities often used as a punishment in schools c (MIJARC/IFAD/FAO, 2012; PAFPNet, 2010). These

erroneous perceptions and actions negatively influence the aspirations of rural youth. Furthermore, the quality of agriculture education is often low, and good, motivated faculty are hard to find, especially in poorly endowed or in less prestigious universities and colleges (FAO/UNESCO, 2003; World Bank, 2008).

PA Education is low or non-existent in Ghanaian universities because there is no motivation for its introduction, there is also a lack of facilities to drive PA education. However, PA education can be popularized and expanded if PA is introduced into university curriculum and taught at all levels of university education. Overall, there is very limited understanding of PA, and concerns have been widely raised about applicability of PA tools, approaches and technology to complex smallholder farming systems. The study revealed that although mobile technology penetration and access is high in Ghana, it is generally widely diffused in rural areas. Furthermore, Internet access is growing steadily but it is expensive. The high costs of computers and the Internet, combined with limited and unreliable electricity supply low ICT literacy levels are exacerbated by lack of financial resources to secure the use of ICTs (World Bank, 2011). The focus group discussion revealed that the main challenge facing PA education is insufficient knowledge, and limited access to PA information and education, which highly limits the acquisition of knowledge and skills. Inadequate access to knowledge and information can hinder the development of entrepreneurial skills and investments in agriculture. In developing countries like Ghana there is an urgent need to improve the youth's access to education, and to incorporate agricultural skills into existing programs in the universities and agricultural colleges. Again, PA Agricultural training and education must be adapted to ensure that skills acquired by graduates match the needs of the labour markets.

Another major challenge identified during the FGD is youth's limited access to land. Access to land is fundamental to starting a farming activity, but Inheritance laws and customs in Ghana often make the access to land, especially to the youth and women problematic. Therefore, there is a need for enabling policies and credit facilities to assist youth in acquiring land.

Inadequate access to financial services is another important challenge. There is limited access to funding opportunities for the youth to pursue technology intensive courses. Provision of funding targeted at youth education, providing mentoring programmes and start-up funding opportunities can all assist to increase the enthusiasm of the youth to pursue agriculture in general and PA in particular.

With limited access to markets, the youth will find it difficult to engage in viable and sustainable agricultural ventures. PA education and training can enable generation and access to reliable market information, which can facilitate youth's access to niche markets, offering significant opportunities for young farmers. Facilitating the youth involvement in agricultural value chains through industrial attachments and internships have potential to improve the youth's access to markets.

Finally, the PA education systems should enhance the youth's involvement in policy dialogue. The youth should be trained to understand the policy process so that they can make meaningful inputs into how their complex and multifaceted needs can be captured in national policy. In this regard, the youth need the requisite skills and capacities for collective action to ensure that their voices are heard. The universities must facilitate active engagements of policymakers in PA education by promoting industry - academia cooperation and involvement in the curriculum design and delivery through seminars and symposia, and on-farm research activities for instance.

Opportunities
Global population is expected to increase to 9 billion by 2050, with youth (aged 15–24) accounting for about 14 percent of this total. While the world's youth cohort is expected to grow, employment and entrepreneurial opportunities for youth – particularly those living in developing countries' remain limited, poorly remunerated and of inferior quality. In view of the agricultural sector's potential to provide sources of livelihood opportunities for Ghanaian youth.

Modern ICT tools such as mobile phones and the Internet should be made increasingly accessible and affordable to Ghanaian students, as they have a high potential to promote access to information to enhance agricultural productivity and profitability by enabling agricultural innovation while providing access to financial services and markets. Research has shown that the youth are likely to adopt technologies related to farming more easily and are enthusiastic about increasing their production through improved and modern technologies" (MIJARC/IFAD/FAO, 2012). The focus group discussion revealed that Ghana has a youthful population, who are keen to pursue technology-based education. The study also showed an increased presence of smartphones and expanding internet access as well as increased access to secondary and tertiary education, with a deliberate attempt by policy makers to promote of ICT knowledge. Moreover, the government has rolled out policies that are aimed to attract the youth into the agriculture industry.

The way forward

While the challenges identified are complex and interwoven, a strategically structured PA education that ensures that the youth have access to the right information is crucial; PA education in Ghana must adopt integrated training approaches so that graduates can respond to the needs of modern agricultural practices, and modern information and communications technologies that offer great potential to increase agricultural productivity and profitability. Therefore, there is an urgent need to improve the ICT capacities of all agriculture students in the universities, Furthermore, counselling and guidance as well as students involvement in tailored agricultural projects and programmes have high potential to provide youth with the needed impetus to enter the agricultural sector; and a coherent and integrated action from policymakers and development practitioners alike is needed to ensure that the major constraints faced by youth are effectively tackled. Results from the FGD showed that each category of respondents had different priorities in terms of what would promote accelerated PA education in Ghana. The three top priorities of each category is summarise in table 2

Table 3: Determinants of accelerated PA education

Priorities	Faculty	Postgraduates	Undergraduates
1	Opportunities for further training (82%)	Funding for PA research (90%)	Improved curriculum that integrates PA technology, communication and entrepreneurial skills (82%)
2	Provision of PA tools and ICT infrastructure (75%)	Scholarships for PA research (85%)	Scholarship opportunities for PA education (80%)
3	Strengthened Industry-Academia linkages (70%)	Improved infrastructure for PA research (80%)	Highly PA skilled faculty (65%)

The FGD showed that faculty prioritise training, infrastructure and industry-academia linkages, postgraduates are more interested in PA research while undergraduate students are more inclined towards PA skills, scholarships and skilled faculty. Owing to the dynamic nature of technology and agricultural economy, agricultural universities are expected to adapt their curricula and integrate improved technology, communication, and entrepreneurial skills to help in transitioning traditional farming to digital agriculture. This way, enrolment in Agriculture and agriculture-related courses are likely to increase in Ghanaian universities. Surveys by the IUCEA (2015) and other organizations across Africa repeatedly show that although technical skills are valuable, employers place much greater importance on 'soft skills' (Kalufya and

Mwakajinga 2016; Ngalomba, 2018). Thus, it is crucial to train agriculture graduates in ways that enable them to continually adapt to a complex and changing ecosystem, by providing them opportunities that ensure their inclusion in networks that promote co-learning and sharing of scientific, technical and market information.

The success of PA in Ghana is highly dependent on curriculum reengineering, outreach and strengthened PA education. Building the skills of both educated and uneducated youth to work along the agricultural value chain has the potential to solve the problem of youth unemployment and, at the same time, increase agricultural productivity. Rapid technological evolution requires a culture of continuous learning and an agricultural education and training system properly focused on both how to learn and what to learn. Such a system must employ innovative e approaches that will position agriculture graduates to lead change, to be adaptable and efficient. Universities should enhance the skills of graduates in ways that will empower them to respond to rapidly changing technological, environmental and structural conditions. They must be innovative and capable of adapting their PA knowledge and skills to complex and changing food systems.

The integration of PA technologies in higher education offers the potential to equip agriculture graduates with the needed skills that will make them employable in a rapidly expanding agricultural industry. Although, PA education and training as crucial to optimize PA's contribution to agricultural development, most universities in Africa will find it hard to stay ahead of the rapid advances in technology associated with PA adoption. Therefore, it is critical to assess and prioritise the PA-training needs of students studying in agricultural universities in Ghana. In accordance with Mondal and Basu (2009), we suggest that significant attention should be given information technologies, such as global information systems (GIS), global positioning systems (GPS), remote and proximal sensing, robotics, and variable rate technology (VRT), that are needed detect and manage spatial and temporal variability. In terms of skills and technical knowledge required for PA education in Ghana, Presently, the wide array of precision agriculture technologies (PAT) including GNSS technology, Geographic Information Systems, yield monitors, soil sampling tools, remote sensing tools, farm management applications, and variable rate application technologies are available (Paustian & Theuvsen, 2017; Robertson et al., 2012)

Although, any attempt to transition traditional agriculture training to PA education in Ghana' will come easily, responses offered during the FGD and interviews offer a sense of hope that there are workable solutions to overcome the challenges faced by young women and men trying to engage in agriculture as a source of sustainable livelihood. PA Education is a potentially effective approach to teaching agricultural skills and providing capacity-building trainings for agriculture graduates, but it should be done in ways that will always transmit the necessary skills, and result in good employment outcomes.

PA education is essential for the development of Ghana's agricultural sector, but agricultural training programmes in most of Africa are often constrained by lack of funding, and weak infrastructural base. Besides, there is often a mismatch between the kind of training offered and the requirements of the labour market in an evolving agricultural sector (Kalufya and Mwakajinga, 2016)., Thus, there is an urgent need for the creation or strengthening of existing universities so that they will focus on PA education and research by establishing linkages with the key players in the Ghanaian agricultural industry. Linking universities with industry is critical to identify knowledge and skills that meet the needs of industry, facilitate participatory research and enhance results dissemination to solve local problems. It is equally important to connect universities with labour market opportunities and to strengthen partnerships with employers to ensure that the PA skills that will be developed in graduates respond to labour market needs so that they become employable (). Unfortunately, in most developing countries, such systems are rarely existed and so enrolments into tertiary agricultural education are low and dwindling.

Conclusion

In concluding, a coordinated PA education that builds the technical knowhow and skills and also enables access to financial services, and niche markets, while building the youth's capacity to actively participate in policy dialogue and developmental agenda setting is likely to increase youth's involvement in the agricultural sector, resulting in increased productivity and profitability. Such a PA education can be replicated in other African countries. In line with responses from the FGD, we propose that existing undergraduate and postgraduate agricultural programmes should be redesigned to include courses such as data science, geographic information systems (GIS), remote sensing, artificial intelligence and digital agriculture courses related to specific disciplines. We further suggest that government policies should include training and re-training of faculty, building the capacity of support staff, and provision of the needed infrastructure and funds for agricultural universities to successfully run PA programmes.

References

- Beintema, N.M., & Di Marcantonio, F. (2010). Female participation in African agricultural research and higher education: new insights synthesis of the ASTI-Award Benchmarking Survey on Gender-Disaggregated Capacity Indicators. IFPRI Discussion Paper 00957
- FAO (2014) Youth and agriculture: Key challenges and concrete solutions. https://www.fao.org/3/i3947e/I3947E.pdf accessed on 9th May 2022
- FAO (2007). Education for rural people and food security: a cross-country analysis, P. De Muro & F. Burchi. Rome.
- FAO (2012). Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security. Rome
- FAO/UNESCO. 2003. Education for rural development: towards new policy responses. D. Atchoarena & L. Gasperini. Rome.
- https://acetforafrica.org/highlights/how-can-agricultural-transformation-be-achieved-in-ghana-answers-from-the-ghana-agricultural-transformation-forum/ Accessed on 9th May, 2022
- Kalufya, N., & Mwakajinga, L. (2016) Employability of graduates from higher education institutions in Tanzania. Institute of Social Work Journal 1 (2), 51 – 68.
- MIJARC/IFAD/FAO (2012). Summary of the findings of the project implemented by MIJARC in collaboration with FAO and IFAD: 'Facilitating access of rural youth to agricultural activities'.The Farmers' Forum Youth session, 18 February 2012 (available at http://www.ifad.org/farmer/2012/youth/report.pdf).
- Mondal, P., & Basu, M. (2009). Adoption of precision agriculture technologies in India and in some developing countries: Scope, present status and strategies. In Progress in Natural Science (Vol. 19, Issue 6, pp. 659–666). Science Press. https://doi.org/10.1016/j.pnsc.2008.07.020
- Ngalomba, S. (2018) Employers need graduates to be taught vital soft skills. Available at: https://www.universityworldnews.com/post.php?story=20181015070551149 (accessed 1 March 2022).
- PAFPNet (Pacific Agricultural and Forestry Policy Network). 2010. Youth in agriculture strategy 2011– 2015: echoing the voices of Pacific youth. Compiled by Pacific Agricultural and Forestry Policy Network, Secretariat of the Pacifi c Community Land Resources Division.
- Paisley, C. (2012). Skill gaps in formal higher agricultural education: a youth perspective. Background paper for the Future Agricultures Conference on Young People, Farming and Food: The Future of the Agrifood Sector in Africa.
- Paustian, M., & Theuvsen, L. (2017). Adoption of precision agriculture technologies by German crop farmers. Precision Agriculture, 18(5), 701–716. https://doi.org/10.1007/s11119-016-9482-5
- Robertson, M. J., Llewellyn, R. S., Mandel, R., Lawes, R. A., Bramley, R. G. V, Swift, L., Metz, N., & O'Callaghan, C. (2012). Adoption of variable rate fertiliser application in the Australian grains industry: Status, issues and prospects. Precision Agriculture, 13(2), 181–199. https://doi.org/10.1007/s11119-011-9236-3
- Romanov, V., Galelyuka, I., & Sarakhan, Y. (2016). Wireless sensor networks in agriculture. 2015 IEEE 7th International Conference on Intelligent Computing and Information Systems, ICICIS 2015, 77–80. https://doi.org/10.1109/IntelCIS.2015.7397200
- Swinton, S. M., & Lowenberg-DeBoer, J. (1998). Crop Economics - Summaries - Evaluating the Profitability of Site-Specific Farming. Journal of Production Agriculture, 11, 391.

- World Bank (2011). ICT in agriculture, connecting smallholders to knowledge, network and institutions. E-sourcebook on ICT in agriculture. Report Number 64605. Washington, DC, International Bank for Reconstruction and Development/World Bank.