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A Framework for Introducing Precision Agriculture Technologies in Egypt

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Precision Agriculture (PA) has been used in many countries and serving the agricultural sectors. The use of PA solutions intervened with many agricultural businesses and supported decision making using data analytics. Precision Agriculture depends on weather, soil, plants, and water information that are essential for farming. Precision Agriculture depends on the use of several technologies such as image sensors, vision machines, drones, robots, machine learning, and artificial intelligence. The use of Precision Agriculture Technologies (PAT) depends on integration between devices, sensors, and systems to ensure the proper implementation of activities. This paper is generated from research on the applicability of PA in in Egypt that ended with a proposed framework for proper implementation of it. The conducted research depended on a survey, focus group discussions, and an online questionnaire that reached 271 respondents from 19 Egyptian governorates. The framework has been developed to enhance the role of an initiative leader to promote PAT through collaboration with other stakeholders in the agricultural sector. The proposed framework can be used by governmental, non-governmental entities, universities and private sector institutions and could be used at countries facing issues with land fragmentation, limited access to information, limited access to agricultural extension services, and increase in agricultural input's prices.

Keywords: Precision Agriculture, precision agriculture technologies, image sensors, robots, machine learning, Internet of Things

Introduction

Agricultural sectors worldwide are served by many technological solutions in the recent years and one of the remarkable digital transformation initiatives is the use of Precision Agriculture Technologies (PAT). Precision Agriculture (PA) depends on data collection tools such as sensors, data collection hubs, and analytical software supporting management decisions. There are technologies serving the precision agricultural implementation such as image processing, vision machines, Machine Learning (ML), and Internet of Things (IOT). One of the used technologies in PA is the identification of plant pathogens using vision machines and image processing as stated by Mahlein (2016). Artificial Intelligence (AI) supports farm managers to use analytics in predicting incidents that might affect their crops in the field. AI, agricultural machinery, and robotics are key elements of the Fifth Industrial Revolution (5IR) which is called "Agriculture 5.0" as highlighted by

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Mancini, Frontoni, and Zingaretti (2019). AI and Deep Learning (DL) technologies support agricultural sectors with analytics and decision improvement tools as stated by Zheng et al. (2019). Khanna and Kaur (2019) emphasized that Internet of Things (IOT) is used in agriculture sector and PA integrated many IoT tools and applications upon its introduction. Torky and Hassanein (2020) emphasized that Blockchain is an important technology enhancing the security of IoT systems.

Finally, the Precision Agriculture depends on many technologies, and it is expected to be enhanced based on the progressive development of these technologies. In this study a focus is given to measure the applicability of PA in Egypt using assessments of agricultural nature, technology, and socioeconomic variables.

Theoretical Background

Zachariah (2019) defined Precision agriculture (PA) as:

> a methodology to farm management that uses information technology (IT) to certify that the crops and soil obtain exactly what they require for optimum health and efficiency. The goal of PA is to ensure profitability, sustainability, and protection of the environment. PA is also acknowledged as satellite agriculture, and site-specific crop management (SSCM). (Zachariah, 2019, pp. 12-13)

while Khanna and Kaur (2019) defined it as:

> an approach to farm management that uses Information Technology (IT) to ensure that the crops and soil receive exactly what they need for optimum health and productivity. The goal of Precision Agriculture is to ensure profitability, sustainability, and protection of the environment. Precision Agriculture is also known as Satellite Farming and Site-Specific Crop Management (SSCM). Apart from the above said, there have been enormous changes in the techniques and methodologies of performing agricultural activities. (Khanna & Kaur, 2019, p. 218)

The authors proposed the following definition to PA as:

> a modern technological approach that is currently introduced to the agricultural sector worldwide. The objective of the precision agriculture is to use sensors, devices, instruments, and equipment to support decisions on use of agricultural inputs such as fertilizers, pesticides, water, animal feed and veterinary products. (Abdelnabby, Khalil, Awny, & Ezzat, 2022, p. 13).

as stated in Abdelnabby et al. (2022). There are many technologies and solutions that are supporting the implementation of PA and are discussed in the following points. Patr ćio and Rieder (2018) worked on computer vision solutions and artificial intelligence algorithms which are employed in mapping field crops such as wheat, rice, maize, barley, and soybean. They proved that computer vision systems are applicable in different agricultural industries but there are some limitations in the application of computer vision machines, and this can be enhanced through use of integrated solutions with agricultural machinery that depend on AI and sensors. Partel, Charan Kakarla, and Ampatzidis (2019) highlighted that sprayers apply agrochemicals uniformly in the field which results chemical unused intervention, cost increase, damaging crops, increase pest resistance, and pollution. They conducted a study to use a smart sprayer supported by vision machine and artificial intelligence technologies to determine target weeds from non-target plants. Orsini et al. (2019) implemented research aimed at designing a robot for cropping system sustainability using precision agriculture technologies. They observed a positive relationship between Normalized Difference Vegetation Index (NDVI) and Chlorophylla+bcontent so, NDVI can be used indirectly to estimate the greenness of the crop which can detect nutritional deficiencies using multispectral images acquired by drone. The precision agriculture is depending on Internet of Things (IoT) as Khanna and Kaur (2019) highlighted that recently, the term (IoT) has created new benchmarks for different industries and sectors. Ahmed and Hussain (2018) confirmed that IoT can help farmers in many ways with the deployed sensors/actuators across farms and machinery, farmers can collect insightful data such as temperature, used water, applied fertilizers, and other agricultural factors. Torky and Hassanein (2020) highlighted that Blockchain is an important technology in many applications of precision agriculture discipline. They conducted a survey on the integration between blockchain and IoT and this study proposed blockchain models of implementation and platforms.

The research has also conducted a mapping of current activities and initiatives implemented in Egypt to address the provided services alone with supporting institutions. It has been noticed that there are several initiatives under the Government of Egypt to support digital transformation and promote precision agriculture. In addition, there are many universities and research centers working on that domain alone with presence of international companies in the field of precision irrigation and other solutions.

Methodological Procedures

The identified research problem is the limited adoption of new technologies in Egyptian agricultural sector and specifically precision agriculture technologies. The main research questions included possibilities in implementing precision agriculture successfully in the agricultural sector in Egypt, then, addressing the impediments to implementation of precision agriculture in Egypt. This paper proposed a framework to implement precision agriculture in Egypt. The research depended on secondary and primary data sources. The primary data collection depended on an online questionnaire that has reached 201 respondents from the agricultural sector including farmers, researchers, agronomists, experts, and investors.

The collected data have been analyzed statistically using Statistical Package for the Social Sciences (SPSS) where Chi-Square tests, weighted percentage techniques, and three-way crosstab Chi-Square test were used. The research collected responses from respondents that were reached randomly through social media channels.

Results

This section of the paper presents the results of primary data collection from the online questionnaire. The collected samples included respondents from19 Egyptian governorates out of 27 governorates which represent around 70% of the country. The overall findings of the study are that Precision Agriculture (PA) is needed to support reclamation projects and manage water resources. However, there are some obstacles affecting the diffusion of PA in Egypt such as limited awareness on the concept, limited number of service providers, and limited role of research centers as well as universities to serve the agricultural sector in that field.

Furthermore, this research depended on an online questionnaire designed to collect responses of farmers, researchers, businesses, and other actors in the Egyptian agricultural sector. The questionnaire was distributed to a sample of 201 participants and included diversified groups of experts from different fields such as crops production, education, research, consultation, developmental projects, agricultural processing, inputs suppliers and other fields as illustrated in the following figure.

Figure 1 shows the distribution of the participants in the sample. The agricultural production professionals were represented with 120 participants followed by 73 working in developmental projects then consultation businesses with 67 and research with 62.

The online questionnaire included a question on the PA information sources where answers included radio and TV, social media, seminars, experts, training courses, workmates, neighbors, formal agricultural extension services, newspapers, and magazines. The following figure illustrates the frequencies of each source based on the selections of the questionnaire respondents.

As illustrated in Figure 2, the obtained results show less dependence on the traditional sources of information such as agricultural extension, neighbors, TV, radio, and newspapers. Responses showed the preference of respondents to various sources of information. Seminars and info sessions was selected 94 times followed by training courses selected 74 times. The third rank was of experts with 65 followed by social media 62.

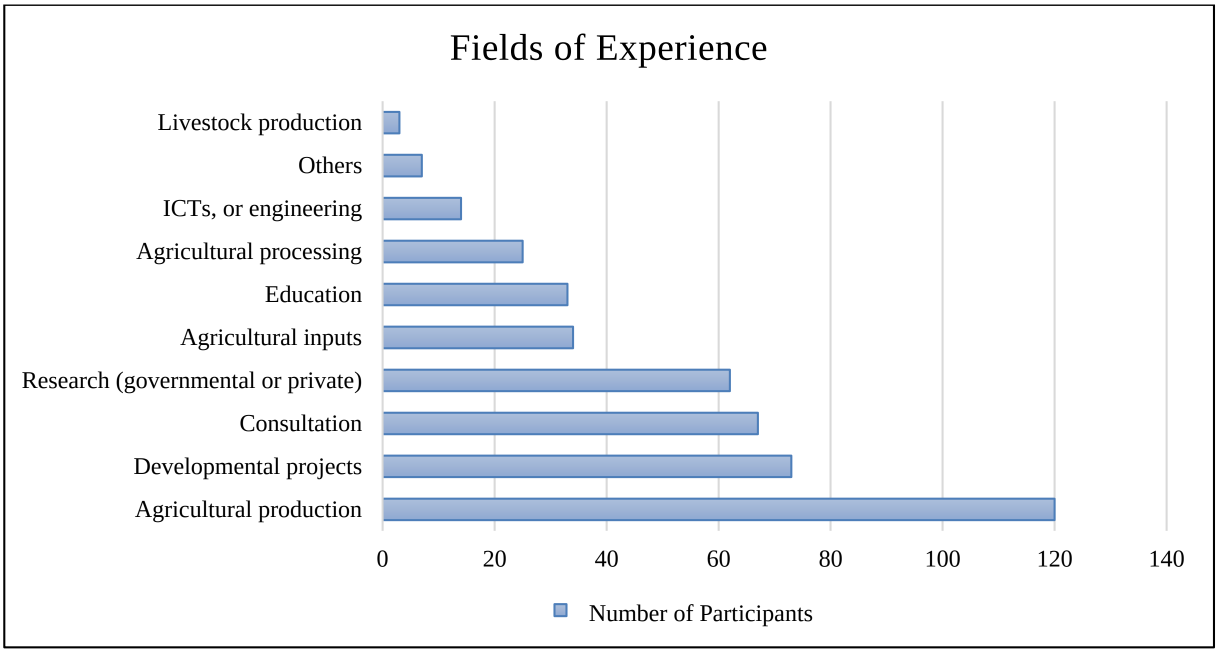

Figure 1. Sample description (fields of experience).

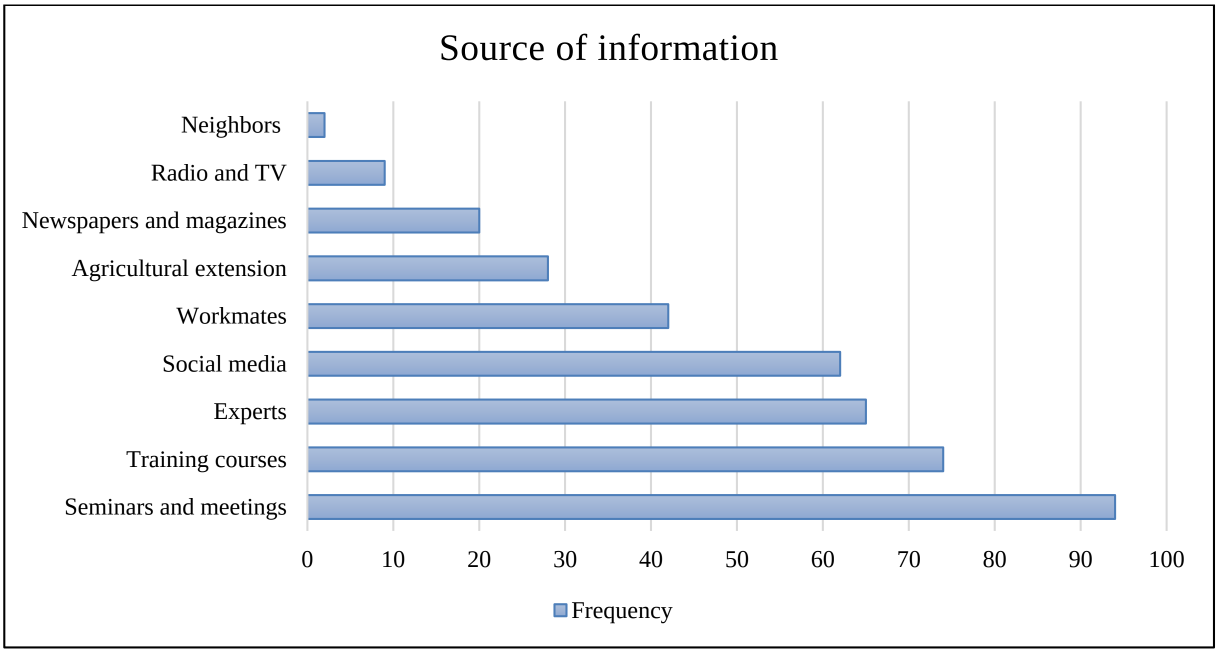

Figure 2. Source of information on PA.

The online questionnaire included a question about the current service providers in the field of PA in Egypt that included research centers, universities, global firms, local agents of international companies, big farms, and others. The respondents were also allowed to select “not aware of any source of PA technologies” to reflect their opinions.

As illustrated in Figure 3, the respondents selected universities and research centers 99 times followed by global firms 74 times, big farms 65 times, and 54 times for agents of international companies. The number of responses selected “not being aware of any PA sources of technologies” is 47.

Dissemination of Precision Agriculture Technologies in Egypt

The online questionnaire included a check list addressing a number of intervention tracks that can be used in disseminating PA in Egypt. A weighted percentage method was used to prioritize diffusion directions of PA in Egypt. This depended on giving a score for each response (agree = 3, neutral = 2, disagree = 1). The total score has been calculated for each statement by summing up the frequencies multiplied by given score. Then the weighted percentage has been calculated through dividing the total score by highest score which is 603 (the number of respondents 201×3 the highest score for responses) as shown in the following table.

Table 1

Proposed Interventions to Disseminate PA in Egypt

Statement	Agree		Neutral		Disagree		Total marks	Weighted percentage% = (Total marks/603(201×3)) ×100	Rank
	F	%	F	%	F	%			
Info session and seminars on the concept and objective of the transformation to precision agriculture, presented by government and research agencies	165	82.1	31	15.4	5	2.5	562	93.2	7
Build local awareness of different practices and applications of precision agriculture through info-programs and social media	171	85.1	27	13.4	3	1.5	570	94.5	4
Support Egyptian companies working in the field of agricultural technologies and enhance their capacities financially and technically	170	84.6	25	12.4	6	3.0	566	93.9	6
Support farmers wishing to implement PA production systems on their farms financially and technically	183	91.0	16	8.0	2	1.0	583	96.7	1
The inclusion of precision agriculture concepts and courses in the technological and agricultural universities in Egypt	174	86.6	23	11.4	4	2.0	572	94.9	3
Facilitating the import of precision agriculture components from abroad	176	87.6	22	10.9	3	1.5	575	95.4	2
Allowing the use of drones in agriculture, whether by importing it or manufacturing it locally	166	82.6	33	16.4	2	1.0	566	93.9	5

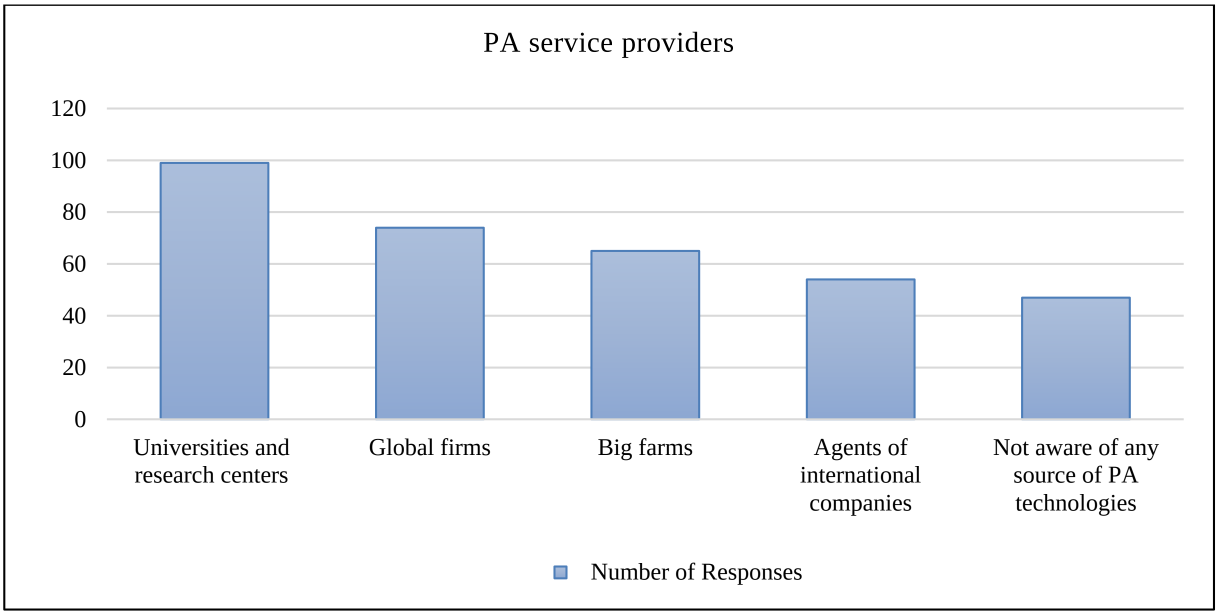

Figure 3. PA service providers in Egypt.

As explained in Table 1, the following interventions can lead to the dissemination of PA technologies in Egypt.

(1) The first track is providing support to farmers willing to transform their fields into PA systems with a score of 96.7%.

(2) The second track is that the government shall facilitate the procedures of importing PA technologies or components from abroad with a score of 95.4%.

(3) The third track is by including the PA as a major in technological schools and universities with a score of 94.9%.

(4) The fourth track is awareness campaigns to introduce the PA technologies using social media and communication channels with a score of 94.5%.

(5) The fifth track is the government approval to use agricultural drones with a score of 93.9%.

(6) The sixth track is the support to Egyptian startups and technological companies working in the field of PA technologies with a score of 93.9%.

(7) The seventh track is conduction of info sessions and agricultural extension programs to disseminate the PA technologies in Egypt with a score of 93.2%.

Discussions and Conclusions

Based on this study results and analysis it became clear that professionals working as farm advisors and service providers tend to be more aware about PA technologies. Therefore, their role in the diffusion of PA technologies is important. The study highlighted that field crops, and horticulture producers are accepting the PA technologies more than other segments of the sample such as livestock and medicinal and aromatic plants. This acceptance is related to the high adoption rate of new technologies for those working in horticulture and crops. The study highlighted that there are many PA applications that are used worldwide which are not known to be applied in Egypt such as image sensors, IOT, blockchain, robotics, and machine learning. Finally, the respondents showed their acceptance to implement PA technologies in the future based on availability and affordability.

The overall conclusion is that PA is applicable and can be implemented in the agricultural sector in Egypt. The study showed that the overall perception of those working in the agricultural sector is that PA can play a significant role in the development of the sector. The study highlighted the important role of universities and research centers to raise the awareness of agricultural professionals of PA, in addition to the role of international firms and agents in transferring the PA technologies to Egypt. It also showed that the awareness about PA is linked to highly educated people. The following points can also be drowned from results obtained:

- The nature of the professional work of the person at farm level is linked with his awareness of the new technologies including PA.
- There are relations between the agricultural patterns or subsectors and the awareness of new technologies including PAT.
- The majority of the applied PA technologies in Egypt are precision irrigation followed by remote sensing and pest control. It is noticed that the implementation of PA technologies in Egypt is not up to date with international modern solutions.
- Agronomists at agricultural production companies are depending on PA technologies more than the other segments of the sample such as researchers, governmental agronomists, and university staff.
- Based on the respondents' opinions, the research efforts in the field of PA are not satisfying the current requirements of the country and the agriculture sector.
- The study concluded that PA could contribute in solving some of the problems affecting the development of the agricultural sector in Egypt such as increase of inputs prices, labour limited availability, and limited access to extension services.

Proposed Framework for PA Dissemination

Based on the above-mentioned conclusions the following figure illustrates a proposed framework for dissemination of PA in Egypt.

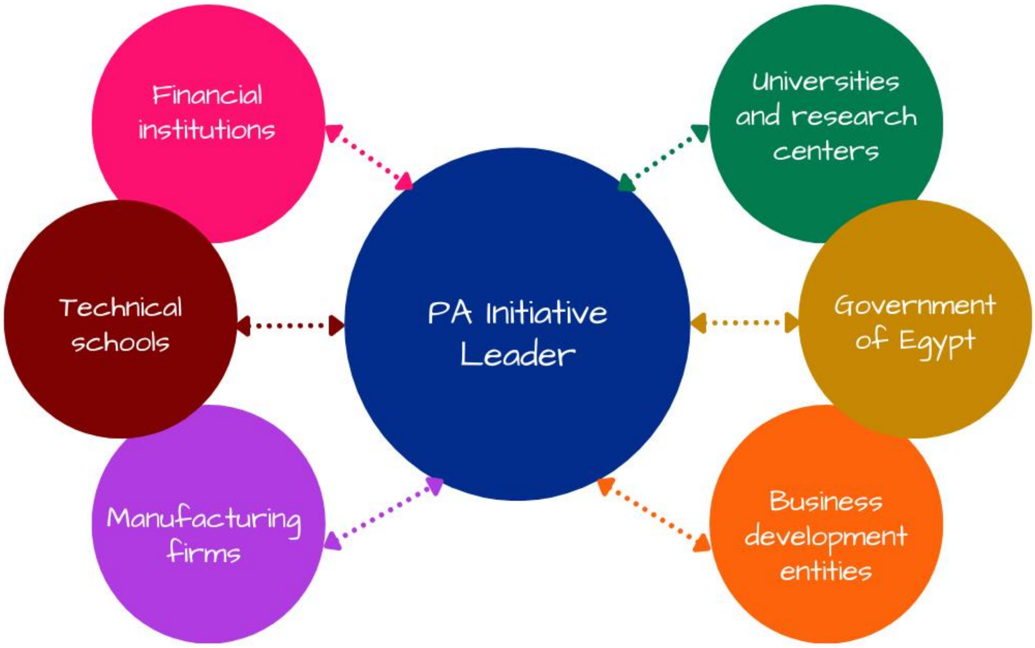

Figure 4. Proposed framework for PA dissemination.

The proposed framework includes integration between stakeholder in Egypt to promote a national initiative led by an initiative leader (national or international). The initiative leader can be governmental, non-governmental entity or a consortium with a university or research centers. The initiative leader/consortium shall collaborate with proposed entities to achieve the successful implementation of PA in Egypt. The following entities may be considered by the initiative leader in the design of activities to ensure the proper achievement of this initiative objective as illustrated in Figure 4. Each entity has a role to play as proposed below:

- Universities and research centers: initiate communications with international universities and research centers in the field of PA. This shall build collaboration bases targeting technology sharing and exchange of knowledge. The role of universities and research centers is essential to build capacities of local professionals in the field and to create a new cadre of specialists that can support agricultural sector in Egypt.
- Government of Egypt: communicate with relevant ministries under GOE such as Ministry of Higher Education and Scientific Research, Ministry of Agriculture and Land Reclamation, Ministry of Communication and Information Technology, Ministry of Planning, Ministry of Irrigation and Water Resources, and other entities, establish technical committees and thinktanks between researchers from international universities and research centers and representatives of ministries in Egypt.
- Business development entities: announce a special incubation cycle for Egyptian startups willing to work in the PA technologies.
- Financial institutions: communicate with Egyptian financial institutions such as Central Bank of Egypt, governmental and private banks to promote the idea of PA dissemination in Egypt. The role of the leader will be to communicate with the banks to collect funds for the implementation of PA technology.
- Technical schools: approach Ministry of Education and other entities such as GIZ and TVET which are working on development of technical and vocational education in Egypt. The objective of this collaboration is to design special programs to the technical schools that are linked to PA technologies and solutions.
- Manufacturing firms: build collaboration with national machinery providers and manufacturing firms to assist in the development of PA solutions in Egypt such as autonomous tractors and crop sensors. The manufacturers can also finance some of the activities or include a number of the incubated companies to work under their cluster.

The proposed framework can be updated and changed based on availability of funds and supporting entities which are interested to help in the PA applicability initiative.

References

Abdelnabby, M., Khalil, T., Awny, M., & Ezzat, M. (2022). A framework for introducing precision agriculture in Egypt (PhD dissertation, Nile University, 2022).

Ahmed, N., De, D., & Hussain, I. (2018). Internet of things (IoT) for smart precision agriculture and farming in rural areas. *IEEE Internet of Things Journal, 5*(6), 4890-4899. Retrieved from https://doi.org/10.1109/JIOT.2018.2879579

Khanna, A., & Kaur, S. (2019). Evolution of internet of things (IoT) and its significant impact in the field of precision agriculture. *Computers and Electronics in Agriculture, 157*(December 2018), 218-231. Retrieved from https://doi.org/10.1016/j.compag.2018.12.039

Mahlein, A. K. (2016). Plant disease detection by imaging sensors—Parallels and specific demands for precision agriculture and plant phenotyping. *Plant Disease, 100*, 241-254. Retrieved from https://doi.org/10.1094/PDIS-03-15-0340-FE

Mancini, A., Frontoni, E., & Zingaretti, P. (2019). Challenges of multi/hyper spectral images in precision agriculture applications. *IOP Conference Series: Earth and Environmental Science, 275*(1), 1-5. Retrieved from https://doi.org/10.1088/1755-1315/275/1/012001

Orsini, R., Basili, D., Belletti, M., Bentivoglio, D., Bozzi, C. A., Chiappini, S., … Zingaretti, P. (2019). Setting of a precision farming robotic laboratory for cropping system sustainability and food safety and security: Preliminary results. *IOP Conference Series: Earth and Environmental Science, 275*(1), 1-6. Retrieved from https://doi.org/10.1088/1755-1315/275/1/012021

Partel, V., Charan Kakarla, S., & Ampatzidis, Y. (2019). Development and evaluation of a low-cost and smart technology for precision weed management utilizing artificial intelligence. *Computers and Electronics in Agriculture, 157*, 339-350. Retrieved from https://doi.org/10.1016/j.compag.2018.12.048

Patrício, D. I., & Rieder, R. (2018). Computer vision and artificial intelligence in precision agriculture for grain crops: A systematic review. *Computers and Electronics in Agriculture, 153*, 69-81. Retrieved from https://doi.org/10.1016/j.compag.2018.08.001

Torky, M., & Hassanein, A. E. (2020). Integrating blockchain and the internet of things in precision agriculture: Analysis, opportunities, and challenges. *Computers and Electronics in Agriculture, 178*, 1-23. Retrieved from https://doi.org/10.1016/j.compag.2020.105476

Zachariah, A. B. (2019). *Precision agriculture: The future of farming*. Burlington: Delve Publishing. ISBN:978-1-77361-806-7

Zheng, Y.-Y., Kong, J.-L., Jin, X.-B., Wang, X.-Y., & Zuo, M. (2019). CropDeep: The crop vision dataset for deep-learning-based classification and detection in precision agriculture. *Sensors, 19*(5), 1058. Retrieved from https://doi.org/10.3390/s19051058