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Palestinian Experience in Enhancing Innovation in Precision Agriculture Technology

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Abstract

in developed countries, precision agriculture (PA) technology rapidly gaining attention as a way of addressing the issue of sustainable agriculture. Understanding current trends in PA aids in avoiding future challenges. In Palestine, the agriculture sector is the most effective and holds significant political and economic value. The use of technologies could allow the agricultural sector to achieve big leaps in Palestine, especially in improving environmental protection, increasing productivity and introducing the cultivation of new strategic classes of crops. With the aim of enhancing and introducing PA technology to Palestine, a team of researchers from ten European and Palestinian universities, including the author of this article, were participants in the Erasmus+ project entitled "Promoting Innovation in Precision Agriculture Education and Research in Palestine (BENEFIT)". Before 2020 the beginning of the BENEFIT project and the Palestinian universities involvement in it, the use of PA technology was limited and there was insufficiency of knowledge and awareness about PA technology in Palestine. In addition to the lack of the content of PA technology in the curricula of Palestinian universities. Hence, this article provides an overview of development and status of PA technologies in Palestine. The topics include promoting Innovation in education in the field of PA, and Innovation in PA– Case Studies from Palestine.

Keywords: *Precision agriculture; Digital Farming; Internet of Things; smart irrigation system; ERASMUS+; Jericho*

1. Introduction

1.1. Overview of agricultural sector in Palestine

The agricultural sector in Palestine represents the strongest pillar carries both economic and political importance. It contributes to covering part of the final food consumption and its contribution to providing goods and raw materials that are used as inputs in many manufacturing industries. In addition to being an important component of

Palestinian exports. Agricultural activity in Palestine is characterized by its reliance mainly on rain, and its limited reliance on modern agricultural methods. Recently, according to the Palestinian Central Bureau of Statistics (PCBS) report, "Performance of the Palestinian Economy, 2022", this sector is employed about 12 % of the labor force. Further, the agriculture income represents 6 % of the gross domestic product (GDP), accounts for 21 % of the total exports, and the percentage of cultivated area out of the total area in Palestine was 18.9 % (PCBS, 2023; PCBS, 2024). More notably, the agriculture in Palestine plays a central role in land protection from Israeli confiscation and settlements. Thus, The Palestinian Ministry of Agriculture (MoA) was adopted strategy aligned to these relevancies, in order to have a sustainable and feasible agriculture sector that can compete domestically and externally; and can effectively contribute to enhancing food security and the connection between the Palestinian people and their land, while also enhancing Palestinian state-building efforts through resource sovereignty (Khalilia, 2020).

The environmental and political challenges are the main factors threaten the agriculture sector in Palestine. However, the effects of these issues are more intensified when considered in the frame of Climate Change. In this perspective, water quantity and quality have been continuously declining during the last years. Further, the scarcity of land resources, rapid population growth, pollution of the aquifers and marine environment, desertification and land degradation are challenging. Under the regional climate changes such as changes in precipitation quantity, rain distribution, and the increases in seasonal temperature variability the environmental problems more intensified. Consequently, negative impact on agriculture sector my realized attributed to damage crops, decrease water availability and loss of biodiversity. Thus, can affect negatively the natural control of agricultural pests, and delay the growing seasons (Skendžić, et al., 2021).

The Palestinian agricultural sector suffers from obstacles and challenges related to the occupation's practices and policies, such as confiscating land, building settlements and the separation wall, stealing Palestinian water, preventing the import of many pesticides and fertilizers, placing obstacles to the export of agricultural crops, and flooding Palestinian markets with Israeli goods to hit the Palestinian agricultural output. The agricultural sector in Palestine also faces internal problems and obstacles, including limited water and agricultural land, increased competition for it from other sectors, soil erosion and low productivity, improper use of chemicals, deterioration in the quality of water used in irrigation, deterioration of vegetation cover, and urban sprawl. In addition to weakness in agricultural research, infrastructure, agricultural and rural financing system, and lack of harmonization of agricultural laws and legislation. In order to overcome most of these challenges, it is necessary to take advantage of modern digital technologies in farm management in a way that increases their efficiency and productivity, without the need to increase the resources used. PA forms the cornerstone for solving most of the previous problems and challenges.

1.2. Overview of Precision Agriculture (PA)

According to the International Society of Precision Agriculture (ISPA), the definition of Precision Agriculture (PA) is "a management strategy that gathers processes and analyzes temporal, spatial and individual plant and animal 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." (ISPA, 2024). While Digital Farming is the use of technology by farmers to integrate financial and field-level records for complete farm activity management. It is the seamless integration of digital

technologies into crop and livestock management and other processes in agriculture (Shang et al., 2021).

Generally, the industrial and digital technologies are expanding in global phenomenon with an emphasis on digitalization, automation, control and robotics in various operations, related to environmental protection, soil cultivation management, optimization of crops nutrition, crop tending etc. (Kraus, et al., 2021). The added value of automated robotic systems to agriculture is the enhancement of their flexibility, concerning farmer decision making to select the optimal technological arrangements during the production process of the field crops, which entails not only economic but also environmental and social aspects (Rose, et al., 2021). As a result, the use of technologies could allow the agricultural sector to achieve big leaps in Palestine, especially in improving environmental protection, increasing productivity and introducing the cultivation of new strategic classes of crops. The knowledge about advanced agricultural technologies have therefore become key for the farmers in these regions, throughout the process of cultivation and harvest.

A number of sophisticated tools that assist in monitoring variation and managing inputs characterizes PA. These include Remote Sensing (RS), Geographic Information System (GIS), 3. Global Positioning System (GPS), Yield Monitoring (YM) and Variable Rate Technology (VRT).

The main goals of digital technologies usage in PA are (Hakkim, et al., 20160:

- Compile and analyze data in real-time that allowing farmers to make better decision,
- Get optimum results from labor & resources
- Yield monitoring,
- Understanding soil and plant parameters
- Lead to use fewer pesticides and nitrogen's,
- Help automate field management
- Reducing water waste and improve crop management
- Reducing greenhouse gas emissions,
- Reducing environmental impact of the agriculture,
- Energy saving,
- Food traceability,
- Get more production – economic growth,
- More efficient agricultural value chain, environmentally sustainable,

1.3. Awareness, knowledge, and perceptions of PA technology in Palestine

It should be pointed out that a high percentage of Palestinian farmers use drip irrigation systems to irrigate their fields (MoA, 2014). However, the majority of Palestinian farming system is a traditional system carried out without well prepared plans and without using modern or evolved equipment; which is because of the absence of financial support and training or both. Finally, the number of agronomists is inadequate; this delays the progress in this sector and restricts the use of such advanced technologies in the sector. In addition, local farmers are not well prepared to deal with modern technologies and prefer conventional systems. At the same time PA or smart farming are not included in the curricula of the faculties of agriculture in Palestine (Deans of faculties of agriculture in Palestine, personal communication). Under these circumstances, the employment of advanced technology in the Palestinian agricultural system will have a positive impact. It will lead to improved productivity

either by increasing the production quantitatively or qualitatively (Abdalla et al., 2019; MoA, 2014).

Recently the author of this review has conducted a research aimed to analyse the agriculture college students' awareness, knowledge, and perceptions towards PA in Palestine. It was found that, among students (n = 211), the majority had moderate; low, and very low level (85%) of knowledge and awareness of PA. While the majority of students (77%) had either strongly agree, agree, and neutral for perceptions toward PA. Generally, the stand of students for PA is positive and there is a strong believe among them that universities have a significant contribution to introduce PA into Palestine, and most students were with the need to develop new courses of PA in Palestine. The study highlighted the need for increased emphasis on PA education for Palestinian universities students enrolled in agriculture programs. While students expressed a positive perception of PA, their knowledge and skills remain at a relatively low level. Curriculum development efforts that integrate PA concepts and provide opportunities for practical application are crucial. Addressing the identified gender gap and ensuring equitable access to PA education are also important considerations. By equipping future agricultural professionals with the necessary knowledge and skills in PA, increased efficiency, sustainability, and productivity can be achieved within the Palestinian agricultural sector (Khalilia et al., 2024).

1.4. Innovation in PA– Case Studies from Palestine

PA has recently witnessed rapid development around the world, especially in some developed countries. The employment of modern technology in the Palestinian agricultural sector will have a positive impact, leading to improved production quantitatively and qualitatively (MoA, 2014; Abdalla et al., 2019). In Palestine, the use of smart farming is still limited. With the aim of introducing PA technology to Palestine, a team of researchers from ten European and Palestinian universities, including the author of this review, were participants in the Erasmus+ project entitled "Promoting Innovation in Precision Agriculture Education and Research in Palestine (BENEFIT)" (https://benefit.edu.ps/), (Balkova et al., 2021; Balkova et al., 2022; Daniel et al., 2023). The BENEFIT project focuses not only on the capacity building aspect for Palestinian universities, but also addresses the challenges faced by Palestine regarding information and communication technologies (ICT), technological developments, and creating a global education and research framework for innovation and development regarding the integration of the newest (digital) technologies into agriculture and rural development. Here we present some of this development in PA case studies from Palestine:

Al-Quds Open University (QOU) in Jericho, Palestine, is the leader of BENEFIT project. In the Agricultural Research Center, QOU has installed a smart and precision irrigation and fertigation system (Figure 1). The system is consisting from the following parts: Fertigation system, Irrigation pump, Fertilizer dissolving tank, polyethylene pipes (75 mm, 50 mm, and 25 mm), irrigation pipes 16 mm, drip irrigation emitters 2 – 8 liter/hour, multilevel soil moisture and temperature sensor, Sap flow sensor, automate filter, monitoring system, fertilizers tanks, Bluetooth module, Nodes, EC and pH meter for soil, weather station, handled crop sensor, solenoid valves, PC, Laptop, and Stand-by diesel generator. In principle, time and amount of irrigated water in smart irrigation system can be determined based on information provided by either soil moisture sensor and weather station sensor (Hardan, 2024).

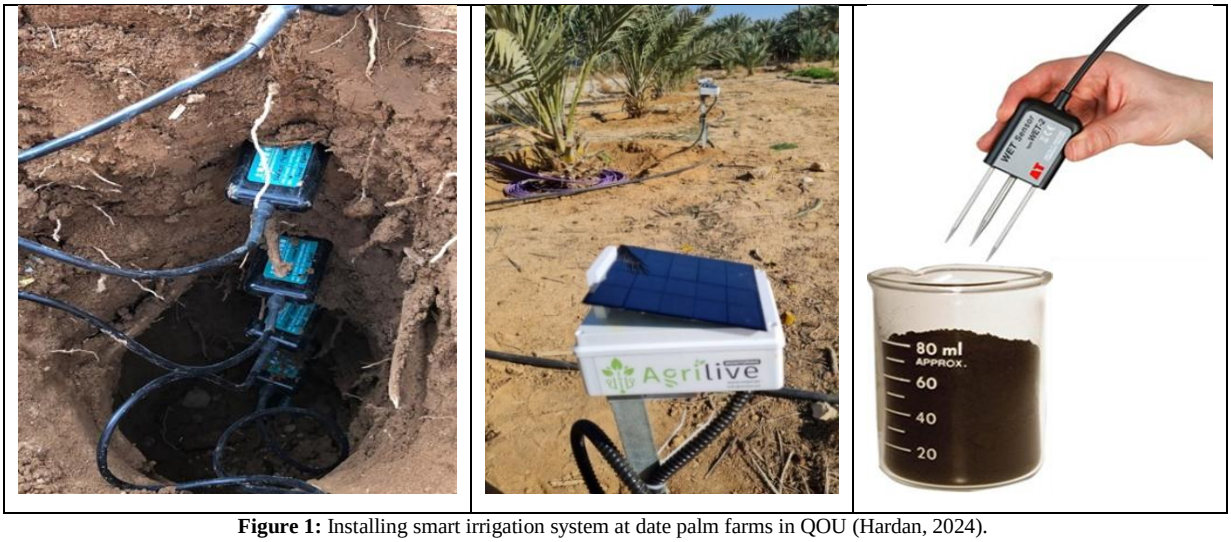

Figure 1: Installing smart irrigation system at date palm farms in QOU (Hardan, 2024).

The system useful for researchers to conduct more scientific research in agriculture and water. In addition, it used to encourage the scientific cooperation with other research centers and institutions regionally and internationally in the field of smart and precision irrigation to cope with climate change in the eastern Mediterranean region.

Hardan (2024) conducted a study using this installed smart irrigation system entitled "Surface and subsurface irrigation in Date Palm farming using smart and precision irrigation techniques". The aim of this study was to show the benefit of subsurface irrigation pattern compared with surface irrigation pattern in date palm farming, in addition to highlight the pros and cons of using smart irrigation system in arid and semi-arid regions where water resources are limited, while demand is ever growing. Hardan (2024) concluded that subsurface irrigation pattern could be considered one of the alternative tools which might be used to cope with water shortage in the extremely arid regions such as the Jordan Valley.

One partner of BENEFIT project is Al Istiqlal University in Jericho, which implemented smart AgriLive system based on information of things (IoT) technology consisting of digital sensors to monitor and control environmental parameters in date palm farms at Jericho. AgriLive monitoring system were developed to collect data in real-time to cloud servers. The Agrilive system composed from gateway, nodes and sensors. It allows multi users authentication and wireless connection. AgriLive is powered by solar energy or battery and provides wide range of sensors included soil temperature, moisture, and electrical conductivity (EC). Current data is presented in the form of a real-time dashboard (Khalilia, 2024).

1.5. Promoting Innovation in Education in the Field of PA

Using PA in education in Palestine is still limited. A team of researchers from BENEFIT project has developed a framework for using PA technology to teach several courses in Palestine. PA is a new concept that will be updated and added to all Palestinian agricultural colleges' courses to improve the knowledge of crop yields, soil, water and plant management as well as using high technology sensor and analysis tools. PA as a science uses a large amount of data and information to improve the use of agricultural resources, yields, and the quality of crops. PA topics have added as chapters or modules for several courses that are taught in the Palestinian agricultural colleges, which works to support the local and regional market with qualified and competent graduates and innovative entrepreneurs, to contribute significantly to agricultural development through applied scientific research and

partnerships with all stakeholders in the agriculture and food sector. In this scene, the Palestinian universities of BENEFIT project namely, Al-Quds Open University (QOU), Al Istiqlal University (PASS), Palestine Technical University Kadoorie (PTUK), Hebron University (HU), An-Najah National University (ANNU), and University College of Applied Sciences (UCAS), has developed/updated new courses with 26 modules of PA. Which offers at the different departments of the agricultural colleges in each university (Table 1).

Table 1: The developed and updated courses for Palestinian Universities during BENEFIT project.

University	Developed/updated courses	References
QOU	➢ Introduction to precision agriculture ➢ Satellite guidance, GIS and data management ➢ Remote sensing, data processing and interpretation ➢ Variable rate technologies ➢ application of PA in irrigation and fertilization ➢ PA, good agricultural practices and IPM. ➢ application of PA in animal production ➢ PA, economics and social aspects	Khalilia and Danial, (2024). Palková et al, 2022
PASS	➢ Food security and Digital Farming ➢ Digital Farming & Environmental Security	Khalilia, 2024 Palková et al, 2022
PTUK	➢ Precision Technology in Fertilizers Management ➢ Precision Technology in Irrigation Scheduling ➢ Big data management and analysis ➢ Application of Precision Agriculture in Closed Poultry Farm ➢ Precision Technology in Plant Physiology	Khalilia and Danial, (2024). Palková et al, 2022
HU	➢ Smart technology application in food industry ➢ Bee Keeping ➢ Poultry Production & Management ➢ Practices in Animal Production Feeds and Feeding ➢ Protected Agriculture. ➢ Soil Fertility and Fertilizers.	Tamimi et al., 2024 Palková et al, 2022
ANNU	➢ Protected Agriculture Management	Palková et al, 2022
UCAS	➢ Irrigation and Fertilization ➢ Vegetable's production ➢ Plant protection. ➢ Safe agriculture	Khalilia and Danial, (2024). Palková et al, 2022

Effective instructional design is essential for efficient teaching and learning outcomes in all disciplines, particularly in the agriculture content-laden curriculum. Instructional design model steps and processes enable faculty to determine the scope of the course contents, sequence of instructions, innovative presentation, and evaluation strategies (Fragkaki et al ., 2020). The BENEFIT-Term of Reference (BENEFIT-ToR) provide learners with clear instructions and the syllabus of the curriculum. It provides the structure and methodology that will be the most effective for BENEFIT- courses syllabus.

BENEFIT-ToR defines the purpose and the structure of the courses developed and the shared goal of the stakeholders, who have agreed to work together to accomplish that goal. It provided developers with clear instructions for the pedagogy, the technology and the content has used for syllabus of the curriculum design. It provides the structure and methodology that is the most effective for BENEFIT course(s) syllabus.

1.6. Establishing the BENEFIT project Incubator and research centers

Establishing a hub for digital agriculture (BENEFIT Incubator) at QOU and five research centers established or updated at the rest of Palestinians Universities, provided the essential equipment and instruments needed for

digital agriculture application.

Specifically, the advantages of such site are:

- A platform for practical courses both for students and staff in the national universities
- A good beginning as demonstration site for business start-up in Palestine.
- Creating an international research network about PA.
- Develop an e-precision agriculture space that provided the BENEFIT stakeholders- and not only- with a multidimensional space (e.g. OER's Repository, Communities of Practices, Research Initiatives, etc.).

The above-mentioned specific objectives should increase and scale up the experience and competent of researchers, teachers, students, agronomists, and extension agents in the universities, field, and markets in Palestine. As well, open the door to all stockholders in a national agriculture in Palestine and even the donors about the important of adopting PA technique as a good tool for increasing the profitability of national agriculture sector. In addition to sustainable use and management of available resources. BENEFIT project with its incubator could leads eventually to start up commercial activities through encouraging national suppliers to import equipment for PA application in Palestine (Khalilia and Danial, 2024).

2. Conclusion

PA in developing countries including Palestine has numerous opportunities for farmers to identify specific crops and to enhance the production and productivity. Palestinian farmer can produce high yielding varieties by using PA technology. High-tech PA can help in possessing a sustainable and feasible agriculture sector that can compete domestically and externally, and can effectively contribute to enhancing food security, land protection from the Israeli confiscation and settlements. Before Palestine has involved in the BENEFIT project, the use of PA technology was limited and insufficiency of knowledge and awareness about PA technology. In addition to the lack of the content of PA technology in the curricula of Palestinian universities. However, the impact of BENEFIT project in Palestine were improving the knowledge and skills in PA for trained staff of Palestinian universities and obtained knowledge used efficiently to develop new or update courses related to PA. Developed courses through BENEFIT project have an added value on improvement of students' knowledge about the topics related to PA, providing them with new PA curricula and practical courses. This group received updated knowledge in smart irrigation, fertigation systems, and new technologies of water harvesting techniques etc. In addition, PA topics were introduced to non-academic communities through either workshop, field visits, informal training courses for fresh graduated students, farmers, and extension agents. Furthermore established BENEFIT project incubator and other updated labs in Palestinian universities hosted mentioned activities. Incubator served as a good platform to demonstrate the benefits of precise agriculture techniques also to encourage business start-up activities. Moreover, this target group will use the project results in the process of continual and/or informal training offered especially by the BENEFIT Incubator.

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