2020 16th International Conference on Distributed Computing in Sensor Systems (DCOSS)

Modelling deployment costs of Precision Agriculture Monitoring Systems

1st Anna Triantafyllou
Dept. of Electrical and Computing Engineering
University of Western Macedonia
Kozani, Greece
atriantafyllou@uowm.gr

2nd Panagiotis Sarigiannidis
Dept. of Electrical and Computing Engineering
University of Western Macedonia
Kozani, Greece
psarigiannidis@uowm.gr

3rd Stamatia Bibi
Dept. of Electrical and Computing Engineering
University of Western Macedonia
Kozani, Greece
sbibi@uowm.gr

4th Fotini Vakouftsi
Dept. of Mechanical Engineering
University of Western Macedonia
Kozani, Greece
fayvak@yahoo.gr

5th Pantzios Vassilis
Kozani Saffron Producers Cooperative
Kozani, Greece
sinkroko@otenet.gr

***Abstract*—Unmanned Aerial Vehicles (UAVs) and smart sensors are the tools towards the fifth agricultural revolution. Remote sensing is thriving in agriculture, broadening the horizons of cultivators and farming practitioners. However, adopting such a technological endeavour in a raw production process is a challenging task for farmers. Operation and maintenance of such systems require specific ICT knowledge. There is also a wide variety of software and hardware equipment to choose from that can greatly impact business costs and system performance according to the kind of cultivation. Due to the lack of guidance regarding the employment of precision agriculture monitoring systems, this paper proposes a detailed decision model regarding the requirements and considerations of deploying remote sensing capabilities on a cultivation. Agricultural businesses are in need of guidance when it comes to the adoption of technological advancements especially in the case when a carefully planned operation can produce a significant amount of profits.**

***Index Terms*—SWOT analysis, Precision agriculture costs, Smart farming, Unmanned Aerial Vehicle (UAVs), Wireless Sensor Networks (WSNs), cost model**

I. Introduction

Precision agriculture and Smart Farming are the future of agri-economy engaging the utilization of modern technological achievements into agricultural practises. Internet of Things (IoT) monitoring systems can provide the farmers with meaningful real-time environmental data from the cultivation fields towards boosting competitiveness and profit. The IoT paradigm is composed by a wide range of networking technologies enabling the operation of various types of smart devices [1]. The deployment of precision agriculture monitoring systems is greatly dependent on the utilization of remote sensing techniques, involving a variety of sensors, and Unmanned Aerial Vehicles (UAV)s. Sensors are focused on measuring macroscopic size signals, referring to environmental parameters like humidity, temperature, etc. and then converting them to an appropriately measurable output signal. UAVs are equipped with different types of sensors able to identify the variations of the crop zones in the fields that require enhanced management [2]. This is made possible through the production of ultra-high spatial resolution images of the crops. The future of Precision Agriculture is highly entangled with UAV-based IoT technology, leading to significant improvements in overall management and monitoring of the fields. Based on the acquired and processed data, farmers can produce statistics regarding the progress in crop production and avoid financial loss, while improving the quality of the crops and accomplishing a considerable rise in production [3].

Smart farming monitoring systems require notable investments and careful financial planning in order to be adopted by agricultural businesses in their current state. There is a variety of expenses involved towards employing remote sensing capabilities and data analysis methods for different kind of cultivation fields. Each agricultural business should take into consideration specific deployment and operational costs towards adjusting smart monitoring to its every day routine and acquire maximum performance results. However, the specification of these expenses vary according to (a) the type of crops monitored, b) prioritization of the goals and c) the capabilities of each agricultural business and its assets. Our contribution lies upon the deployment of a detailed decision model regarding the requirements and considerations of employing remote sensing capabilities on a cultivation. Agricultural businesses are in need of guidance when it comes to the adoption of technological advancements especially in the case when a carefully planned operation can produce a significant amount of profits.

2325-2944/20/$31.00 ©2020 IEEE
DOI 10.1109/DCOSS49796.2020.00048

More specifically, in Section II we introduce a SWOT analysis towards presenting the general pros and cons of precision agriculture monitoring systems. In Section III, different categories of remote sensing deployment costs are discussed, while Section IV focus on operational costs. In Section V, the detailed decision model is proposed regarding smart farming investments. Finally, Section VI concludes the paper.

II. SWOT ANALYSIS

In this section we present the S.W.O.T. analysis as the most appropriate approach to evaluate strengths, weaknesses, opportunities and threats when it comes to evaluating the added value that smart farming technologies can offer to a cultivator. Table I summarizes the general pros and cons of precision agriculture monitoring systems in terms of strengths, weaknesses, opportunities, and threats (SWOT). Farmers or agriculture companies can tailor a SWOT analysis to specific kinds of cultivation, in deciding whether to employ such a system or not [4].

A. Strengths

There is a wide variety of benefits that precision farming can offer. Remote sensing, GPS and data analytics enable the upgrade of farming equipment towards managing variations in the field more efficiently and accurately, while reducing production costs [5]. Real time monitoring on the soil and plant physicochemical parameters will allow the acquisition of useful data regrading electrical conductivity, nitrates, temperature, evapotranspiration, radiation, leaf and soil moisture. Controlling the status of these parameters the optimal conditions for plant growth and irrigation can be achieved. Remote sensing and real time monitoring can provide agricultural businesses with the ability to upgrade the crops quality and increase productivity, with minimum costs. Based on a smart farming monitoring system, farmers can make better management decisions and keep electronic records regarding the state of production, equipment and sales, while saving time and costs [6]. Data acquisition from the fields can help reduce fertilizer and chemical application costs, while also minimizing pollution through less use of chemicals. Any kind of decease can be identified before it is too late to be dealt with, animals raging through the crops can be immediately detected, as well as the presence of weeds between the cultivated crops.

B. Weaknesses

Despite its benefits and strengths precision farming requires specific software and hardware in order to be implemented. Farmers do not usually own this kind of equipment and lack the knowledge of using it as well. In addition, such modern systems despite their user-friendly interfaces require specific kind of maintenance and set up procedures [7]. Moreover, farmers will need to provide an initial fund so as to acquire all necessary devices and tools. For the average producer the complexity of the computer technology needed, equipment costs, and time needed to learn and keep up-to-date with the system will likely exceed what most individuals are willing or able to invest. Regarding the system′s operation, a major weakness of precision agriculture monitoring is the limited battery life of sensor nodes that are spread across the cultivation fields [3]. For real-time monitoring, frequent changes of battery are required to sensor nodes, as well as to UAVs. Furthermore, there is a high chance of data loss due to a lot of noise, collision and unreliable data links existing in WSNs. Although the importance of missing data in wireless sensor networks is very prominent, the research on this problem is still relatively rare.

C. Opportunities

The utilization of a smart farming system brings farmers closer to modern technologies that can be of significant use in agricultural procedures. More effective business plans will be designed and initiated towards raising profits, while also collaborating strategies and partnerships will be employed for the expansion of significant products [8]. Moreover, a more efficient management will be deployed regarding field working hours. Last but not least, the employment of modern technologies in agriculture can have a significant impact on the vocational guidance of urban population resulting to rising trends in agroeconomics.

D. Threats

The investment on precision agriculture monitoring systems involves different kinds of risks. Smart farming is supposed to increase yields quality, but it can not eliminate the possibility of crop failure. A bad crop season may involve bigger losses if up-front payments for soil sampling or equipment maintenance are included. Furthermore, despite the technological progress in agricultural equipment, data security and privacy are still progressing and not fully safeguarded. Modern IoT technologies have been shown to be vulnerable to cyber-attacks, so safeguarding the integrity and confidentiality of the farmer′s personal information, as well as the privacy of collected data from sensors and UAVs in the appointed cultivation fields is a challenging task [3]. Moreover, natural disasters like drought, strong winds or floods may cause unstable production and wreck hardware equipment. What is more, there is always the risk of losing experienced staff members that operate a specific kind of smart equipment during production. Their replacement if not instant may decrease production rate.

III. DEPLOYMENT COSTS

In this section, an estimation is provided regarding the additional deployments costs farmers have to consider in order to employ precision agriculture technologies into their business. These costs are presented in Table II. Before any kind of equipment is bought, a detailed market research is advised to take place in cooperation with ICT professionals. This collaboration will help farmers to identify the most suitable smart devices and IoT technologies for their products and cultivation procedures. Since farmers do not have this kind of knowledge, beforehand planning is essential in order to choose the right equipment. Furthermore, once planning

TABLE I
SWOT ANALYSIS

Strengths (internal)	Weaknesses (internal)
-Crops irrigation control -Fertilizer utilization decreased -Eco-friendly remote sensing -Upgrade crop quality -Reducing production costs -Raise profits and productivity -Real-time weed, disease and animal detection in the fields	-Limited sensor battery life -Reliability (data loss) -Lack of initial fund -Lack of hardware and software -Lack of operational knowledge -Difficulty in set up and maintenance
Opportunities (external)	**Threats (external)**
-Get acquainted with modern technologies -Management of field working hours -New collaboration strategies and partnerships -New business plans -Impact of vocational guidance of urban population	- Data security and privacy issues in modern technologies - Natural disasters (storms, floods, fire) -Hardware risks -Experienced staff to be dismissed suddenly

procedures are completed, farmers should consider purchasing the specified hardware and software tools, as well as the according licenses for their operation.

A. Hardware costs

As far as hardware is concerned, significant hardware updates may be required to the computer posing as the server base station of the monitoring platform in order to execute all parallel processes in terms of computing power. What is more, smart sensor nodes and UAVs are important hardware components in order to monitor and collect the agricultural parameters [9]. Sensors can be placed on the ground, on the leaves of the crops, under ground (in the soil) or on UAVs. On the ground sensors are able to monitor environmental parameters like humidity and temperature, leaf wetness, wind speed and direction, barometric pressure, light intensity, solar radiation and rainfall. On the other hand, underground sensors are specially manufactured in order to be water resistant and usually measure soil moisture and temperature, ph value, electric conductivity and chemical properties in the soil like the amount of carbon dioxide [3]. Regarding UAVs, three kinds of sensors are usually employed enabling the operation of RGB, multispectral, hyperspectral or thermal cameras [2]. Drone-based hyperspectral sensors collect data that are not identifiable by other sensors, in the form of series of narrow and contiguous wavelength bands. This kind of data have a high level of performance in spectral and radiometric accuracy, where each pixel contains location data. On the other hand, multispectral sensors focus on capturing the reflection of light energy off objects in the environment. Regarding thermal sensors, their advantage lays on detecting heat coming from almost all objects and materials turning them into images and video. By utilizing drone-based advanced sensing significant information can be obtained regarding the state of crops during cultivation.

B. Software costs

The brain of a smart monitoring system includes state of the art software components. The system′s core software program will be installed in the appointed office computer which will constitute the main server of the smart farming monitoring system. If not already obtained, the acquisition of an operating system, usually Microsoft Windows and its according applications are essential for the monitoring platform's operations. Sensor and UAV data collection will be gathered and stored in a local or cloud database, whose use will enable a significant increase in storage costs over time [10]. Based on UAV orphotographes, a digital image processing tool, like Pix4Dmapper should also be purchased enabling the calculation of various vegetation indices concerning the crops state. Vegetation indices are mathematical quantitative combinations of the absorption and scattering of plant in different bands of the electromagnetic spectrum [11]. The calculation of these parameters will enable the identification of useful crop information regarding significant biological and physical parameters of the vegetation. The Normalized Difference Vegetation Index (NDVI) [2], is a well known parameter which specifies the vegetation index ratio and its calculation is based on the visible and near infrared light reflected from the vegetation.

C. Networking costs

For the operation of monitoring platform, a local area network should be deployed, if not already established in the real estate premises. A router device is a basic component of such a network, so as to enable the wireless communication of smart devices and UAVs with the server and the database. Turning on of a network line will be an additional expense to the farmer′s business, as well as acquiring static IP addressees for all his smart devices.

D. Installation and integration costs

Another kind of deployment expenses involves the installation and integration process of the new hardware and software equipment. Achieving interoperability is a challenging task in modern IoT technologies due to the variety of networking protocols and mechanisms [1]. The agricultural business can acquire additional and permanent workforce for this task, keeping in mind that they will be of use for future maintenance or repair issues and providing them with a monthly fee. On the contrary, by following a different deployment strategy the farmer can employ one-time experts to perform the software

TABLE II
DEPLOYMENT COSTS

Categories of expenses	Details	Market
Hardware costs	Sensors above and under the ground	Humidity sensor, Temperature sensor, Leaf wetness sensor, Ph sensor, Wind speed sensor, Luminosity sensor
Hardware costs	UAVs with according sensors and cameras	HAI Pegasus, EADS 3 Sigma, BSK Defense Erevos MALE, HCUAV Surveillance UAV
Hardware costs	Server, laptops, tablets, smartphones	HPE, DELL, Lenovo, Amazon (AWS), Microsoft (Azure), IBM
Hardware costs	WAN/LAN equipment	Router, switch, cables
Hardware costs	Hardware updates	Faster CPU, additional RAM memory, updated graphics card, additional hard drive
Hardware costs	Sensor batteries	AA battery type for sensors
Software costs	System software (Operating system)	Windows OS, Linux OS, Android OS
Software costs	Database software	SQL, MYSQL, Oracle Database, MongoDB
Software costs	Application Software (office applications, mail)	Microsoft Office, LibreOffice, Google Docs
Software costs	Photogrammetry software suite for drone mapping	Pix4D, AgiSoft Photo Scan
Software costs	Web-based data monitoring platform	SmartFarmNet, Wildeye
Software costs	Sensor software technology	LoRaWAN, ZigBee, SigFox, IEEE802.15.4
Networking costs	Sensor and UAV Static IPs	Pay an amount upstream to rent the address range
Networking costs	Turn on a network line	Make a contract with a telecommunications company
Networking costs	Virtual servers and bandwidth utilization	Physical server total cost, Shared storage cost, Virtualization software cost
Installation and integration costs	Software installation	Service contract
Installation and integration costs	Hardware integration	Service contract
Training costs	Existing workforce training	Seminars, Workshops, conferences
Licensing costs	Drone license	Software license, flying license
Licensing costs	Sensor network technology license	Subscription licensing, sensor-based licensing
New hires costs	ICT experts	Computer and telecommunication engineers and technicians
New hires costs	System administrator	Programmer, website developer
New hires costs	Maintenance team	Technicians and mechanical engineers

installation and hardware integration for the monitoring platform, while training the existing workforce to maintain the system in the future.

E. Training costs

Training costs are compulsory since the current personnel is unfamiliar with modern technologies and their operations. The farmer can either organize workshops in the business premises lead by ICT experts in order to educate the workers specifically for the new system's operation or enroll them to precision agriculture seminars by on a monthly fee. According to the business′s deployment strategy and the according knowledge gained, workers can efficiently operate the monitoring platform during their every day routine in the fields and help identify the existence of any kind of technical problem in time.

F. Licensing costs

The acquisition of a remote pilot certificate is compulsory in order to freely use a UAV in the EU [2]. The agricultural business may choose a member of the existing staff to obtain the certificate and perform the necessary flights or cooperate with another business in order to handle UAV operations. What is more, an additional licence may be required for the performance of remote sensing depending on the employed networking technology and the desirable features.

G. New hires costs

According to the deployment strategy of the current agricultural business, new hires′ costs may involve individual staff members, a team of experts or even an entire business as a partner. Nevertheless, precision agriculture monitoring systems require efficient ongoing maintenance regarding the involved hardware devices and software tools as well. The agricultural business should hire additional ICT experienced staff to manage and monitor the system daily and once every month a detailed check of all utilized equipment should be scheduled. Additionally a system administrator should be appointed between the staff with higher privileges in the platform for efficient and secure system management, answering directly to the business owners.

IV. OPERATIONAL COSTS

In this section, an estimation of operational costs is provided associated with the maintenance and administration of an agricultural business utilizing a smart farming monitoring system on a day-to-day basis. These costs are presented in Table III. A business's operating costs are of two types, fixed costs and variable costs. A fixed cost is one that does not change with an increase or decrease in sales or productivity and must be paid regardless of the company's activity or performance. On the other hand, variable costs, like the name

TABLE III
OPERATIONAL COSTS (IN A DAY-BY-DAY BASIS)

Operating Costs Components	**Details**	**Type of business operational costs**	**Categories of expenses**
Real estate expenses	1) Rent 2) Property taxes 3) Furniture 4) Office supplies 5) Electricity costs	Semi-fixed cost	Operating expenses
Personnel wages	1) UAV and WSN specialists 2) ICT system administrator 3) Training costs for existing staff 4) Legal advice	Fixed costs	Cost of goods sold
Repair and maintenance costs	1) Hardware urgent repair costs 2) Software regular maintenance costs	Variable costs Fixed costs	Cost of goods sold Cost of goods sold

implies, are comprised of costs that vary with production. Unlike fixed costs, variable costs increase as production increases and decrease as production decreases. As presented in Equation (1), the operational costs of an agricultural business are comprised of the total operating expenses and the total cost of goods sold, based on the company's income statement [12].

$$OperationalCosts = CGS + OE \tag{1}$$

where $CGS =$ total cost of goods sold and $OE =$ operating expenses.

In addition, operational costs are greatly depended on the business′s deployment strategy regrading the new platform. The farmer may choose to operate the monitoring platform on his own, by training the current staff and hiring ICT experts. However, there is also the possibility of collaborating with an ICT company and split a percentage of the profits without acquiring new staff. The farmer′s decision regarding the system deployment is related to a number of factors, with the most important ones being the kind of product cultivated and the initial amount of funds the agricultural business posses. Table IV summarizes the deployment and operational expenses for the employment of remote sensing capabilities in a traditional agricultural business.

A. Real estate expenses

Remote sensing deployment requires the existence of a server base station. The station can be established inside the real estate of the agricultural business or in a remote location. In that case, the farmer must ensure the sufficiency of existing facilities in order to install the according equipment or modify accordingly a specific location inside the premises. Based on this plan, rent and property taxes may be increased by altering the nature of an existing location. In addition, extra costs may include office and furniture supplies, as well as electricity. On the other hand, the farmer may choose to collaborate with an ICT business in order to employ UAV remote sensing capabilities in the cultivation procedure. Following this scenario, the farmer is able to avoid all real estate modification costs, since the required equipment will be managed and stored in the premises of the other business partner.

B. Personnel wages

Regardless the location of the server station, the operation of a smart farming monitoring system requires the skills of engineers in order to manage the systems procedures in a daily basis. The farmer will have to hire new personnel with the according skills towards executing technologically advanced procedures in the fields like programming UAV flights, adjusting different kinds of sensors around the fields, extracting useful information from UAV orphotographes based on digital image analysis and evaluate the state of vegetation indices produced by the system [2]. A system administrator should also be appointed, having a deeper understanding and knowledge of the system in order to avoid data privacy breaches and potential backup failures. The additional workforce may be hired from an according company based on a monthly or yearly contract. Alternatively, the agricultural business may wish to create its own technical team and hire separate employees via interviews and proclamations.

Aiming to increase productivity, the business should also consider providing training courses to the existent personnel in order to have a better understanding of the cultivation study and subordinate the overall procedures towards achieving efficiency.

Last but not least, it would be wise for the farmer to keep in mind the sensitivity of private information being exchanged through the smart monitoring platform and seek legal advice in case of a system security breach. Based on this fact, a legal representative should also be hired in order to define all necessary precautions and countermeasures.

C. Repair and maintenance expenses

A significant category of operating expenses, are the repair and maintenance costs concerning software and hardware equipment. Despite their multiple benefits, modern IoT technologies require attention and specific handling regarding their operations. Maintenance is the services required to ensure the entire system′s longevity. Preventive maintenance helps resolve potential problems before a failure occurs, creating safer conditions for employees.

A rather significant procedure for such systems is the backup process. Backups can be of use during system failures

TABLE IV
DEPLOYMENT AND OPERATIONAL EXPENSES

Categories of expenses	Specified cost	Type of cost
Deployment	Hardware costs	Semi-fixed costs
Deployment	Software costs	Semi-fixed costs
Deployment	Networking costs	Semi-fixed costs
Deployment	Installation and integration costs	Semi-fixed costs
Deployment	Training costs	Variable costs
Deployment	Licensing costs	Fixed costs
Deployment	New hires costs	Fixed costs
Operational	Urgent repairs	Semi-fixed costs
Operational	Maintenance costs	Fixed costs
Operational	UAV and WSN specialists	Fixed costs
Operational	ICT system administrator	Fixed costs
Operational	Legal advice	Fixed costs
Operational	Real estate expenses	Semi-fixed cost

or data loss. System repairs can be either routine, urgent or emergency ones. Instead of replacing the entire equipment due to a critical failure, a repair is performed before a failure occurs and the cost is reduced to the price of the component and to the work required for repair. Nevertheless, according to the deployment strategy of the remote sensing capabilities, the farmer will either train his own personnel to handle the modern equipment or hire a team of ICT professionals to help maintain the system′s efficiency. Moreover, in case of a failure occurrence, the agriculture business should keep in touch with according professionals or business in order to replace any kind of false equipment if necessary or for acquiring assistance.

V. DECISION MODEL

In this section, a decision model is provided aiming to help farmers aggregate all relevant economic aspects of utilizing a precision agriculture monitoring system in their business. In order to design a personalized financial plan for each agricultural business, the identification of the expenses accompanying this endeavour is required. The proposed model, presented in Figure 1, is consisted of a series of decisions to be made by the farmer towards specifying the according expenses. More specifically the agricultural business should define the following:

- The type of operational environment of the monitoring platform
- The goals and quality indices
- The cultivation calendar
- The deployment strategy

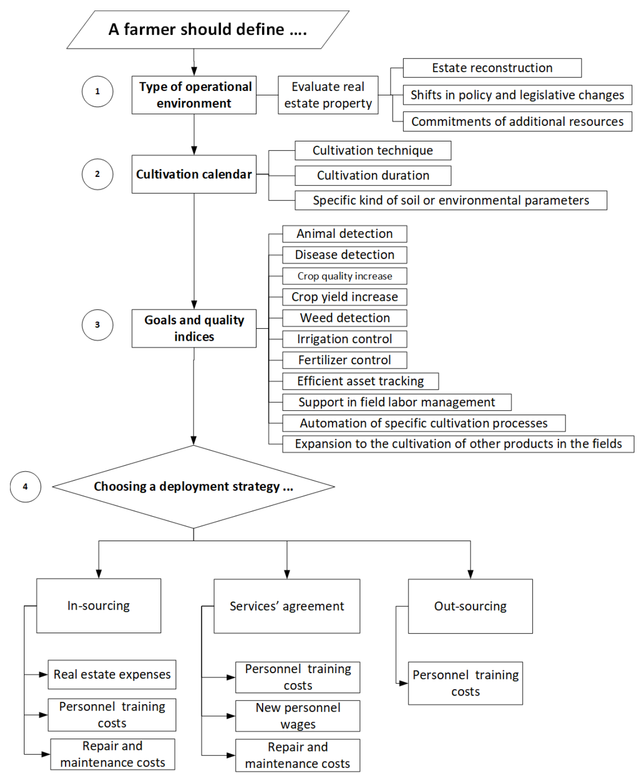

Fig. 1. The steps of the proposed decision model

A. Define type of operational environment

It is a fact that agricultural businesses rarely own real estates suitable for hosting advanced technological equipment. Farmers are focused on direct labor by utilizing traditional field tools and equipment to produce their products and effectively cultivate their fields. Until recently, agriculture was distant from modern technologies. Now, farmers are provided with the ability to improve productivity and quality of production by familiarizing with aspects of networking technologies and UAVs.

However, in order to adopt and host this modern equipment, agricultural businesses have to evaluate their real estate property. More specifically, decisions regarding estate reconstruction may be involved, focusing on establishing a control room of the new monitoring platform and storage rooms for the involved equipment. In addition, shifts in policy and legislative changes may be required. Furthermore, adjustments in institutions and commitments of additional resources should be considered. The choice of the smart monitoring system′s operational environment is a significant factor in the investment of the precision agriculture practices. Moreover, safety precautions should be considered during UAV flights and a stable connection link to the online database for the storage of the collected data. Providing that the agricultural business can host this technological endeavour and has the appropriate amount of funds to back up all required operational modifications, the investment plan can move forward.

B. Define goal and quality indices

Precision Agriculture and Smart Farming involve a number of techniques that can greatly impact the rate and quality of production in the fields based on detailed data analysis. Nevertheless, each agricultural business may require the services of these technologies for different kinds of reasons. Farmers may be satisfied with the quality of their products, but lack in production rate. Another case may involve the need of animal detection inside the field and immediate actions in order to lead them away from the crops. Others may focus on adding different kinds of crops in their fields without disturbing current production rate. Precision farming can help farmers manage and combine multiple cultivations at the same time, by achieving the best possible results. In other words, agricultural businesses should identify their goals and needs before purchasing any kind of equipment or initiate any kind of partnership with another business. The desired quality indices in production have a huge impact on the technologies and equipment required. Goal identification can save the business from additional unwanted expenses and help farmers invest in what they really need for their business in order to succeed. Goal and quality indices may include the following:

- Crop quality increase
- Crop yield increase
- Disease detection
- Animal detection
- Weed detection
- Irrigation control
- Fertilizer control
- Efficient asset tracking
- Support in field labor management
- Automation of specific cultivation processes
- Expansion to the cultivation of other products in the fields

C. Define cultivation calendar

The utilization of precision agriculture techniques should be kept in line with the cultivation calendar of each production. Not all crops are cultivated based on the same technique and duration of time. Every crop has different requirements and needs in order to grow. Additionally, specific kind of soil or environmental parameters may be required for cultivation. Smart farming monitoring systems produce a significant amount of information that help farmers evaluate existing cultivation variables and prevent any future damage in production.

Following this assumption, UAV flights should be scheduled based on the required cultivation procedure for each crop kind. Additionally, sensors may need to acquire data on specific dates of each month, where the collected data can actually reveal useful information for the crops state and growth rate. UAV flights may be required every week, twice a month or only three times a year before harvesting period. Taking into consideration the cultivation calendar is quite important towards achieving high return of investment in precision agriculture. A significant amount of expenses can be avoided by adjusting the monitoring process in a way that fields would be observed only in critical periods of time. These key periods will be appointed by the farmers themselves based on their experience regarding the production of the specific crop kind.

D. Define deployment type

Once the agricultural business defines a direction regarding each one of the previous concerns, a deployment strategy should also configured. The deployment strategy determines the way that precision agriculture processes will be handled and performed. Based on this strategy, potential partnerships can formed focused on advising and supporting the agricultural business regarding the employment of IoT technologies in the fields during cultivation process. Regarding this decision the agricultural business has the following alternatives:

- *In-sourcing*: Host the platform inside its real estate premises, buy the overall equipment and train to operate it themselves. Hiring new workforce to operate the entire process is also a possibility in this category.
- *Services' agreement*: Rent the overall equipment from another business, but train in order to operate it themselves.
- *Out-sourcing*: Partner with an ICT business and place it responsible for the entire platform operation.

Each of the alternatives above leads to different flow of operational expenses, as presented in Figure 1.

According to the *In-sourcing* strategy, if the agricultural business chooses to buy, host and operate the monitoring platform on its own, all operational costs mentioned in Table III will be included. More specifically, real estate costs involving building and storage rooms reconstruction, additional personnel wages to support all processes, as well as repair and maintenance costs based on the external businesses for equipment replacement and existing staff capabilities. Moreover, the agricultural business will have to deal with new personnel wages. The monitoring platform will be operated only by the trained staff, including UAV and WSN specialists, as well as a system administrator. The farmer will still supervise the entire cultivation process and make the final decisions regarding each action. The additional workforce could also handle repair and maintenance procedures.

According to the *Services' agreement* strategy, the server base station of the monitoring platform will be located on the business partner′s premises. This partner will provide all necessary services and according equipment for field monitoring, including sensors, UAV and software tools for data analysis. The farmer will be able to rent all according equipment via contract to the according business and utilize it whenever is needed. All collected information will be stored and protected in a separate database, where the farmer will have advanced privileges. In this case, the agricultural business will have to deal with additional staff wages and training costs of existing workforce to operate the provided equipment. Repair and maintenance will be appointed to the agricultural business workforce as well.

Last but not least, the *Out-sourcing* strategy proposes a full and on-going partnership with an ICT business. In this case the agricultural business will develop a contract with an ICT expert company in order to increase production profits and crop quality. Based on this partnership, the farmer will be able to avoid real estate costs, personnel costs, as well as repair and maintenance expenses. The ICT business partner will handle all technical aspects of precision agriculture processes. However, the existing agricultural workforce might need to attend specific training courses in order to participate in joined initiatives during the cultivation process. It is also a fact that such collaboration will require a significant amount of the production profits.

VI. Conclusion

It is proven that smart farming monitoring systems can greatly benefit crop quality and production rate. Nevertheless, a carefully designed investment plan can actually provide farmers with the desirable financial profits these technologies have to offer. In this paper, a SWOT analysis was provided regarding the adoption of precision agriculture monitoring systems to agricultural businesses, as well as a detailed discussion regarding deployment and operational costs. Our goal was to propose a financial decision model regarding the adoption of remote sensing capabilities. In the future, focus will be given on ROI specifications and the implementation of an actual case study for the proposed decision model.

Acknowledgment

This research was co-funded by the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship, and Innovation, grant number T1EDK-04873, project ”Drone innovation in Saffron Agriculture,” DIAS.

References

[1] A.Triantafyllou, P. Sarigiannidis, and T. D. Lagkas, “Network Protocols, Schemes, and Mechanisms for Internet of Things (IoT): Features, Open Challenges, and Trends,” Wireless Communications and Mobile Computing, vol. 2018, Article ID 5349894, 24 pages, 2018, https://doi.org/10.1155/2018/5349894

[2] D.Tsouros, S. Bibi and P. Sarigiannidis, ”A Review on UAV-Based Applications for Precision Agriculture”, Information, 10, 349, 2019, 10.3390/info10110349.

[3] A. Triantafyllou, P. Sarigiannidis and S. Bibi, “Precision Agriculture: A Remote Sensing Monitoring System Architecture”, Information, 10, 348, 2019, https://doi.org/10.3390/info10110348.

[4] A.Ommani, ”Strengths, weaknesses, opportunities and threats (SWOT) analysis for farming system businesses management: Case of wheat farmers of Shadervan District”, African Journal of Business Management, Vol. 5,22, pp. 9448-9454, 30 September, 2011.

[5] J. Muangprathub, N. Boonnam, S. Kajornkasirat, N. Lekbangpong, A. Wanichsombat and P. Nillaor,”IoT and agriculture data analysis for smart farm”, Computers and Electronics in Agriculture, Volume 156, Pages 467-474, 2019, https://doi.org/10.1016/j.compag.2018.12.011.

[6] G.A. Musat, M. Colezea, F. Pop, C. Negru, M. Mocanu, C. Esposito, A. Castiglione, ”Advanced services for efficient management of smart farms”, Journal of Parallel and Distributed Computing, Volume 116,Pages 3-17, 2018, https://doi.org/10.1016/j.jpdc.2017.10.017.

[7] T. Popović, N. Latinović, A. Pešić, Ž. Zečević, B. Krstajić and S. Djukanović, ”Architecting an IoT-enabled platform for precision agriculture and ecological monitoring: A case study”, Computers and Electronics in Agriculture, Volume 140,Pages 255-265, 2017, https://doi.org/10.1016/j.compag.2017.06.008.

[8] V. Puri, A.Nayyar and L. Raja, ”Agriculture drones: A modern breakthrough in precision agriculture”, Journal of Statistics and Management Systems, 20:4, 507-518, 2017, DOI: 10.1080/09720510.2017.1395171

[9] N. Pavón-Pulido, J.A. López-Riquelme, R. Torres, et al.,”New trends in precision agriculture: a novel cloud-based system for enabling data storage and agricultural task planning and automation”, Precision Agric 18, 1038–1068, 2017, https://doi.org/10.1007/s11119-017-9532-7.

[10] M. Roopaei, P. Rad and K. R. Choo, ”Cloud of Things in Smart Agriculture: Intelligent Irrigation Monitoring by Thermal Imaging,” in IEEE Cloud Computing, vol. 4, no. 1, pp. 10-15, Jan.-Feb, 2017.

[11] Y. Huang, K.N. Reddy, R.S. Fletcher, and D. Pennington, ”Proceedings of the UAV Low-Altitude Remote Sensing for Precision Weed Management”, Weed Technol, 32, 2–6, 2018, doi:10.1017/wet.2017.89.

[12] S.M. Pedersen and Kim Lind, ”Precision Agriculture: Technology and Economic Perspectives”, Springer International Publishing, 2017, 10.1007/978-3-319-68715-5.