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IBANESS
University of Agribusiness and Rural Development/Bulgaria
University "St. Kliment Ohridski" Faculty of Economics/Macedonia

PROCEEDINGS

Editors
Prof.Dr. Dimitar Kirilov DIMITROV
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FOREWORD

International Balkan and Near Eastern Congress Series brings together many distinguished social and behavioral science researchers from all over the world. Participants find opportunities for presenting new research, exchanging information, and discussing current issues.

We are delighted and honored to host the IBANESS Congress Series in Kırklareli / Turkey. Presented papers have been selected from submitted papers by the referees. Sincere thanks to those all who have submitted papers.

We hope that through exchange of the presented researches and experiences, the Congress will enhance communication and dissemination of knowledge in Balkan and Near Eastern Countries.

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Farm Management Software for Increased Productivity and Competitiveness

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Abstract: As world population grows, increases the need for more efficient food production. On the other hand, contemporary farmers are facing a fast-changing business environment, tough market conditions and fierce competition, more than ever before. High exposure to financial risks imposes the need for making better agribusiness-related decisions on all levels and during all phases of food production chain. One way to stay competitive is to incorporate innovative solutions in all phases of the decision-making process. Hence, during recent years, technology-oriented companies, especially those belonging to the ICT sector, are creating a range of agricultural software and hardware, services, farming techniques, and more, all aimed at bringing more data and efficiency to the agricultural and/or agribusiness sector, timely and accurately. Management Information Systems (MIS) refer to computerized data-processing systems, encompassing both hardware and/or software, designed to support the activities of a company or an organizational management. When applied in the agribusiness sector, such systems, also known as farm management information systems (FMIS) or farm management software (FMS), become powerful, yet an indispensable tool for data acquisition, data processing, and reporting needed for successful process management in the agribusiness environment. Based entirely on the extensive use of secondary sources, the paper aims at providing a comprehensive overview of the latest research done on this topic. It also tries to identify the key FMS requirements and presents a general architecture of a two-tiered Web-based FMS solution. Finally, the paper scans the current situation in the Republic of Macedonia vis-à-vis FMS usage, as well as the current status and trends in this expanding field on a global scale.

Keywords: agriculture, agribusiness, farm management software (FMS), farm management information systems (FMIS), Republic of Macedonia.

Introduction

Agriculture, also known as farming, is the art and science of cultivating the soil, growing plants and other crops, as well as raising animals for food, other human needs, or economic gain (Bareja, 2014). Taking into account its long tradition dating before 10,000 BC, its large coverage and dynamics, its varied application as a science, practice, and business, other purposes including legal matters, and continuous inclusion of new technologies and specialized fields into its fold, agriculture today remains highly important, yet reliable source of livelihood for mankind, playing a vital role in national economies in many countries worldwide. As being a backbone of every economy, agriculture makes its contribution to the economic development in many specific ways, regardless of the development stage a certain country is in.

On the other hand, the term 'agribusiness' refers to the overall business activities involved in agricultural production. It has a broader meaning than agriculture since it includes agrichemicals, breeding, crop production (farming and contract farming), distribution, farm machinery, processing, seed supply, as well as marketing and retail sales. It includes all types of diverse activities involved in growing, harvesting, transporting, processing, and distributing food (Bernard et al., 2012). According to Ricketts & Ricketts (2008), it includes all economic activities in the food and fiber system, which encompasses the input supply industries, agricultural production, and post-harvest, value-added activities such as commodity processing, food manufacturing, and food distribution. As a linguistic blend of the words 'agriculture' and 'business', agribusiness is often used as a synonym for the term 'corporate farming', referring to the wide range of activities and disciplines encompassed by modern food production, usually intrinsic to large-scale, industrialized, vertically integrated food production. As

such, it is often contrasted with smaller, family-owned farms that are usually associated with the term 'agriculture'.

Agriculture is one of the primary industries in many countries, especially in Balkan and Near-Eastern countries. While approaching 2020, not only the national agricultural policies of these countries, but also regional ones, are facing the newly imposed global challenges more than ever before. An abundance of research publications and studies made recently by many authoritative international organizations and research centers generally agree upon the conclusion that all open questions related to world agriculture have to be analyzed and solved in the context of solving the global population feeding problem and the sustainable usage of natural resources. These are the most prominent challenges, but also factors/drivers that are expected to shape the development of world agriculture trends in the next 30 to 40 years from now on. The most intriguing challenges at the moment include, but are not limited to (CropLife International, 2009; Anakiev, 2014):

a) An exponentially growing human population on a global scale;

b) The shift from rural to urban population base due to inner population migrations;

c) Diminishing agricultural workforce;

d) Rise in per capita food consumption, particularly in developing countries;

e) Increased prices of key agricultural commodities on a long term due to steadily decreasing of their corresponding stocks on a global scale and the increase in energy prices;

f) Constantly declining global stocks of key agricultural commodities due to decreased production and growing demand;

g) Decreased production of agricultural commodities due to poor harvests, as a result of severe climate changes, water scarcity, and land degradation, including desertification and soil erosion;

h) Increasing chronic hunger and malnutrition due to increasing poverty, lowered incomes, increased unemployment, and persisted high food prices;

i) Increasing demand on the world's finite natural resources: increased demand for arable land, increased water consumption, increased demand for energy sources;

j) A steadily declining ratio of arable land to population, mainly in developing countries;

k) Endangered access to sources of drinkable water, water scarcity, water pollution, mainly due to severe climate changes;

l) Worsening impact of climate changes: land degradation due to desertification and soil erosion; drought and flooding; increased soil salinity due to excess irrigation and intrusion of sea water into land, increased soil acidity due to carbon emissions, water and air pollution; both flora and fauna diseases; and endangered biodiversity.

Obviously, there is a multitude of issues to overcome along the path to sustainably provide agricultural growth in order to meet current and future challenges of the growing world. All of the previously mentioned key factors endanger our capacity to successfully meet the growing demands of our civilization and more than ever point to the necessity of finding sustainable ways of farming. However, there are no easy ways to solve issues such as rapid population growth, climate change or increased human demand on the Earth's finite resources. Knowing this, it is a high imperative for national economies, and especially agricultural policies and activities of the global community to stay committed to looking beyond traditional paths to help provide crop production solutions to meet the challenges of a growing world.

The myriad of new technologies and production techniques that accounted for dramatic increases in yields in many crops and across many countries in recent years have been a direct result of the great scientific breakthroughs made in the plant science industry. The emergence of improved crop varieties,

including hybrid crops, drought-resistant crops and herbicide-tolerant crop varieties is attributed to advances in crop protection and plant biotechnology sciences. Nevertheless, in order to successfully cope with all the challenges imposed by climate changes and increased human demands, farmers of the modern age have to embrace innovations, which are needed not only in the plant science industry. Innovations in diverse technologies, especially innovations in information and communication technologies (ICTs), and their applications on all levels in agriculture can significantly help at every stage in the agricultural value chain, from soil and water management to seed hybridization, post-harvest logistics, and improved market access. The innovative farming and management techniques based on ICT solutions can significantly ease, simplify and improve the complex and time-consuming processes of controlling, monitoring and managing specific tasks inherent to agricultural processes.

The rest of the paper is organized as follows. Section 2 briefly introduces the concept of farm management information systems (FMSs) and their basic components and gives an overview of some of the recent research made on this topic. Section 3 describes the specific tasks and key management activities that farmers are expected to perform and describes the most vital characteristics that FMSs must possess in order to be adopted by farmers. This section also proposes a general, two-tiered Web architecture of a Web-based FMS. The current status with agriculture and FMS adoption in the Republic of Macedonia is presented within the Section 4, whilst Section 5 deals with the current FMS market status and trends on a global scale. Section 6 concludes.

Related Research

The methodology used for the purposes of this study involves an extensive use of secondary data sources, including market reports and brochures, white papers, research articles, project reports, and Web-based data generated by farm management software developers.

Last two decades the academic community has witnessed an abundance of scientific work related to the concepts, architecture, and usage of so called 'farm management software' (FMS), also known as 'farm management information systems' (FMIS). Before we present some of the most prominent recent work related to this matter, we first briefly introduce the notions of the information system, business information system, and management information system.

Information system (IS) is a collection of components (both hardware and software), that work together towards fulfilling a common goal, i.e. to provide an accurate, timely, complete, and relevant information to management which will enable them to make decisions which ensure that an organization is controlled (Hardcastle, 2011). More specifically, *Business Information System* (BIS) is "a group of interrelated components that work collectively to carry out input, processing, output, storage and control actions in order to convert data into information products that can be used to support forecasting, planning, control, coordination, decision making and operational activities in an organization" (Laudon & Laudon, 2007). One of the two categories[1] of business information systems, which provide support to an organization's day-to-day business activities and managerial decision making are *Management Information Systems* (MIS). MIS gathers, organizes, summarizes, and reports data for use by managers. When applied in the agribusiness sector, such systems, also known as farm management information systems (FMIS), become powerful, yet an indispensable tool for data acquisition, processing, and reporting needed for successful business process management of a vast gamut of farm-related operations on a daily basis. The five key resources, that FMISs are based on, encompass people, hardware, software, communications, and data. People resources include the users (farmers, farm managers, agronomists, agricultural engineers …), the developers of an IS, and those who help maintain and operate the system. Hardware resources include computers, smartphones and all other kinds of electronic devices that make a FMIS operational. Software resources refer to computer programs (software components, software modules, software applications), and associated instruction manuals. Communications resources include networks, including the Internet, and network-related

[1] The other category is represented by Operations Information Systems (OIS), which are generally concerned with process control, transaction processing and communications.

hardware and software to support them. Finally, data resources cover the data that an organization has access to, in both paper and electronic form, including computer databases (Hardcastle, 2011).

Farm management software (FMS) includes all the software used for supporting various processes involved in advanced agricultural operations like contract management, crop management, customer management, financial management, greenhouse management, inventory management, labor force management, livestock management, pricing management, supplier management, as well as order processing, financial calculations and analysis, bar-coding/RFID, and traceability (Capterra.com, 2017). FMS is an innovative technology used for optimizing the use of resources in the farms. It includes best agricultural practices based on usage of farm software, data analytics solutions, and software delivery models, among others. This kind of software helps in enhancing farm production and reducing the wastage of input and is integrated with hardware equipment and devices to enhance the productivity of the farmland with the help of GPS, sensing, and communication technologies (MarketsAndMarkets, 2016).

Recently, a large volume of research work has been done on the increased usage of ICTs and the Internet in agriculture, especially regarding the development and usage of FMS (FMIS). We provide a glimpse into the most recent ones.

As a constituent part of the EU FP7 funded project named 'FutureFarm', Sørensen et al. (2010) define, describe, and analyze both the FMS system boundaries and scope in terms of actors and functionalities, as well as the relevant decision processes inherent to contemporary farming and, consequently, propose a concept of a novel FMIS representing a shift towards precision farming. Novković et al. (2015) give a brief overview why software modeling has not had its breakthrough in the farming sector so far. In particular, appropriate FMSs hardly exist for small- and mid-sized farms, including multifunctional ones (Husemann & Novković, 2014). According to them, a general FMIS model can provide a solid basis for obtaining an adequate general structure and the basic functionalities for concrete FMISs, however, a lot of adjustments, proportional to the farm complexity, have to be made in order to depict all farm production processes accurately.

As a part of a project that intends to support small farmers in poor regions in Brazil, Climaco et al. (2013) present a Web-based system for farm management that implements a conceptual framework for design and modeling the production system at a farm scale. Their Web system supports three subsystems, including the decision support subsystem, the technical subsystem, and the biophysical subsystem. Recently, bin Mohd Danuri & bin Shahibi (2015) have described the process of developing a Web application of FMIS for smallholder farmers in Malaysia (MyAgris) by using rapid application development (RAD) prototyping methodology in information system research design. Kaloxylos et al. (2012) specify and present the functional architecture of a farm management system that takes advantage of the new characteristics that the 'Future Internet'[2] offers. These come in terms of generic software modules that can be used to build farming-related specialized modules. In addition, they also analyze the technological enablers that will make this architecture a reality. Carli & Canavari (2013) have developed a model of a new information system for agribusiness management that adopts Direct Costing (DC) and Activity Based Costing (ABC) approaches to elaborate cost data, thus enabling what-if analyses to support farm management decisions.

Kevorchian et al. (2014) have focused on Cloud Computing and Big Data paradigms in building the architecture of information systems for farm management. According to them, all actors belonging to the agri-food chain (farmers, wholesalers, processors, retailers) should become consumers of IT services in real time and at low costs. A similar approach to building FMIS, based purely on Cloud Computing architecture, also propose Mocanu et al. (2015), who argue that such architecture can help in creating an integrated intelligent system for improving product quality and business development in farm fields.

[2] 'Future Internet' is a Public-Private Partnership Programme, launched by the European Commission in 2011, with a goal to advance a shared vision for harmonised European-scale technology platforms and their implementation, as well as the integration and harmonisation of the relevant policy, legal, political and regulatory frameworks. As set forth in the Digital Agenda for Europe, these are considered to be prerequisites for realizing a European online Digital Single Market (DSM) and, more broadly, an inclusive knowledge society.

Farmers can access diverse sets of information and farm-related data, in an integrated and unified approach, in order to make right and timely decisions.

Farm Management Information Systems: Scope and Features

By helping the agribusiness clients to truly transform their operations, agricultural IS can help agricultural companies and people involved in agricultural activities significantly enhance their competitive advantage. This can be achieved by improving underlying business processes with the support of robust and secure IS. Innovative information systems and data utilization are the inputs of today's agribusiness, transforming the agribusinesses across the whole value chain. The agribusiness industry is benefiting from advances in technology that allow companies to stay ahead of the market and succeed even in times of low commodity prices.

In the ongoing academic discourse, three main factors why the need for a sophisticated farm management is recognized as a highly important and challenging task have been identified, including (Sørensen & Bochtis, 2010):

a) *The complex environment* (dealing with biological systems, uncertain weather conditions, market-related risks, financial risks, etc.);

b) *The complex inner farm structure and organization* (involvement of numerous different processes and operations); and

c) *The introduction of modern ICT technologies in the agricultural sector* (computers: hardware & software, communications, the Internet …).

All of these generate large volumes of data, which have to be adequately gathered, transformed, stored, processed, managed, and utilized for obtaining meaningful and useful information needed in the complex processes of strategic decision making. To handle and benefit from such enormous data volumes, farmers are expected to be capable of performing the following tasks (Husemann & Novković, 2014; Novković et al., 2015):

a) Data acquisition;

b) Data processing;

c) Providing data; and

d) Using data.

Successful dealing with these four tasks by farmers undoubtedly impose the need for introducing information systems (IS) in farming, also known as FMS or FMIS, which play the role of decision support systems (DSS). However, encompassing the huge number of uncontrollable factors and their significant influence on farm's profitability leads towards building complex models, which are both expensive to develop and implement, and difficult to understand and use (Novković et al., 2015).

An FMS that is well-balanced regarding the trade-off between its complexity and accuracy can significantly contribute to making better management decisions. The minimum requirement for such FMSs is the support of the following management activities, found within all key farm production and business processes (Figure 1), including (Husemann & Novković, 2014; Novković et al. 2015):

1) *Planning* (running scenario analyses);

2) *Organization* (allocation of resources);

3) *Monitoring* (data collection/acquisition);

4) *Controlling* (comparing actual key performance indicators (KPIs) with targeted ones); and

5) *Identification of optimization potentials* (profit maximization).

At last, but not at least, a good FMS design is a key to a successful product. Besides *correctness* (i.e. the ability to accurately depict various farm processes) and *efficiency* (i.e. high ratio of a useful work performed), few desirable characteristics that every good FMS design must possess are the following ones:

a) It has to be easily *understandable*;

b) It has to be *easy-to-use*;

c) It has to be *as simple as possible* (has to have minimal complexity);

d) It has to have an *intuitive graphical interface*;

e) It has to be quite *flexible*, i.e. both quickly *adaptable* and *configurable* apropos different farm types/organizations/sizes;

f) It has to be quite *extensible*, i.e. to allow easy adding of new functionalities;

g) It has to be *lean*, i.e. it should only contain functionalities that it needs to run properly, no more and no less;

h) It has to be easily *maintainable*;

If all of these conditions are successfully met at a *reasonable price*, then a given FMS is likely to be adopted and used by farmers.

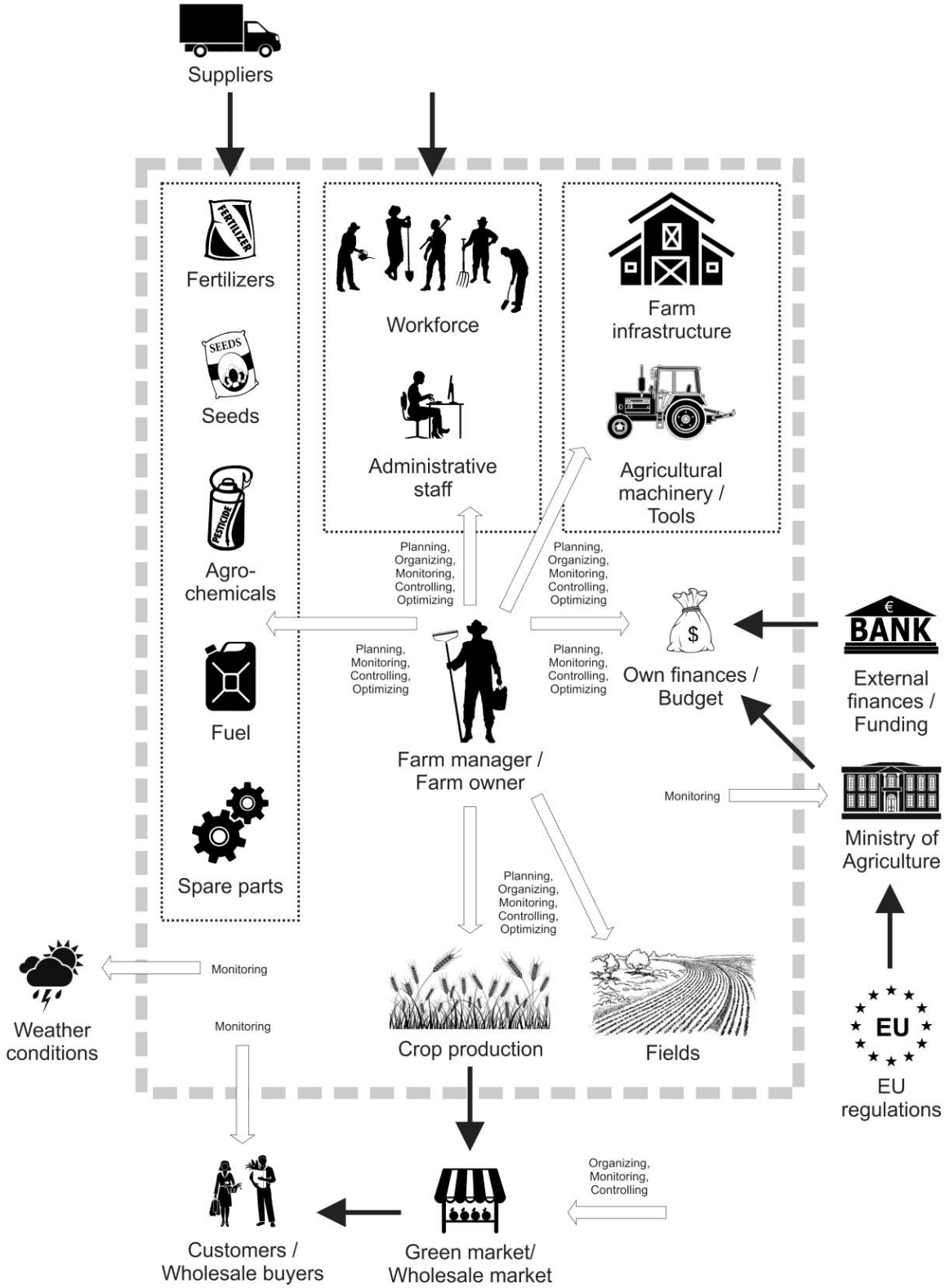

Figure 1. Key farm production and business processes that are expected to be managed by the farmer

(Source: Authors' own representation based on Sørensen et al. (2010))

One possible layout of a Web-based FMS general architecture is schematically depicted in Figure 2. It is based on a two-layered (i.e. two-tiered) Web architecture.

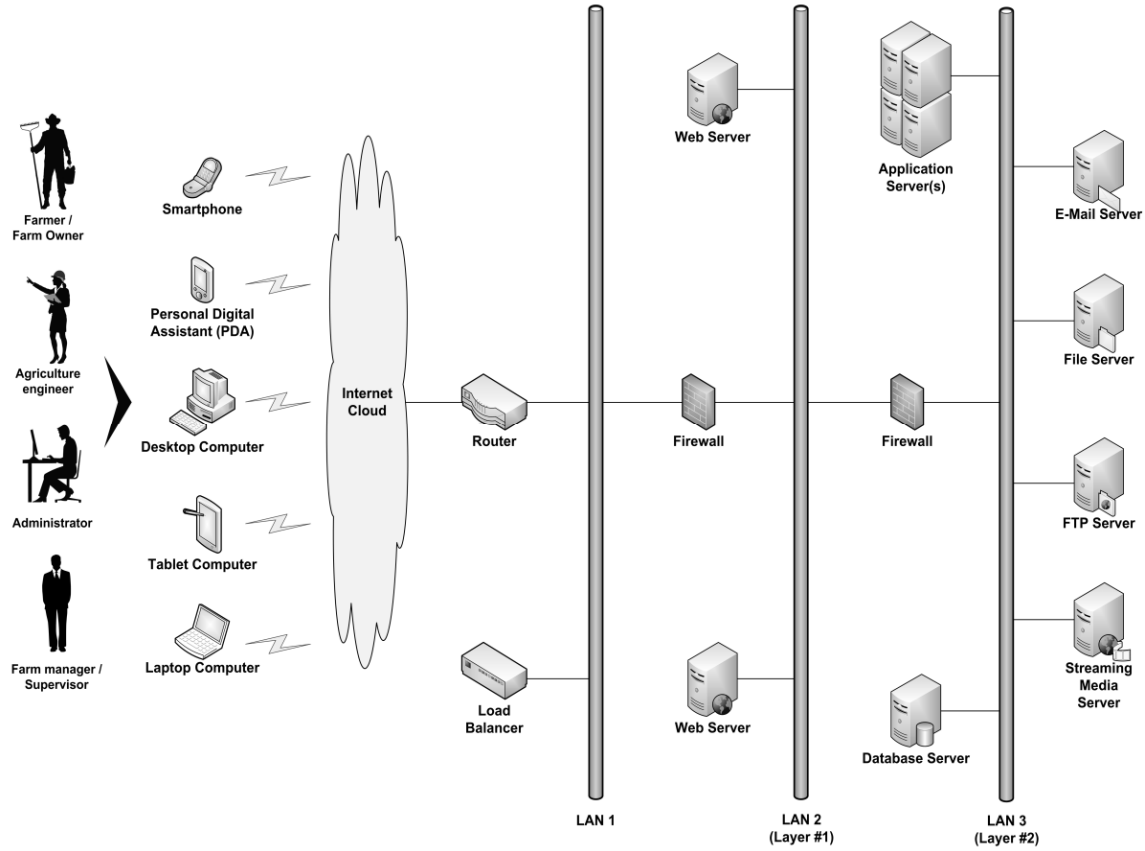

Figure 2. Typical two-tier Website architecture of an FMS system (Source: Authors' own representation)

Each tier handles a particular set of functions. The first layer, also called the *presentation layer*, embodies the user interface with the Web services. FMS Web users (e.g. farmers/farm owners, agriculture engineers/agronomists, farm managers/supervisors, and administrators) enter data, edit data, and receive information through their Web browsers, which interpret HTML or XML code. New interfaces are already available for processing Web services from mobile devices (smartphones, PDAs, tablet computers, laptop computers). This layer consists of Web servers. The second layer embodies both the *business logic layer*, also known as the *application layer*, and the *data service layer*. The application layer, which consists of application servers, encapsulates a collection of rules to implement the application logic through the implementation of FMS system modules and FMS system features/functionalities. The data service layer, which consists of a database server and other types of servers (e.g. e-Mail server, file server, FTP server, streaming media server, etc.), is a repository of persistent data that are managed by mechanisms guaranteeing reliability, stability, and availability. The separation of the second layer from the first layer results in new levels of autonomy and security and makes the Web applications more robust. Such architecture allows the FMS Web users to access the information any time, at any place, by any device. It also helps farmers to increase operational efficiency at reduced costs, so they can improve their yields and reach a higher production level.

Agriculture-related Software: Evidence from Macedonia

The Republic of Macedonia is, generally, an agricultural country. In 2014, the agricultural land, which includes the cultivable land and the pastures, took about 1,263,000 ha, which is 56.20% of the total area of the country (SSO, 2015). As per the employment by sectors of activity, during recent years (2011-2014), the sector of Agriculture, including Forestry and Fishing, have had the highest share of the total employment (127,438 out of 690,188 employees, or 18.46%), right behind Manufacturing (SSO, 2015). In 2014, the sector of Agriculture, Forestry, and Fishing with its 10.2% of GDP was among the four biggest sectors in the country, right behind Wholesale & Retail Trade, Real Estate Activities, and Manufacturing (SSO, 2014). During the recent years, its share of GDP has remained relatively stable (10%-12%). Taking into account the food-processing industry, the share of agricultural sector in GDP rises to 16%-18% (ECoM, 2016). In 2014, the value of total purchases of agricultural products reached over 215 million EUR (SYRM, 2015), whilst the estimated total value of the Macedonian agriculture was over 820 million EUR in 2015 (Angelovska, 2016).

Family businesses comprise the basis of the Macedonian agriculture, which, mainly, consists of small farms. In 2016 there were 170,581 registered individual farmers and merely 304 agricultural firms in the country, out of which only 10% have 50+ employees. The big agricultural organizations/ collectives/ associations, which were prevailing in the past, now are reduced to a minimum. For instance, in 2015, 58.2% of the total cultivated area (315,863 ha) were agricultural plots with an area of up to 1 ha. Out of the total cultivated area, 75% is arable land and gardens, 12% are meadows, 7% are vineyards, and 6% are orchards (Angelovska, 2016).

The potentials of Macedonian agriculture are far from being fully exploited, despite its long tradition, favorable climatic conditions, and the governmental financial support for farmers, introduced in 2007. As a result, Macedonian agriculture has a lower growth rate than the industrial production, which continually grows during the recent years. Governmental subventions have somewhat relieved the situation, however, they have merely helped the farmers to survive, but not to develop significantly. In fact, the positive effects of subventions on the agriculture have yet to be evaluated. Despite the fact that the annual import of agricultural products and food grows continually, a great portion of agricultural land is still unused; for instance, in 2014, 134,000 ha out of 511,000 ha of cultivated area (i.e. 26.22%) have not been utilized (Faktor.mk, 2015). A great portion of the agricultural properties, mainly in rural areas, are not utilized. They present 'a dead capital' that poor people both cannot and do not know how to exploit or take advantage of (Dimovska, 2013). The majority of Macedonian farmers do not possess tractors and/or other agricultural machinery (Angelovska, 2016). Such unused areas hide great potentials that can significantly improve the economic situation vis-à-vis the living standard of rural population and agricultural production (Dimovska, 2013). This is attributed mostly to low profitability/cost-effectiveness of the agribusiness, absence of special programs and a strategy on a national level. The crop production on the cultivated areas is quite variable and unstandardized, thus prone to high risks, which is a very important issue, taking into account high criteria and quality standards imposed by global markets.

All aforementioned facts and figures are a solid basis for stimulating skillful and accurate management of farms, which is one of the most important success factors for their effective functioning, their sustainable development, and survival in today's rapidly changing environment. The usage of farm management software appears to be a powerful, convenient and crucial tool to cope with the newly enacted conditions found with contemporary farming.

Realizing the fact that the application of ICTs in agriculture has generally brought great benefits to farmers in America and Western Europe, the Federation of Farmers of the Republic of Macedonia (FFRM) has become one of the beneficiaries of the project entitled "Agro IT", which started in 2014 (FFRM, 2014b). The project's implementation has already begun in seven European countries, including Slovenia, Denmark, Portugal, Romania, Austria, Poland, and Macedonia. The main goal was the development and implementation of a software platform PANTHEON® Farming™[3], a farm management

[3] PANTHEON® Farming™ is a trademark of Datalab Technologije, d.d. from Ljubljana, Slovenia.

information system that integrates everything that is important for farmers to optimize their business operations. It encompasses all the key applications, state-of-the-art ICT technologies, and Web services needed to fully support the successful managing of farms using computers and/or mobile devices. The software integrates multiple IoT systems (weather, GIS feeds, field sensors, robots, and agricultural machinery) and incorporates software modules that can be applied to a wide gamut of agricultural sectors (crops, vegetables, grasslands, livestock, poultry, grapes & wine, fruits & nuts), including the support of a myriad of back-office operations (servicing, invoicing, inventory, personnel, POS, financials, accounting, warehousing, goods, taxes, assets, calendar, procurements, e-Documents, compliances), thus allowing farmers to fully exploit the potentials of a fast and precise strategic decision-making. Initially, a limited range of software modules[4], including farm accounting and evidence of agrotechnical measures, has been implemented in 15 pilot farms throughout the Republic of Macedonia. In 2016, this number has raised to more than 150 farms. The main objective of this initiative is to help farmers to reduce administrative costs, radically cut the time needed in fulfilling administrative procedures, improve the food quality, and increase the volume of food production. In addition, it contributes to preventing eventual harms, reduce the costs and waste, minimize the losses, and limit the environmental pollution through reducing the fuel consumption. The introduction of contemporary software solutions in agriculture allows farmers to properly plan the production, forecast the yields, calculate the exact production costs, estimate the real retailing price of their products and consequently, to forecast the cost-effectiveness of their production, so they can avoid possible merchant manipulations and become more concurrent on the market (RSM, 2016).

In 2014, a Web-based platform[5] for monitoring the prices of fruits and vegetables on the markets throughout the country has been presented within the project "B2B Forum – We work together to improve the fruits and vegetables value chain" (FFRM, 2014a). The platform acts as a repository of information about the supplies and demands of fruits and vegetables on the green markets, including the prices for a range of agricultural products. Such information, which is obtained from both farmers and traders, is fed from eight FFRM offices, helps in detecting problems, disputes and bottlenecks, and also helps in establishing a dialog among the involved actors, thus providing a solid basis for the creation of national strategies vis-à-vis the development of agricultural sector.

Macedonian Telekom, the top-most successful telecommunications company and the largest provider of phone, mobile, entertainment and Internet services in the country, actively participates in the development of agriculture, encouraging even the owners of the smallest farms to start using the advances and benefits brought by the smart ICT solutions, and also supports the efforts of improving traditional farming with their innovative projects and M2M solutions in the agribusiness sector (Telekom, –). It offers its customers a plethora of advanced ICT solutions, comprising of systems for remote control of agricultural mechanization, systems for an automatic analysis of the quantities of fertilizers and water needed, including those for an automatic analysis of the quantities and types of food needed for livestock, and sensor-based systems that monitor and optimize the climatic parameters (e.g. the temperature, humidity, pH values, …) in order to prevent appearance of illness with crops and livestock.

Even though the following is not directly related to FMS issues, it is also worth mentioning that the Ministry of Agriculture, Forestry and Water Economy (MoAFWE) of the Republic of Macedonia have already implemented all the necessary components of the Agricultural Information System (AIS), which can be usually found with EU countries and those pretending to become EU members, during the last ten years (2007-2017). It consists of the following pillars/subsystems: (a) Agricultural Statistics with Economic Accounts for Agriculture (EAA); (b) Farm Accountancy Data Network (FADN); (c) Agricultural Market Information System (AMIS); (d) Farm Register (FR); and (e) Land Parcel Identification System (LPIS). All of these are functional components of the Integrated Administration and Control System

[4] PANTHEON® Farm Accounting™

[5] The software has been promoted by the consulting firm "Epicenter" in cooperation with the Federation of farmers of the Republic of Macedonia (FFRM). The project was supported by SIPPO (Swiss Import Promotion Programme).

(IACS), which considerably ease the realization of the governmental policies and the support for agricultural and rural development (OGRM, 2012; MoAFWE, 2014).

At the moment, Macedonia is at a crossroad. The country has to shift towards smart/precise agriculture as soon as possible. Such new trends have been already adopted by Western countries with advanced economies. The new paradigm includes acquisition, storage, processing, and manipulation of on-time and accurate digital information, needed for farmers to make correct decisions vis-à-vis all crucial aspects of crops/livestock, their protection and treatment, as well as the expected quality and quantity.

However, the majority of Macedonian farmers are still too skeptic regarding the adoption of new ICT solutions. Rather than thinking about it as a necessary tool, they take it as an "act of unnecessary modernization and luxury" (RSM, 2016). When it comes to run their own farm businesses, they still prefer to rely more on their intuition and/or rules of thumb than on usage of proper FMS tools. A great majority of farmers are not interested in using FMS for various reasons, including lack of technical expertise (i.e. lack of computer usage knowledge), or because of both the price and complexity of commercially available FMSs, which are typically intended for usage with mid- to large-scale farms. This can be attributed to the fact that the existing farmer population in the country is growing old, since young people, who are much eager and capable to adopt new ICT technologies, prefer not to deal with land cultivation and/or livestock breeding for a living.

As the country strives to transform the national agriculture into a more concurrent and export-oriented sector, profound changes have to be made in the strategic targets defined in the national agricultural policy, and clearly defined measures and activities have to be undertaken for their successful and efficient realization, as well.

Farm Management Software: Current Status and Trends on a Global Scale

The great importance of agriculture in the contemporary world economy and the effects caused by the ongoing processes of globalization have already fostered the development of dedicated software tools that are expected to ease, help, and intensify the management processes related to different aspects and/or different phases of the food production chain. Better process management, in turn, significantly improves productivity and profitability, which are fundamental premises for increased competitiveness. As a result, recent years have witnessed a vast proliferation of so called 'farm management software tools' on a global scale. However, these are just a small part of a much wider group of contemporary ICT technologies that are oriented towards increasing efficiency of farms by providing tools for technology-enabled/technology-enhanced farming, which can be generally broken down into the following main categories (Krishnan, 2017):

- *Farm Management Software (FMS)*; software, i.e. management information systems that allow farmers manage their resources more efficiently, as well as their crop production, farm animals, etc.
- *Smart/Precision Farming Software (PFS) and Predictive Data Analytics*; systems that focus on using highly advanced technologies, like GPRS[6], GIS[7] and M2M[8] technologies, along with both Big Data and Internet of Things (IoT) paradigms, including predictive analytics in addressing farm-related issues for making better farm-related decisions, in order to save energy, increase efficiency, optimize herbicide and pesticide application, and manage risk; These include an extensive usage of:

[6] General Packet Radio Service (GPRS) is a packet-oriented mobile data service on the 2G and 3G cellular communication system's global system for mobile communications (GSM).

[7] GIS stands for a geographic information system, a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data.

[8] M2M stands for 'Machine-to-Machine', which refers to a direct communication between devices using any communications channel, including wired and wireless.

  - *Sensors*; smart sensors that collect data and help farmers monitor crop health, weather, air & soil humidity, and soil quality;
  - *Robotics*; robots or intelligent farm machines that perform various farm functions (i.e. routine operations) more efficiently;
  - *Drones*; unmanned aerial vehicles (UAVs) and related services that cater to agricultural needs (e.g. crop field monitoring);
  - *Autonomous vehicles*;
- *Animal Data*; software and hardware specifically aimed at better understanding livestock, from breeding patterns to genomics;
- *Smart Irrigation*; systems that help monitor and automate water usage on farms;
- *Next Gen Farms*; technologically advanced systems that provide alternative methods to enable farming in locations and settings that cannot support traditional farming;
- *Marketplaces*; systems that offer virtual marketplaces relevant to agriculture by connecting farmers directly to suppliers or consumers without any middlemen. While some are classical e-Commerce platforms, others use advanced technologies to facilitate physical marketplaces.

The global FMS market is anticipated to exhibit tremendous growth during the forthcoming years. The significant increase in the demand for FMS is due to the growing demand for food and agricultural by-products worldwide. According to a recent report released by TechNavio.com (2016), it is expected that the global farm management software market is going to grow at a compound annual growth rate (CAGR) of 16.81% during the period 2016-2020. Similar predictions can be found in another report made by MarketsAndMarkets (2016), which claims that the global farm management software market is expected to grow from US$ 1.14 Billion in 2015 to US$ 4.07 Billion by 2022, at a CAGR of 17.2% between 2016 and 2022 (Figure 3). In addition, the region of Asia and Pacific (APAC) is expected to grow at the highest rate during this period, whilst Americas are expected to retain the largest share of the FMS market on a global scale. This can be attributed to the presence of a number of major FMS providers in the region. In addition, the supportive government regulations play a major role in the growth of this market. The Americas is a major market for farm management software as this region has a high penetration of ICT technologies compared to other regions. On the other hand, economy modernization initiatives in emerging countries and government support are the major factors contributing to the growth of the farm management software market in APAC. The presence of over-populated countries such as India and China in APAC makes this region a potentially profitable market as rapid urbanization is likely to foster the appearance of new, and the economic growth of current FMS providers.

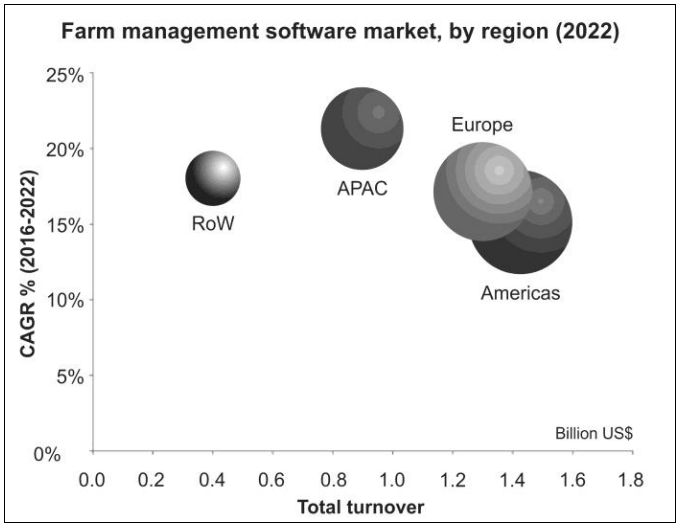

Figure 3. Projections on the CAGR % (2016-2022) and farm management software market (2022), by world regions (Source: MarketsAndMarkets, 2016)

The key drivers for the growth of this market are:

- Worldwide growing demand for food;
- The need for optimal usage and management of available resources: time, money, people, energy, land, water…;
- The need for maximizing yields, minimizing waste, and detecting operation deficiencies & process bottlenecks;
- Increasing penetration of cloud computing and mobile computing in farm data management area;
- Technological advances in FMS designing (e.g. intuitive & easy-to-use user interfaces, improved interactivity, enhanced features, enriched functionalities…);
- Technological advances vis-à-vis the processes of data acquisition, data management, data processing, and reporting techniques;
- Promotional activities carried out by governments to adopt modern agricultural techniques, including government regulations and initiatives;
- Increasing adoption rate of advanced software solutions by new-generation farmers;
- Strengthening the intellectual property rights over agricultural innovations.

The key FMS market opportunity is the constantly growing mobile subscriber base, which is a premise to increased integration of the mobile technology with farming techniques (Figure 4). Smartphone users have a great privilege to access Internet and Web 2.0 online applications & services anytime and from anywhere, which is particularly convenient for farmers. However, despite the industry trends like mergers and acquisitions (M&A) and venture funding, advanced paradigms like Big Data and Internet of Things (IoT), and increased usage of sensing, navigating and positioning technologies, which are all strong factors influencing global FMS market's trends and dynamics, the market faces three major restraints at the moment: the need for heavy capital investments, unawareness about the benefits of using FMS among farmers and agronomists, and the lack of technical acumen/expertise. These, along with the need for more sophisticated output data management and the need of FMS companies/startups for effective access to capital markets, are considered the most prominent FMS market challenges (MarketsAndMarkets, 2016).

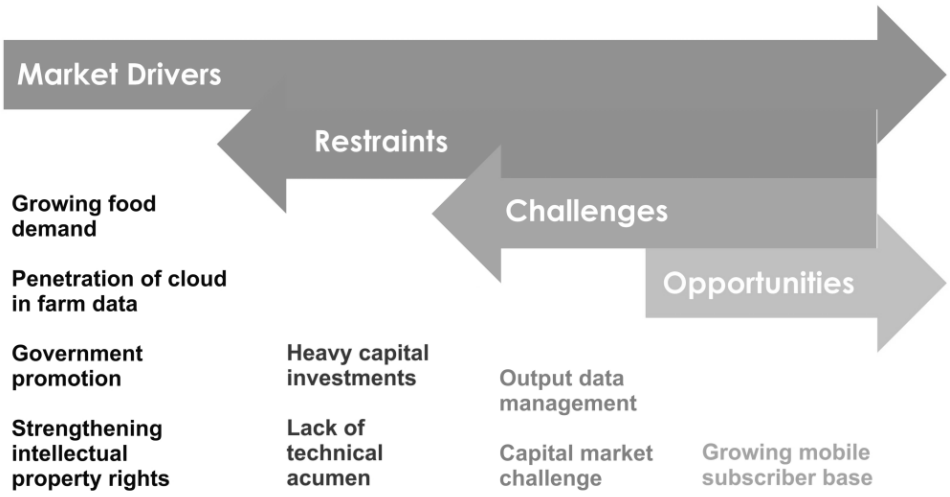

Figure 4. FMS market drivers, restraints, challenges, and opportunities (Source: MarketsAndMarkets, 2016)

As Figure 3 shows, in mature markets such as the Americas and Europe, the adoption rate of farm management software is considerably higher as compared to emerging markets like Asia-Pacific (APAC) and the rest of world (RoW). The large-scale adoption of such software in these regions is due to the increasing awareness among agriculturists regarding advanced farming solutions and the presence of technology-supporting infrastructure (MarketsAndMarkets, 2016).

The abundance and variety of stakeholders currently present in the FMS global market reflect the complexity and the wide application range of such software. The list of FMS market stakeholders includes, but is not restricted to (MarketsAndMarkets, 2016):

- Raw material and farm equipment suppliers;
- FMS developers;
- Agricultural engineering subject matter experts;
- Software designers;
- Government agencies;
- Farmer groups & associations;
- Agricultural consultants;
- Original equipment manufacturers (OEMs):
    - Sensor manufacturers;
    - Display device manufacturers;
    - Guidance & steering manufacturers;
    - GPS/GNSS device manufacturers;
- Dealers & distributors,
- Agriculture cloud service providers;
- Remote sensing service providers;
- Global navigation satellite system (GNSS) signal service providers;
- Geographic information system (GIS) developers;

- Research institutes and organizations;
- Universities, faculties, and research institutes;
- Market research and consulting firms.

FMS global market is generally segmented on the basis of several aspects, including the farming type, methods of delivery, services offered, and applications/functionalities.

According to the farming type, FMS solutions can be roughly categorized into two categories: FMS for crop farming, and FMS for livestock farming.

There are, generally, two methods of delivery of FMS: the software itself can be either cloud-based (i.e. Web-based) or installed on-premises.

The on-premises model of delivery can be considered as a 'static' approach of using software since it refers to software that is installed locally. On the contrary, the cloud-based delivery model is a 'dynamic' one, enabling effective management of farm-related operations even from remote locations. Cloud-based models include two sub-types: Software-as-a-Service (SaaS), and Platform-as-a-Service (PaaS).

Very similar to the old thin-client model of software provision, SaaS enables clients (i.e. farmers) to access software running on remote servers using their Web browsers as points of access. In SaaS, operating environment is largely irrelevant, and fully functional software applications are provided. Use of SaaS applications moves the task of managing software and its deployment to third-party services and tends to reduce the cost of software ownership by removing the need for technical staff to manage installing, managing, and upgrading software, as well as reduce the cost of licensing software. SaaS applications are usually provided on a subscription model (Colman, 2013).

PaaS functions at a lower level than SaaS, typically providing a platform on which software can be developed and deployed. In PaaS, operating environment is included, and applications of choice are deployed. PaaS providers abstract much of the work of dealing with servers and give clients (i.e. software developers) an environment in which the operating system and server software, as well as the underlying server hardware and network infrastructure are taken care of, leaving the users free to focus on the business side of scalability, and the application development of their product or service (Colman, 2013).

In fact, the increasing penetration of cloud-based delivering model in agriculture is driving the overall growth of the FMS market. So, despite the current dominance of the on-premises model of software delivery, it is expected that the cloud-based FMS is going to prevail and hold the largest market share by 2022. The market for the cloud-based delivery model is expected to reach USD 2.71 Billion by 2022, growing at a CAGR of 25.3% between 2016 and 2022 (MarketsAndMarkets, 2016). This delivery model has increased the reach of software companies by providing them a platform to extend their customer base. The advantages offered by cloud-based FMS solutions include optimized performance, effective energy utilization, and ease of access. Moreover, software companies using cloud-based delivery model offer their services in real time. It is also an emerging area of investment for the companies. Many start-up software companies are entering the FMS market by using the cloud-based delivery model to provide additional, non-standard services, such as farm analytics and reports.

The FMS market offers two kinds of services: managed services and maintenance & support services. Both of these help in maintaining control over farm operations and proper working of software & hardware, which, in turn, helps in improving the yield productivity. Put differently, services are required to help farmers to effectively manage large amounts of data in a constantly changing agriculture environment (dynamic market conditions, weather conditions, soil conditions etc.), especially to help those who lack adequate specialized knowledge and insights.

Managed services are focused on farm operations, data services, and analytics. These services help in maintaining high-quality control standards in farm management software. Managed services are expected to lead the FMS market by 2022 (MarketsAndMarkets, 2016).

Maintenance & support services help in providing sustainable farm management solutions, which include continuous software updates, troubleshooting problems related to farm-related software and hardware, design & integration of software with hardware devices and equipment, high-quality consulting services concerning the analysis of process outputs, maintenance & repair of hardware devices and equipment, technical support needed for proper and efficient functioning of software, and farm data management. All of these components are encompassed with maintenance and protection plans, safety and training services, warranties, and manuals providing relevant technical help and user support. Maintenance & support services help in building good relationships with customers and reduce expenses associated with maintaining farm management solutions.

FMS solutions, especially those dedicated to crop farming, support the following main applications/functionalities:

- Record keeping;
- Farm mapping;
- Monitoring & forecasting;
- Farm economics;
- Resources & inventory management;
- Other: market alerts, customer management, payables & receivables, profit center analyses, tax management, etc.

Out of these, record keeping is expected to retain the largest market share for an on-premise delivery model of FMS from 2016 to 2022 (MarketsAndMarkets, 2016).

At the moment, about 150 state-of-the-art software solutions dedicated exclusively to farm management exist on the global market (Capterra, 2017). However, it is worthy to mention that those software solutions are too robust, too complex and not well suited to satisfy the relatively modest daily operation needs of smallholder farmers. This notion raises the necessity for the development of small-scale software FMS products that would be dedicated exclusively to smallholder farmers.

Conclusion

Over the last three decades, the demand for food has gradually gone up and has created a huge opportunity for companies to invest in the agriculture sector. Many other objective factors, like weather conditions, pollution etc., have additionally stressed out the need for more effective agriculture that will entail increased food production. Only well-managed farms can generate enough funds not only to guarantee its survival but also to finance its sustainable development in today's rapidly changing, globalized business environment. However, a sophisticated management is a challenging and time-consuming task and has to be organized as efficiently as possible.

Recent experiences worldwide have already confirmed the synergy between the agriculture and the advanced intelligent ICTs. The shift from traditional farming to 'smart' farming using software saves time, money and resources, and contributes to consuming less energy. The effective management of farming-related information leads towards increased agricultural productivity, profitability and competitiveness, improved economic viability, and reduced environmental impact. In addition, the computerized farm management supports efficient production planning, yield forecasting, a significant reduction of costs, prevention of possible harms, and minimization of losses.

Today, the usage of farm management software and other related ICT technologies becomes an inevitable part of advanced agricultural operations. It is 'a must' for transforming the traditional agriculture into a modern and prosperous sector across national economies. Since it helps farmers in managing their financials, resources, and farming operations, countries worldwide are adopting the usage of farm management software at a significant pace. Making investments in ICT solutions is a mandatory premise for moving towards a modern, concurrent, and export-oriented agriculture.

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