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Studying Mobile Apps for Agriculture

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Abstract: *Given that nowadays agricultural stakeholders have to manage heterogeneous and complex information ranging from cultivation techniques to product prices, this study investigates the potential of mobile apps to support them by providing access to information, markets and services. This study uncovers the current status of mobile agricultural apps in the global mobile ecosystem. It also studies agricultural stakeholders' interest and willingness to use mobile apps in their daily agricultural activities in Greece.The empirical research shows that a very small number of apps is available in relation to the significance of agriculture worldwide. Finally, the study proposes that the development of mobile apps should support agricultural activities by providingaccurate, certified and validated content and services that would take into account the peculiarities of geographical areas. Also, the successful spread of mobile apps requires the active involvement of public agencies and ministries.*

Keywords: *mobile communications, mobile apps, agriculture, smartphones*

I. Introduction

The dynamic growth of mobile communications combined with the widespread use of all types of mobile devices (i.e.smartphones and tablets)has changed significantlycitizens'daily life and business practice.According to the International Telecommunication Union [1], mobile connections in 2015 have reached 7.08 billion. Towards the same direction, in 2015 the smartphone market grew 13% and it is forecasted that in 2017 more than one third of the world's population will own a smartphone.The increasing penetration of smartphones is due to the fact that it has become the dominant meansfor communication, entertainment, information, daily life and business. Among the technical advantages that have turned these devices into useful and necessarytools are: the wide touch screens, easily readable and adaptable to the needs of each user; the high resolution cameras that can substitute to a large extent other devices, such as cameras and camcorders; the geographic positioning system (GPS) that supports specialized navigation services; the powerful processors; and file storage capabilities, music player, radio tuner function, video player, etc. These technical characteristics are used by specialized software and mobile applications (apps) [2].

Mobile apps are software programs designed to run on smartphones, tablets and other devices[3]. Initially, mobile apps were developed for undertaking basic tasks of computer programs,such as email, web browsing, calendar, contacts, weather forecast etc. Today, the growing demand for new mobileproducts and services puts pressure on both businesses and organizations to develop mobile apps for commerce, banking, health, and tourism in order to meet specific needs of various business sectors.The agricultural sector in particular comprises an important pillar of the economy and as a business sector covers the food needs of the world population. However, the development of mobile apps for agriculture compared with other business sectors is limited[4].In the context of this work, the term "mobile agricultural apps" is used to characterize any mobile app targeting to the needs of the agricultural sector and its stakeholders, such as farmers, agricultural businesses and cooperations.These apps cover a spectrum of activities from the field (e.g. cultivation techniques) to the agricultural market (e.g. buying and selling products and commodities). More specifically, mobileagricultural apps offer various kinds of services, such as weather forecasting for farmers[5], agricultural business news, information for agricultural machinery and equipment, agricultural product market prices, management of agricultural product, dairy farming [6], management of irrigation systems, management of crop sensors[7], yield forecasting and monitoring, registration of soil types, and calculation.

This study intends to uncover the current status of mobile agricultural apps. Firstly, it describes the global mobile agricultural apps ecosystem through a number of characteristics. Secondly, it focuses on the Greek mobile agricultural apps ecosystem and studies agricultural stakeholders' interest and willingness touse mobile apps in their daily agricultural activities.The structure of this study is as follows: the next section provides a brief overview of the advantages of mobile apps to agriculture. Section 3 investigates the current situation of mobileagriculturalapps worldwide and the most well-known mobileapps are studied. Section 4 presents the empirical findings from the Greek case study. Finally,we summarize the study, draw conclusions and endeavour to explain the challenges of mobile apps in the agricultural domain.

II. Mobile Agricultural Apps

The rapid expansion and use of mobileapps has created a new field in the digital ecosystem, which consists of thousands of developers, popular software platforms and millions of users. Mobile apps are typically available through native distribution platforms, so-called app storesthatare operated by the owners of the mobile operating system. Some of the most popular native stores are Apple's App Store, Google Play, as well as Windows Phone Store and Blackberry App World.Until June 2016, the number of mobile apps available todownload through Google Play was2.2 million apps,and through the Apple's App Storewas 2 million apps.More than 102 billion mobile apps were downloaded, which produced $22 billion compared to $8 billion in 2012[8].Mobile apps increasingly constitute complete ecosystems to support business, such as entertainment, health, tourism, shopping, education and farming. In particular, the mobile agricultural apps show significant potential for the modernization of the agricultural sector, in both developed and developing countries.For example, they can contribute to increasing the income of small-scale producers, reducing the transaction costs in supplying and distributing products, improving traceability and quality criteria for consumers, as well as providing new opportunities for financial institutions. According to the World Bank [9] the benefits of these apps in the development of the agricultural sector could be achieved through the following ways:

- *Provision of better access to information:* By providing to producers immediate access to market information,higherproduct prices and increased demand is achieved. Also, by accessing accurate information regarding weather and pest and diseases, better risk management is achieved.
- *Provision of better access to agricultural extension services:* Accurate advices for good farming practices and support can be given. This could result in crop yield improvements and more accurate assessments for the condition of pastures.
- *Provision of better connections with the market and distribution networks:* With the improvement of links among producers, suppliers and buyers value chains become more transparent and efficient, less manipulated by intermediaries. In addition, better accounting and traceability helps to increase the efficiency and forecasting, and reduce administrative burden and fraud.
- *Provision of better access to funding opportunities:* With access to funding and insurance opportunities and alternative payment methods, farmers can achieve an increase in crop yields production diversification and reduction of economic loss.

In developing countries there are various examples of apps offered by public organizations.The popular mKisangovernment portal (mkisan.gov.in) in Indiasupports mobile apps for agriculture, horticulture, animal husbandry and other agricultural fields. For example, MKisan appenables farmers and all other stakeholders to obtain advisories and information being sent by experts and government officials at different levels through mKisan portal without registering on the portal.iCow is a Kenyan SMS and voice mobile app, providing a variety of informationunder a subscription service to increase farms' productivity through access to knowledge and experts.Modisarapp is helping farmers in Botswana to manage livestock by tracking their farm records, cattle herds, farm costs and sales.Krishi Ville regards agricultural commodities, weather forecast updates, and agricultural news updates, taking Indian farming into consideration. WeFarm aims at small-scale farmers enabling them to ask questions via SMS and receive answers from other registered users in Kenya, Uganda,Tanzania and the Ivory Coast. Relevant examples from developed countries, such as Sweden are the "green" encyclopedia, the calculation of the attack risk by insects, the identification of the most common pests in field crops and weed monitoring.F-Track Live is an Australian on-the-go farm management app that lets multiple users record and access all of their farm information in real time.

III. A Survey on Mobile AgriculturalApps

A survey for the identification of the characteristics of mobile agricultural apps in the most well-known app stores has been undertaken. It focused on the mobile apps that are displayed in the App Store, Google Play, and Windows Phone stores. The results showed that the availableapps with Android are 551, and with iOS 589, which regard the following categories: business and financial data,animal production, farm management-crops , pests and diseases,agricultural technology and innovation, agricultural machinery, spraying related activities, weather forecast, training, agricultural news, and other issues [10]. Table 1 shows the actual numbers of Android and iOS mobile apps for each category. Due to the fact that the WindowsPhone store is relatively recent, it has only 42 mobile applications for the agricultural sector. Many of these aredisplayed on more than one of the app stores.

Table 1: Agricultural Mobile Apps

Category	Android	iOS
Business and financial data	121	123
Animal production	65	65
Farm management -Crops	69	91
Pests and diseases	20	24
Agricultural technology and innovation	73	88
Agricultural machinery	39	35
Spraying related activities	30	31
Weather forecast	18	17
Training	41	39
Agricultural news	41	46
Other	44	30

Due to the fact that many of the above apps have similar content and functionalities, the fifty most popular were studied. The popularity of the apps was based on the downloads and the rating provided by users in each store's related tag. The selected apps were described according to the following characteristics: *Logo*: the graphic mark of theapp; *Title*: the name of the app; *Source*: the Internet address (URL) of the app; *Category*: the agricultural topic or task covered by the app, such as cultivation techniques andtrade, as mentioned in Table 1; *Description*: a brief overview of the functionalities of the app; *Language*: available languages; *Country of origin*: the country that the app is developed; *Provider*: data of the developer or the company that developed the app; *Geographical coverage*: the country or countries in which the app can be used; *Target group*: groups of people the app is addressed to (producers, suppliers, buyers, agronomists, agricultural organizations); *Date*: the release date of the app or the date the app has been updated; *Cost*: the cost for acquiring the app (e.g. free, subscription or one-off payment); *Size*: the size (in MB) of the app on the user's device; *Downloads:*the number of times an app has been downloaded; *Rating*: evaluation of the app by the users in each store; and *Support*: operating systems and devices that support the app.The analysis of the survey percharacteristic has given the following results:

Category:the apps regard specialized activities of the above categories. These arefarm management (8), calculators (13) andtrade (6), soil sampling (1), the prevention of accidents when handling agricultural vehicles (1), GIS (5), weather forecast (3), agricultural information on a variety of topics (9), and agricultural news (4).
Language:35 apps support only the English language, 5 support two languages i.e. English and a second language, and the remaining 10 support more than two languages.
Country of origin: the majority of the apps(92%) has USA as country of origin.
Geographical coverage:25 apps have limited geographic coverage, 22 have global, while3 apps haveundefined coverage.
Target group: the majority of the apps focus on producers as the "target group".
Date:26 apps have been releasedfrom 2015 to middle 2016, while the rest between 2010 and 2014.
Cost:7 apps require payment for downloading, five of which cost $0.99, one $1.99, one $ 14.99 and one $ 299.99. The remaining forty-two (86%) apps are free. However, many apps require add-ons with a feeto gain full functionality.
Size: most apps have small size. Specifically, 9 of them have a size less than 1 MB, 19 of them have a size from 1 to 10 MB, 21 have a size from 10 to 82 MB, and 1 is 539 MB because it has 7,500 images for plant identification.
Downloads: the most popular app is related to agricultural equipment and has been downloaded over one hundred thousand times. It has been reviewed by 524 users and is rated as "very good". Two applications that belong to the farm management category with over fifty thousand downloads are rated as "very good". Also, seven applications have been downloaded more than ten thousand times and 8 over a thousand times.
Rating: the rating of these apps is relatively low andit is calculated based on a small number of evaluations.
Support:54% of the appsare supported simultaneously by both Android and iOS, while only one (2%) is available in addition for Blackberry. Three (6%) are used exclusively for Android, eighteen (36%) for iOS, and one (2%) for Blackberry.

IV. Greek Case Study

Greece has a population of 10,858,018 people. The number of persons working in farms (regular labour force) is 1,212,720, representing about one quarter of the overall labour force in Greece [11]. In total, there are 723,010 agricultural holdings. According to the Hellenic Telecommunications and Post Commission the total mobile subscriptions by the end of 2015 was 15.4 million. However, the active subscribers were 12.6 million. The data usage through the mobile devices presented significant increase by 69% in 2015. A similar process as in the previous section has been followed for identifying the Greek mobile agricultural apps. By early 2016, 15 Greek mobile agricultural apps have been identified, 8 of which have been developed by companies and the rest from universities. These apps are basically targeted to farm management (FarmManager, BeeFiles, Professional

Farmer, Agri-Accountant), promotion of products (Greeks Do Eat Better), provision and management of information (CropDiagnosis, Certified Farmers, InfoFarm), calculator (SurfaceCalculator), communication between producers (FarmChat, Sima), mapping (FieldMap) and education (Agriculture Dictionary). The main Greek mobile agricultural apps are two, namely theTotheshelf(www.totheshelf.com) and iFarma (ifarma.agrostis.gr). Totheshelf aims at linking production, processing, marketing and retailing of agricultural products, at local and global levels. In Google's Play store it has been downloaded between 1,000 and 5,000 times and it has been rated by 72 users with 4.3/5, however, in Apple's App store there are no ratings and no information regarding downloads. iFarma enables management of technical and financial aspects of a farm. It includes economic analysis, GIS, search for pesticides and fertilizer etc. In the Google's Play store it has been downloaded between 5,000 and 10,000 and it has been rated by 61 users with 3.8/5.The analysis of the survey per characteristic has given the following results:

Category:the apps regardfarm management-crops (5), GIS (1), business and financial data (2), training (1), agricultural news and communication (3), calculator (2), trade (1).
Language:4 apps support only Greek, 2support only English and 9 support both languages.
Geographical coverage: 8 apps refer to Greece, 3 have global geographic coverage, while 4 have undefined coverage.
Target group: all the apps focus on producers; however three apps refer to consumers, merchants or students.
Date:5 apps have been released in 2014, and 10 from 2015 to mid-2016.
Cost:3 apps require payment for downloading, and the rest are free, except one that requires a fee to gain full functionality.
Size: 9 apps are between 1 to 10 MB, and the rest of them between 11 to 43 MB.
Downloads: Totheshelf and iFarma are the most downloaded apps.
Rating:6 apps have been rated from 4.1 to 5 stars, 4 apps from 3.1 to 4 stars and the rest have lower rating.

The small number of available mobile agricultural apps in comparison to the great number of Greek people involved in agricultureshows that the supply of these apps is limited. This fact raised the question regarding which is the status of current demand from Greek farmers. In this context, a study investigatesthe interest and willingness to use mobile agricultural apps. We conducted a surveywith 148 agricultural stakeholders inthe prefecture of Achaia in SouthWest Greece. Personal interviews have been conducted in the period August - September 2015. A structured questionnaire was used, includinggroups of questions on demographics, the use of smartphones and tablets, and the use of mobile apps[12]. For the analysis and processing of the results the statistical program SPSS 17 was used.The resultsanalysis shows the following: 131people of the samplewere men and 17 were women. The majority of therespondents(95.3%) wereup to 35 years old. Regarding their *educational level*, the highest proportion (53%) has finished secondary school, 37% have higher education, 8% have primary education, while only 2% hold a Master's degree.Regarding their*main occupation*, 70% are self-employed, 12% are public or private employees, 9% operate exclusively in the agricultural sector (farmers, breeders, agronomists), 7% statedoother professions and only 2% was reportedas retired.The survey participants informally stated that a high proportion ofthe self-employed belong to the broader agricultural sector and that their main and secondary occupations contribute equally to their income. Therefore, it is apparent that all participants are engaged in agricultural activities.Then, participants were asked about the most *frequent problems* they face in their agricultural activities. They answered that the main problem is weather (54%),financial management (30%), calculating optimum amounts of agrochemicals, such as for spraying,fertilizers and seeds (8%), pests and diseases (5%), and agricultural management in practice (cultivation techniques, plant varieties, etc.) (3%) (Fig. 1). Regarding the ways they confront these problems, 32% stated that they consult their family and friends, 30% are informed by the media, 20% use the Internet (social networks, websites, blogs, etc.), 12% consult their local agronomist and 6% face these problems with the knowledge and experience that they already have.

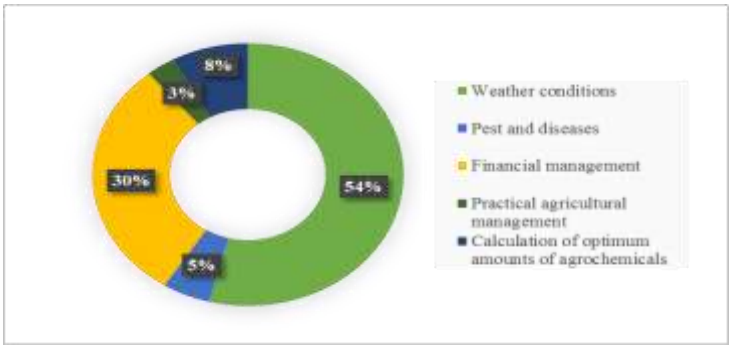

Figure 1: Frequent problems in agricultural activities

Regardingthe participants' use of mobile devices, 38%own only a smartphone, 18% own a smartphone and a tablet, while 44% donot acquire none of the two. Among those who acquire smartphones and tablets, 35% have Android, 26% iOS, 24% WindowsPhone, 10% Blackberry, and 5% have other operating systems (Fig. 2).

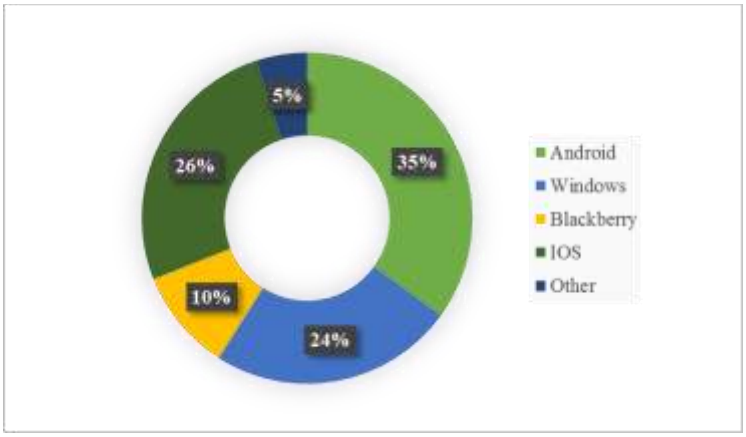

Figure 2: Operating system of the device

They were alsoasked regarding having Internet access via their devices. Among them,60% responded positively, while the remaining 40% donot use these devices forInternet services. Moreover, 13% use daily their smartphone or tablet for more than 5 hours, 43% for 3-5 hours, 22% for 2-3 hours, 12% for one hour and 10% for less than half an hour. In addition, theywere asked to specifyin order of priority the purposesthat they use their devices for. 39% use it for recreational purposes (games, music, videos etc.), 27% to improve productivity at work, 20% for communication (e-mail, messages) and finding information, and 14% for purchasing products and services. Regarding the use of mobile agriculture apps, 95% replied that they do not use any mobile app for their agricultural activities. The main reason for not using any mobile agricultural app is that they are not informed on the availability of apps, as well as on the value of these apps to support daily farming.

V. Summary and Conclusion

Mobile apps present exponential growth in many business sectors, such as entertainment, information, education, banking, tourism and health. For example in the mobile health app market 100,000 apps have been added since the beginning of 2015, amounting 259,000 mobile health apps currently available on major apps stores [13]. The contrary has been observed in the mobile agricultural app market, where the number of displayed apps is about 1,300, a very small number in relation to the significance of agriculture in global economy. It was found that the mobile agricultural apps do not follow similar growth and that the supply side is at its infancy. The survey also showed that the mobile agricultural apps have low rating in stores' related tag, indicating that they do not meet agricultural stakeholders' requirements. The majority of these apps focus on farmers' needs and more than one third of them are free to download. iOS is still the primary platform among the publishers for mobile agricultural apps (581 apps), closely followed by Android (551 apps). Other platforms are gaining less attraction. Most of the apps are published in the USA and the primary language is English. They have also limited geographic coverage for other countries.

The Greek case study has shown the majority of the participants (95%) have never used a mobile app for their agricultural activities. Specifically, a very small proportion takes advantage of the opportunity that is offered by smartphones and tablets for agricultural activities. The explanation of this situation could be the lack of development of dedicated apps, lack of apps with Greek content, poor quality of the apps, lack of awareness of the app possibilities in the target groups, and lack of adoption of such practices by agricultural stakeholders.In the current financial crisis experienced by the country, apps are offering the opportunity to producers to modernize practices, improvemanagement, reduce costs, and consequently increase yields and maximize their income. The development of mobile agricultural apps presents major challenges, described as follows:

- Researchers and domain experts of information technology, agronomy, biology, agricultural engineering, meteorology and other sectors should cooperate with agricultural extension and businesses for the development of dedicated apps.
- The development of mobile apps should supportthe agricultural fields and their activities, such as horticulture, animal husbandry, fisheries, crops, farm management, business and financial management, pest control, pesticide calculations, weather forecasting, estimations, training, and selling.
- Mobile apps should focus on the peculiarities of particular geographical areas. In each area specific cultivation techniques are applied according to its characteristics, such as geographic coordinates, altitude,

weather, annual sunshine, soil and water. Therefore, there is a need for location specific apps, taking into account the above characteristics.

- Mobile apps should provide accurate, certified and validated content for daily farming. Agricultural app content should be validated and certified by pertinent public bodies, offering quality services to farmers.
- Future mobile apps should cover a greater spectrum of agricultural activities, taking into account location awareness, and combine different technologies, such as sensors and drones.
- Agriculture as an important economic sector requires the active involvement of public agencies and agricultural institutionsin the development, promotion and distribution of mobile apps. Policy-makers should take strategic decisions and give guidelines for the development of mobile apps.
- In order to increase mobile agricultural app acceptance and use, and receive full benefits of mobile devices, agricultural stakeholders should be informed, educated and trained adequately.

In the future, our research will be extended to include the qualitative evaluation of mobile agricultural apps based on a set of criteria such as usability, usefulness, reliability, quality of content, and aesthetics.

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