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Farming Smartification

The role of IoT in the Sustainable Development Triangle

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Statement of originality

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Abstract

The emerging Internet of Things (IoT) model is already becoming established worldwide in many fields, among them agriculture. The aim of this dissertation is to explore the dimensionality of the Sustainable Development Triangle through the applications of smart farming. Based on secondary and primary research findings, the key idea of the hypothesis is to study the challenges and opportunities of IoT applications embedded in a smart farming environment affecting the Sustainable Development Triangle pillars; economy, environment and society. A sequential two stage qualitative and quantitative mixed methods research was conducted, giving data that were triangulated with the primary research findings in order to draw conclusions. The main outcomes of this study indicate that the administration of a cultivation practice with precision through a computing cloud, increases production rates while decreasing environmental pollution and at the same time creates various social opportunities that pave the way towards a more integrated smart farming ecosystem. Greek farmers denoted their interest about the implementation of a smart farming system, but they don't seem completely ready for a full integration. Finally, exploring the dimensionality of the Sustainability Triangle, sub aspects of the main pillars can be highlighted as health, education and politics.

Keywords: Farming Smartification, IoT, Sustainability Triangle, Mixed Methods Research

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Abbreviations

AIOTI - Alliance for Internet of Things Innovation

DNS - Domain Name Service

EPC - Electronic Product Code

ESD - Environmentally Sustainable Development

FAO - Food and Agriculture Organization of the United Nations

GIS - Geographic Information Systems

GPS - Global Positioning System

GSMA - Groupe Speciale Mobile Association

HVAC - Heating, Ventilating, Air Conditioning

IoS - Internet of Services

IoT - Internet of Things

LTE - Long Term Evolution

M2M - Machine to Machine

MEMS - Micro-Electro-Mechanical Systems

NFC – Near Field Communication

ONS - Object Name Service

RFID - Radio Frequency Identification

RS - Remote Sensing

SMS - Short Messaging Service

USDA - United States Department of Agriculture

WAN - Wide Area Network

WAP - Wireless Application Protocol

WLAN - Wireless Local Area Network

WoT - Web of Things

WPAN - Wireless Personal Area Network

WSAN - Wireless Sensor and Actor Networks

WSN - Wireless Sensor Networks

WSNs - Wireless Sensor Networks

1. Introduction

Sustainable and precise agriculture is the latest trend of contemporary society, that is providing agricultural goods with the minimum environmental impact and the highest possible productivity rates.

Pursuant to an analysis of the Beecham Research (2014) it is estimated by the Food and Agriculture Organization (FAO) that the need for food in the following 35 years will be augmented about 70% more than it is required at present, in order to provide a daily intake of 3,000 calories to the 9.6 billion world population. This highlights the importance of pioneering solutions in the field of agricultural production. As cited by Revesz et al. (2014), the Intergovernmental Panel on Climate Change (IPCC) reports that the climate of the planet is changing, predicting that by the end of the century the average temperature will have increased by 4 °C, with direct consequences to the field of Agriculture. Agricultural production is sensitive to weather and therefore directly affected by climate change, while cropland area, trade, and prices show the greatest degree of variability. On the other hand, Nelson et al (2014) mentions that consumption shows the lowest degree of variability. FAO also suggests, as cited by Foley et al. (2011) that farming sectors should be equipped with innovative tools and techniques that derive from digital technologies. Additionally, food production must grow substantially to meet the world's future food security and sustainability needs, while agriculture's environmental footprint must shrink dramatically.

At the same time the emerging Internet of Things (IoT) model is in the process of being established worldwide, introducing a new era in a great variety of fields such as Agriculture, Healthcare, Security, Sports and Retail Management. Based on past literature (Zhao et al., 2010) the Internet of Things (IoT) is a technological revolution that uses networks of Internet-enabled devices that operate with the minimum required human intervention while representing the future of computing and communications. Jonathan Brandon (2013) mentioned in Business Cloud News (BCN) that "the Internet of Things will be one of the biggest drivers of innovation since the steam engine." The aforementioned information indicates the importance of this promising combination of IoT and Agriculture and why it is interesting to examine in detail Farming Smartification, how it is applied in contemporary farming practices and the possible impact that an IoT ecosystem would have in preserving environmental, economic and social sustainability. Based on internet statistics of July 2015,

Agriculture is among the ten most popular applications of IoT and more specifically it is reported that smart farming is on the rise in the IoT applications spectrum ranking from the tenth to eighth position (Pantzer, 2015).

The objective of this study aims to explore the emerging field of Internet of Things (IoT), to understand the agricultural needs of IoT and its applications, to comprehend the role of underlying technologies (sensors, RFID, etc.), and explain the challenges and opportunities regarding the field of Agriculture in an IoT ecosystem. Based on the research findings, the goal is to reflect on the way farmers could apply them in a farming environment in order to increase production and preserve environmental sustainability, while exploring the role of Internet of things in the framework of the Sustainability Triangle.

This dissertation spans six chapters. In the second chapter, Literature review, the emerging IoT ecosystem is presented along with its applications and the role of underlying technologies in the agricultural field. Moreover, it is reported how the IoT contributes to agricultural practices and improves precision Agriculture, leading to Smart Farms, and it is examined whether Farming Smartification can also contribute to the combination of increased productivity and minimal environmental impact or provide a more sustainable solution within the Sustainability Triangle in the farming sector. The third chapter is the Methodology Research in which the research objective is stated and the methodology approaches chosen as most appropriate are analyzed. The fourth chapter is the Findings, where the results of the research are interpreted. The fifth chapter, the Discussion, presents the research findings that have been cross-checked with the secondary research of the Literature review chapter. The dissertation concludes with the Conclusions chapter where further suggestions for the improvement of the study are noted.

2. Literature Review

The aim of this chapter is to provide literature review findings regarding farming smartification and the Sustainability Triangle theory. First presented are the most common agricultural practices and a brief reference on important IoT components that will help with understanding the functionality of the system. Key findings of prior research are presented for the application of IoT in the farming sector and the challenges and opportunities that accrue from the implementation of this technological innovation in agribusiness. Finally, the main pillars of the Sustainability Triangle are mentioned in order to examine the role of IoT within the Sustainability Triangle model.

The agricultural field is directly dependent on technological evolution in order to address human needs. As cited by (Dener and Bostancıoğlu, 2015), the agricultural discipline includes the process of strategically producing food and fiber in order to meet the critical needs of the population. Nowadays there is an aim to halt the conditions that contribute to climate change (e.g.: global warming), and in order to secure and increase the agricultural production, a suggested solution is the collection and constant analysis of the underlying data, as to efficiently use them for the field's benefit. FAO (2011) states that remote sensing can significantly contribute to providing a timely and accurate picture of the agricultural sector, as it is very suitable for gathering information over large areas with high revisit frequency. It also presents the need of increasing production for feeding the predicted population number of 9 billion people, while at the same time stating that the environmental impact of agriculture should be minimized despite the fact that climate change disrupts this effort.

As defined by the United States Department of Agriculture (2015), *sustainable agriculture production aims to protect the environment and natural resources while conventional farming considers the yield increase.* Cultivation has a seasonal character and presents a strong dependence on weather and environmental conditions. Those characteristics constitute the precarious character of production.

At this point, the agricultural discipline comes to meet and cooperate with information technology, detecting and transmitting data efficiently and continuously, creating an environment known as a smart farm. The data gathered from a "smartified" farm environment could

be for example, the fertilizers and the chemicals that plants need to grow irregardless of the type of the soil structure of the different regions, in conjunction with the size of the farm, aiming to decrease the waste of natural resources and the use of chemicals while, at the same time, increase productivity.

2.1 Agricultural practices

Over the past few years, people from the agricultural and other industries, cope with climate change and share the same concern about the future of the planet and the quality of life for the coming generations. Crop production has been intensified aiming to meet increasing food demands. As a result of our versatile society, agricultural production is evolving, making use of more sophisticated approaches and techniques.

Pursuant to the Alternative Farming Systems Information Centre (AFSIC) (2015) the prevailing agricultural system, called "conventional farming," "modern agriculture," or "industrial farming" has conveyed remarkable gains in productivity and efficiency. Food production worldwide has risen in the past 50 years while Sundar (2006) suggests that between 70 and 90 percent of the recent increases in food production are the result of conventional agriculture rather than the expansion of cultivated land. At this point, in order to understand more deeply the difference between the various types of agricultural practices, it is crucial to distinguish the characteristics that define those categories and the underlying modification that these practices underwent along the years, while aiming to achieve the most environmental friendly methods that preserve sustainability not only for nature itself but also for economic and social reasons.

As stated by (Smit and Smithers, 1993) definitions of agriculture vary regarding to dimension (e.g. resource base, crop production, management and economics, rural community) and spatial scale (e.g. plot, field, farm, region, globe). More specifically, conventional agriculture, as defined by Knorr et al. (1984), is characterized as the '*capital-intensive, large-scale, highly mechanized agriculture with monocultures and extensive use of artificial fertilizers, herbicides and pesticides, with intensive animal husbandry*'. It is explained by AFSIC (2015) that although conventional farming systems vary across farms and countries, they share many characteristics such as rapid technological innovation, large capital investments in order to boost production, farm size, the choice between single crops or row crops grown continuously over many seasons, the uniformity of high-yield hybrid crops, the

extensive use of pesticides, fertilizers and external energy inputs, high labor efficiency, and the dependency on agribusiness.

In various attempts to decrease the intensive character of conventional farming cultivation, integrated agriculture is applied. Based on the International Fund for Agricultural Development, integrated farming consists of a variety of practices aiming to save resources and achieve acceptable profits, while providing high and sustained production levels. At the same time the objective is to minimize the negative effects of intensive farming and to preserve the environment (Rota et al., 2010).

In recent years organic farming has become a trend that attracts incrementally more and more supporters. USDA (2015) distinguishes organic from conventional farming with respect to the more environmentally friendly methods applied and the absence of synthetic materials like pesticides and antibiotics. In order to be certified as organic, the produced food and fibre, from farm to table, has to follow a set of standards, regarding the general organic principles, including soil and water quality, pest control, livestock practices, and rules for food additives. FAO (2009) defines organic agriculture as "*a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasises the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system.*"

However, the most promising system that can be adapted by any current agriculture practice is Precision agriculture. There are several definitions of Precision agriculture. Haverkort (2007) supports that Precision agriculture is defined as "*a holistic and environmentally friendly strategy in which farmers can vary input use and cultivation methods – including application of seeds, fertilizers, pesticides etc*." while Terry (2006) analyzes Precision agriculture into a three stages cycle. The first phase of the cycle refers to data collection, the second refers to data interpretation or data analysis and the third one refers to data application. United States Department of Agriculture (USDA) (2007) gives the following definition of Precision agriculture: "*a management system that is information and technology based, is site specific and uses one or more of the following sources of data: soils, crops, nutrients,*

pests, moisture, or yield, for optimum profitability, sustainability, and protection of the environment."

With the aid of those technological innovations, farming could fulfill the requirements to the point where sustainability, productivity and reduced cost coexist. The farming practices are not performed based on a pre-planned schedule as is the case in Conventional and Organic farming, either on a field or in a greenhouse; instead, data are gathered in real time and can be used for an overall precise management of the agricultural practices. Sherine M. Abd El-kader (2013) underlines the great importance of mapping soil characteristics, and mentions the technologies that are used in Precision farming, i.e. Remote Sensing (RS) (Weng, 2011), Global Positioning System (GPS) (G. Xu, 2007), and Geographic Information System (GIS) (F.J. Pierce et al, 2007).

Taking into consideration the aforementioned information about the farming sector, there is an evident need for a constant high productivity rate in order to cover worldwide nutrition needs while preserving the environment for the following generations. As implied by Munasinghe (2013), in order to achieve an overall sustainable development, the sustainability development triangle should be achieved, which suggests that economic, social and environmental aspects should coexist and be taken equally into consideration for profound sustainable development. Hence, for the purposes of this study, the definition of Precision Agriculture of USDA will be retained, as it is the most evolved system that can be applied by any agricultural practice and also holds great potential to evolve further in an Internet of Things ecosystem.

2.2 Internet of Things applications and technologies

Due to the huge advances in the field of electronics and the evolution of wireless communication systems, nowadays humankind has the privilege to use the Internet of Things to their advantage in any aspect of their life, like entertainment, health or even business. Jeremy Rifkin analyses on video, in his "Talks at Google" speech, the transformative shift IoT brings to our lives by radically increasing productivity, reducing the marginal cost of producing and delivering a full range of goods and services to near zero, across the entire economy while reporting that we traverse through the third industrial revolution (Talks at Google, 2014).

There are many attempts to give an appropriate definition for the IoT. IEEE (Minerva, Biru, and Rotondi, 2015) gathered a great variety of definitions by technology experts. A conceivable definition has been given from the IoT European Research Cluster IERC (Guillemin et al., 2015), "*A dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual 'things' have identities, physical attributes and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network*." The GSM Association (GSMA, or Groupe Speciale Mobile Association), an association of mobile operators and related companies devoted to supporting the standardising, deployment and promotion of the GSM mobile telephone system defined in 2014 the Internet of Things (IoT) as "*the use of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects*".

The GSMA also reports that as of January 2014, 428 mobile operators offered M2M services across 187 countries that equals to four out of ten mobile operators worldwide. Machine to Machine (M2M) solutions is an important subset of the IoT that uses wireless networks to connect devices to each other and to the Internet, with minimum direct human intervention, in order to deliver services that meet the needs of a wide range of industries. Moreover, the highest proportion of operators offering M2M services are in Europe, this correlates to just under half of operators in the Americas, Asia and Oceania. Furthermore, it is also stated that market forecasts indicate that by 2020, the number of connected devices in the world will almost triple from more than 9 billion today to 25.6 billion. Specifically, 10.5 billion of these will be connected using mobile technology, with a dedicated SIM and a connection to a mobile network, while the remaining devices will use alternative communication technologies, for example short-range radio connections to a communications gateway, Wide Area Network (WAN) radio, fixed line telecommunications or Wi-Fi networks.

IoT ecosystems have now become a reality. Zhao, (2010) mentions that the IoT ecosystem idea is not new but it recently became relevant to the real world, mainly because of the progress made in hardware development in the last decade as the decline of size, cost, energy consumption and hardware size allowed the manufacturing of extremely small and inexpensive low-end computers. It is also mentioned that after the World Wide Web (of the 1990s) and the mobile Internet (of the 2000s), we are now heading to the third and potentially most "disruptive" phase of the Internet revolution, with the emerging IoT which is also known as

"Ubiquitous Computing". IoT applications span across diverse areas including agriculture, healthcare, retail, transport, environment, supply chain management, infrastructure monitoring etc.

The most important characteristic of an IoT ecosystem is the constant wireless connection of a variety of sensors embedded in different devices and applications in order to provide information to the user without his obligatory activity. There is a necessity to understand the technology that makes the idea of an IoT ecosystem feasible. The key components of an IoT ecosystem as reported from Mohsen et al. (2015) are Radio Frequency Identification (RFID) and Electronic Product Code (EPC), while Gubbi et al (2013) suggests that RFID and Wireless Sensor Networks (WSN) are the most important components of an IoT ecosystem.

Recently, the use of low cost and low powered miniature devices that have the ability to sense, compute, and communicate wirelessly in short distances, has been more prominent as a result of the advancements and the convergence of micro-electro-mechanical systems (MEMS) technology, wireless communication, and digital electronics. These ultra-small devices are called nodes. As suggested by Akyildiz (2002) the devices interconnect to form a WSN and find a wide range of applications, for example in environmental monitoring, infrastructure monitoring, traffic monitoring, retail, etc. By using the nodes in conjunction with a WSN, the overall vision of ubiquitous computation as outlined by Weiser (1999) could be realized.

Welbourne et al. (2009) and Juels (2006) both stated that RFID technology enables the design of microchips for wireless data communication. The microchips called RFID Tags act as an identifier of the object that are attached to, akin to an electronic barcode. RFID is mainly used to identify objects from a few meters' distance and determine the approximate location of objects. In addition, Mohsen et al (2015) outlines that RFID frequency bands range from low frequency/LF to super high frequency/SHF and the tags consist of at least three basic components: A chip that holds information about the object to which it is attached and transfers data to reader wirelessly via an air interface, an antenna that allows transmission of the information to/from a reader and a packaging that encases the chip and antenna that allows the attaching of the tag to an object for identification. As also stated by Juels (2006) the Tags are either passive or active, by using the reader's electromagnetic signals as a power source or a small battery. Passive RFID Tags are already being used in cred-

it cards issued by banks or in toll booths passes, whereas the active ones are mainly used in port containers for monitoring cargo.

In order to understand profoundly how an IoT ecosystem operates it is important to understand that IoT is not only a single or novel technology but there are also several technological developments which come together to help create the bridge between the virtual and the physical world.

First of all, communication is attained, as stated by Tongke (2013) by a ubiquitous computation network like 3G, LTE, GSM, WLAN, WPAN, Wi-Max, RFID, Zigbee, NFC, Bluetooth or other wireless communication protocol technologies. Optical cables and other wired communication protocols & technologies can also be part of an IOT network. Addressability follows and implies that IoT objects can be addressed by using an Object Name Service (ONS), an automated networking service similar to the Domain Name Service (DNS). Identification plays an important role. IOT objects have unique identification features with the aid of technologies such as RFID, EPC, NFC that automatically read labels or bar codes. A crucial part of an IoT ecosystem are the sensors that collect data from IOT objects and forward it to the readers. Location refers to the necessity of locating IOT objects; their physical location is utilized using technologies such as Global Positioning System (GPS), Mobile Networks location services, or Radio Frequency. Analytics platforms or tools are also an important aspect of an IoT environment. These can be a simple statistical tool or even a more sophisticated machine learning approach able to gather big data collected from other IoT devices. Finally, User Interface (UI) is imperative for IOT objects to convey information to users in an appropriate way (voice, text, or image).

It is mentioned by Wilde (2007) and Guinard et al (2010) the notion of Web of Things (WoT) which is considered as the evolution of IoT physical components that are fully connected and integrated by using Web standards. While according to Kagermann et al., (2013), integrating the Internet of Things (IoT) and the Internet of Services (IoS) in the manufacturing process mark the fourth industrial revolution known as Industrie 4.0.

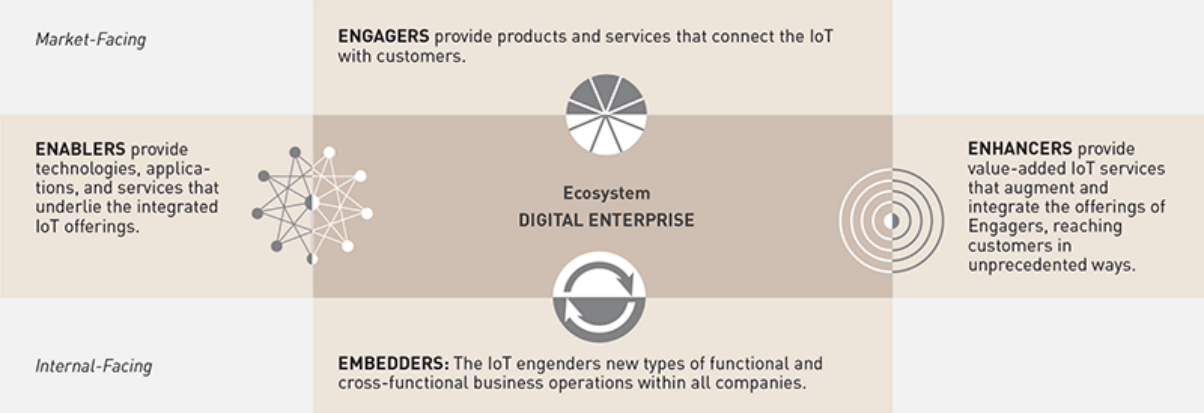

Figure 1: Business opportunities in a digital enterprise ecosystem

The IoT era also opens a range of new business opportunities, as Burkitt (2014) reported. These opportunities tend to be divided into three broad strategic categories. The first category includes the "Enablers" that develop and implement the underlying technology, the second one includes the "Engagers" that design, create, integrate, and deliver IoT services to customers and the third one corresponds to the "Enhancers" that devise their own value-added services, on top of the services provided by Engagers. The interplay of those three categories and the way they collaborate is showed in Figure 1.

The application of an IoT platform in a business presents various opportunities, opportunities indubitably present in the agribusiness of Precision agriculture practices within an IoT ecosystem. Wireless Sensor Networks (WSNs) represent an emerging technology for intensive farming, as stated by Li et al., (2011). Wireless technology yields flexibility in sensor installation and network robustness, while reducing both maintenance complexity and associated costs. Previous work of Gómez et al. (2012) has contributed to precision farming through the implementation of a technological platform based on free software for monitoring cultivation zones, such as a greenhouse or farmlands.

2.3 Applications of IoT in agriculture and food production

Many researchers report that embedding IoT technologies in the Agricultural field can benefit farmers in terms of production profitability, and that they also are a means of preserving natural resources and benefiting social aspects of local society, even improving the farmer's quality of life. Zhao et al. (2010) mentions that data important for cultivation, such as the critical temperature, humidity and soil signals, can be collected in real-time during the agricultural production process, which is transmitted by wireless networks through M2M sup-

port platforms that gain real-time data of the agricultural production environment using SMS (Short Messaging Service), web, WAP (wireless application protocol) patterns; this way, production can be guided directly from the terminal.

Applications of wireless sensors and networks in agriculture and food production as noted by Wang et al (2005) can be classified into five main categories: environmental monitoring, precision agriculture, machine and process control, building and facility automation and traceability systems. Each category is analyzed below.

Environmental monitoring refers to measurements of environment variables, such as weather data and geo-referenced water quality data that are usually still dependent on stationary sensors and data loggers, pencils and paper notebooks, which are labor-intensive and susceptible to errors during transcription (Vivoni and Camilli, 2003). For example, a farmer could easily monitor each area of his cultivation in real-time to avoid frost, manage irrigation, determine fertilizer applications and arrange his harvest schedule. As reported by The Guardian online press, environmental aspects can be monitored with the use of unmanned aerial vehicles (UAVs or drones) that hover low over fields with embedded sensoring devices. Data are provided instantly and the constantly decreasing cost of drones can make them affordable to a great percentage of the population (Van Vark, 2016).

Precision agriculture can be realized through a wireless sensor system information while conducting local field survey and collecting data on water availability, soil compaction, soil fertility, biomass yield, leaf area index, leaf temperature, leaf chlorophyll content, plant water status, local climate data, insect-disease-weed infestation, grain yield, etc. (Gomide et al 2001). For example, according to Evans and Bergman (2003), wireless sensors can be used in a system to assist irrigation scheduling using combined on-site weather data, remotely sensed data and grower preferences.

Machine and process control includes applications of M2M to vehicle guidance, machinery management, robotic control and process control. A WLAN-based, real-time, vehicle-to-vehicle data communication system had been established by Guo and Zhang (2002) in order to exchange information between vehicles, on variables pertaining to the state of the vehicle and operational control.

Building and facility automation refers to agricultural facilities, such as greenhouses and animal-feeding facilities, and includes HVAC, lighting control, energy management, access

control, structural monitoring and fire/security. Concerning greenhouse control, Liu and Ying (2003) reported a greenhouse monitoring and control system that uses Bluetooth technology to collect environmental data from a sensor network in a greenhouse and transmits the data to a central control system. Monitoring climate-related variables within an animal house can help maintain good animal health. Pessel and Denzer (2003) developed a portable, mobile instrument to measure temperature, relative humidity, noise, brightness and ammonia content in the air within the house and transferred the data wirelessly to a computer through an infrared data link.

Traceability systems. Given the increasing demand for security and safety, complete documentation of food products, from field to customer, has in turn become increasingly demanding (Thysen, 2000). RFID has been accepted as a new technology for a well-structured traceability system on data collection, and human, animal and product tracking (Sahin et al., 2002). It has been projected that the applications of RFID would grow rapidly between 2003–2010 with a compound annual revenue growth rate of 32.2% (Sangani, 2004).

Taylor and Mayer (2004) reported a study on a "smart", comprehensive animal management system in which each animal can be fed through a mote equipped with a wireless sensor, providing accurate location measurements and health-related information regarding the animal wirelessly. Chandler (2003) discussed the potential of RFID tags for "smart packaging", automatic checkout, "smart appliances", "smart recycling" and marketing/promotional opportunities. In the same study, it is reported that this type of technology could improve security, productivity, inventory control, and traceability and result in capital and operational savings in the food packaging sector.

Gebresenbet et al. (2003) and Geers et al. (1998) proposed an on-the-road monitoring system for animals during transportation. The system included sensors installed in the animal compartment to identify the animals and to monitor air-quality, vibration and animal behavior. A GPS provided the location of the vehicle in order to send data to a service center via the GSM network. It was reported that the system greatly improved animal welfare during handling and transportation.

These applications are a prime example of the fact that the quality of the generated products improves through IoT applications. A lot of squandered time can be amended for business, or even for the farmers' personal improvement or the improvement of the local society. As a

result of applying these technologies, chemical usage is minimized with local ecosystems recovering. IoT can improve economic, environmental and social aspects of the field of agriculture, from the quotidian life of a small family farm to large scale production systems.

2.4 The opportunities of IoT in Agricultural field

In the field of agriculture, the same technology equipment such as sensors and actuators that are used in smart houses can also be used in order to measure data such as temperature and humidity in a small greenhouse or in a field of many acres of crops. According to Chui et al., (2010) applications in agriculture can control cultivation characteristics including soil and plant monitoring, greenhouse environment monitoring and control systems, monitoring of the food supply chain, monitoring of animals, etc. Combining Precision farming equipment with wireless links to data collected from remote satellites and ground sensors, can analyze crop conditions and adjust the way each individual part of a field is farmed. For instance, extra quantity of fertilizer can be spread on areas that the soil needs more nutrients. As a result, there could be a yield increase for the financial maintenance of the farmer, as conditions of the cultivation are time controlled and decision making is instant.

More specifically, as pointed out by FAO (2011), the Agriculture field has the constant need of timeliness in agricultural statistics and the associated monitoring systems. The monitoring of agricultural activities faces problems that are not similar to other fields. Such problems result from the production seasonal patterns due to the biological lifecycle of crops, the physical landscape, and agricultural management. Climate variables also affect production. According to Atzberger (2013), Agricultural monitoring systems provide the opportunity of timely information on crop production, status and yield in a standardized and regular manner from the sub regional to the national level, as early as possible during the growing season(s) and update periodically through the season until the time of harvest. Thus, farmers are less stressed when managing their cultivation, changing their practices in accordance to particular demands that their production has, without the need of constant attention.

An IoT ecosystem can counterpoise the precarious character of agricultural production with the advantage of information management. To this point Zhao et al (2012) underlines that as agriculture is undergoing industrialization worldwide, it is important to develop agricultural informatization, a term that has become a developing trend for global agriculture. Combining IoT and RFID technology, the “agricultural information cloud” could be created in order

to promote fast development of agricultural informatization as part of smart agriculture. At the same time, Mueller et al (2012), as cited by Atzberger (2013), report the strong role remote sensing plays within the agricultural sector in providing information at the right time to assist with decision making. As a result of the expected changes in the agriculture sector such as meeting food requirements while protecting the environment, there will be requests for objective information in the future. The prevention of various instances during production could be made easier and appropriate intervention more accurate, organized, and timely, along with a decrease in the waste of pesticides, fertilizers, water or other energy resources.

Nowadays, Smartphones have become a common and somewhat integral part of our daily life primarily because they are portable, ubiquitous, small and light. Similar to other fields such as engineering, agriculture is adopting changes correlated with smartphones, and several agricultural applications have been generated. Rafoss et al., 2010 describe a real-time mobile phone application. The new generation of advanced operating systems, such as iOS or Android, has facilitated the development of real-time applications that operate using large datasets processed by the device or a cloud server. This mode of operation is a key aspect of decision support (Antonopoulou et al., 2010; Zheng et al., 2011) or tracing systems (Sallabi et al., 2011). Therefore, many sectors may benefit from the information generated by mobile devices in optimizing systems and procedures, stresses Montoya et al. (2013) as farmers could control and make decisions for their cultivation instantly, through smart devices gaining more free time to improve or expand their agribusiness.

In addition, as reported by Dlodlo (2015) IoT technologies can support precision agriculture, the form of agriculture whose goal is to maximize return of investment. Important aspects of cultivation can be arranged through various structures such as irrigation, water detection, and soil detection sensors that give alerts which in turn help protect a farmer's crop and relay information wirelessly, for example to water reserve points on when to irrigate. Furthermore, farmers could adopt automated drip irrigation in areas where water is scarce. This can be achieved by linking data from various sensors which control both water release and water quantity. Moreover, in order to minimize crop damage by plant eating pests, animals and veld fires among others, in-field monitoring sensors can help prevent those incidents and purge cultivation. These sensors are able to inform farmers of any attack on their crops or fires detected before they spread. Despite the aforementioned opportunities that can

be presented with the adoption of sophisticated technological innovations in Agribusiness, challenges appear also.

2.5 Challenges of an IoT ecosystem in Agribusiness

An IoT ecosystem is characterized by obstacles that should be overcome. The agricultural field also faces challenges. Wang et al. (2006) in past research characterizes the whole wireless sensor development path as a "zigzag". Although great potential is recognized and there is a great support for wireless sensors technology, there is also a significant share of people that are not ready to integrate new technologies in their business. There is mention of security and compatibility issues, creating confusion, together with the required cost of creating a new infrastructure. Moreover, power supply and the reliability of wireless systems continue to pose concern to potential adopters of this technology, while the lack of experienced staff capable to overcome such obstacles is a constant worry. Another challenge that will rise from the Industrie 4.0, reported in The World Economic Forum, is an eventual job vacancy decline. It is predicted that «5 million jobs in 15 major developed and emerging economies» will be lost while «2.1 million jobs will be created in computer engineering and mathematics» indicating that the market would grow in demand for more specialized professionals. (Deutche Welle, 2016)

Concerning the Agricultural field, the challenges are more or less equivalent with other fields; more accurately, Aqeel-ur-Rehman et al (2011) underlines that the cost is intense for farmers in order to adopt WSN and WSAN while a generalized solution of each service and problem is not available. Furthermore, significant technical knowledge is required to implement complex solutions that cannot be confronted as a whole but have to be managed as smaller parts of the problem, for example data acquisition, data processing, storage techniques or network related ones. That implies that a farmer without particular technical expertise cannot handle the problems that may arise. Guerrini (2015) author in Forbes online press mentions that investments and innovation in agriculture face difficulties due to the extremely low marginal cost. Another concern is about data ownership and data safety. Big companies may take advantage of farmers by charging them for the data, in order to sell the same data for profit. Moreover, real time information of yield increase may for example be used as a poverty value index of farms for corporations.

2.6 The Sustainability Triangle

Taking intensive cultivation into account, which can exhaust environmental resources and directly affect human health, there is a need to comprehend sustainable agricultural practices and apply them more extensively in the future. Sustainable agriculture constitutes a part of an overall sustainable development. As stressed by Ikerd, J. E. (1993) Sustainable agriculture must use farming systems that conserve resources, protect the environment, produce efficiently, compete commercially, and enhance the quality of life for farmers and society overall. A generally accepted definition of sustainability was given by the Bruntland commission (WCED, 1987): *'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their needs*'.

Serangeldin and Steer (1994) approached the objectives of an Environmentally Sustainable Development (ESD) through a triangle, the Sustainability Triangle. This is divided into three dimensions: economic, environmental, and social. The Sustainability Triangle implies that in order to have a sustainable development each one of these three dimensions should be evenly integrated into the core of the decision making process. Upcoming development projects should be evaluated on their economic and financial viability, as well as ecological and social sustainability. The economic criteria refer to financial growth, equity and efficiency. The ecological sustainability criteria such as natural resource conservation and ecosystem integrity are poorly defined but the indicators of social sustainability, for instance equity, social mobility or social cohesion, cultural identity and institutional development are even more poorly defined. In Figure 3, the tree pillars of sustainable triangle as suggested by Serangeldin and Steer (1994) are demonstrated.

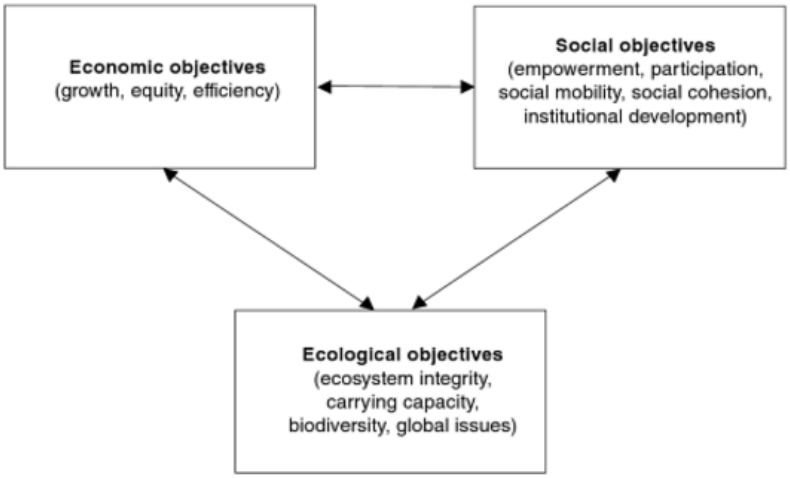

Figure 2: Institutional context of Sustainable development Triangle

The IoT directly impacts the economic aspect of agricultural and farming activities. As reported from the Alliance for Internet of Things Innovation (AIOTI, 2015) through manage the increasing population can be met minimizing food loss or waste. Furthermore, reducing obstacles in regards to the supply chain can improve the economic efficiency while reaching sustainable profitability.

Concerning the environmental dimension, there are multiple benefits in using IoT technologies. Production becomes more efficient, animal health and welfare is improved and product quality and safety are sustained. The impact of machinery traffic on land is reduced and the delivery of environmental goods and services becomes more effective. Moreover, using smart technologies from the first stages of the agri-food chain can create an environmental friendlier operation along the whole chain, contributing to "big-picture decisions" of environmental concerns, like greenhouse gas emissions, air quality and land conditions. IoT also contributes to the livestock farming sector, in cases of husbandry or breeding, using non-intrusive interconnected devices for safer animal growth and reproduction.

The Societal impact and benefit of IoT request further research as these emerging technologies are new and the outcome is not yet extensively reported. But is it possible to add a new dimension in the present Sustainability Triangle? In the following chapter the research methodology that explores the dimensionality of the Sustainability Triangle model in an IoT ecosystem and the possibility to create a superior model concerning the field of agriculture is analyzed.

3. Research Methodology

The purpose of this chapter is to provide an outline of the research objectives and the methodology used to conduct this research project. Initially, the aim of this study will be clarified and the applied methods will be discussed, explaining the rationale for their selection. Further information about the participants and the procedure will then be provided and the limitations of these methods will be highlighted.

3.1 Research purpose

The purpose of this study is to examine the role of IoT in the Sustainability Triangle. More specifically, the objective of the dissertation is to explore the dimensionality of the Sustainability Triangle, regarding the way an IoT ecosystem in Agricultural field affects the economic, environmental and social aspects of the triangle while trying to investigate if it is possible to suggest a superior model for the Sustainability Triangle. This chapter presents the research approaches and strategy that have been chosen as the most appropriate in order to investigate the existing body of knowledge and answer the research questions of the study: “What is the role of IoT in the Sustainability Triangle? Can the contribution of IoT in farming sector add a new dimension in the Sustainability Triangle?”

Before we answer the research question, the hypothesis that should first be examined is formed through the following three sub questions:

Hypothesis 1: What are the challenges and the opportunities that arise from the implementation of smart farming in the Sustainability Triangle?

Hypothesis 2: Do Greek farmers believe that IoT technology will benefit their cultivation practices?

Hypothesis 3: To what extent are Greek farmers willing to use IoT applications in their crop production?

3.2 Research approach

Aiming to conduct an empirical study and to understand deeper the "essence" of the experiences of the sample, a phenomenological approach is selected. This approach, as stressed by Creswell (2003), involves the study of a small group of subjects through extensive prolonged analysis to understand their intentions. As Kruger (1988, p 150) stated, phenomenology refers to those who "have had experiences relating to the phenomenon to be researched". Thus phenomenological methods can be considered more effective in accentuating the experiences and perceptions of the subjects from their own perspective.

The phenomenological approach is related to the Personal Construct Theory, a psychological theory of human cognition, which suggests that reality is based on constructs rather than absolutes, indicating that each person has a unique way of forming his or her own subjective reality. Personal Constructs are developed by people as internal ideas of reality, in order to perceive the world around them, while the meaning and the understanding of things is subject to his or her own past experiences (Heine, 2009 pp.). The different ways of perception and the differences amongst other individuals, known as the idiosyncratic views of individuals, can define unique personalities. It is also well grounded and stated from previous researchers that the view a person has is objective to other people with whom he or she interact and is made up of a collection of similarity–difference dimensions, referred to as personal constructs. These hierarchically interrelated constructs are used to predict how the world might behave.

In order to collect verbal data, as a naturalistic verbal report, at first a qualitative research will be conducted. As language is the most essential way of communication, interpretation and understanding the narrative reports of the participants' perceptions, leads to understanding the phenomenon (Smith, 2015). However, taking advantage of the outcomes of the qualitative phase, the subject can be further examined, taking research results a step forward by also conducting a quantitative research.

Qualitative research is based on the interpretivism model, which focuses on understanding and assessing the experiences of people in different contexts and is more subjective in nature, using an inductive approach of developing knowledge (Bryman & Bell, 2007). The most frequently used qualitative methods include, unstructured or semi-structured interviews and have the advantage of generating data by eliciting an "insider's view" of the stud-

ied subjects. Furthermore, they offer the opportunity to modify and probe questions, allowing participants to clarify ambiguous answers (Carr, 1994). As cited by Harwell (2011), qualitative research methods focus on discovering and understanding the experiences, perspectives, and thoughts of participants exploring meaning, purpose, or reality, while quantitative research methods attempt to maximize objectivity, replicability, and generalizability of findings, and are typically interested in prediction.

Quantitative methods are based on the positivism tradition, which stresses the importance of using an objective "scientific" method of collecting and analyzing countable data generalized to a wider population, and composing a deductive approach of attaining knowledge (Anderson, 2013). Surveys and questionnaires are the most common quantitative methods, as they allow to study a large number of people, by keeping a distance from participants and therefore reducing potential bias. Moreover, they increase the reliability and validity of the findings, as they offer anonymity, which support participants to be more honest (Saunders, et al., 2012). Qualitative research methods can reduce the verbal data of the phenomena to numerical values in order to perform statistical analysis. Therefore, it is considered that the mixed methods research strategy is the most appropriate method to explore and investigate the main hypothesis of this project as it allows to collect quantitative data which can analyze quantitatively using descriptive statistics.

Harwell (2011) states that mixed methods research combine qualitative and quantitative methods in ways that ostensibly bridge their differences in the service of addressing a research question. However, Creswell (2003) notes that using a mixed methods approach the researcher tends to base knowledge claims on pragmatic grounds (e.g., consequence-oriented, problem-centered, and pluralistic). Data collection involves gathering both text information as well as qualitative numeric information from quantitative methods so that the final database represents both qualitative and quantitative information. Also, Creswell analyses qualitative and quantitative methods indicating that a quantitative approach is the one in which the investigator primarily uses post positivist claims for developing knowledge, employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data.

Using both qualitative and quantitative research methods the research process can be controlled more efficiently, and when appropriate sampling is used, it is possible to generate findings that are representative of the whole population at a lower cost than collecting the

data for the whole population (Saunders et al, 2009). Christensen et al. (2010) suggests that the information acquired in the quantitative research can be presented most easily in the form of graphs or diagrams.

3.3 Research strategy

The phenomenological approach is considered to be the most suitable method to answer the research question, as it aims to uncover meaning through lived experiences of farmers concerning the technological evolutions available on the crop production field. A two-phase, sequential mixed methods research is considered as the most appropriate research method to examine if IoT could play a role in the Sustainability Triangle and explore its dimensionality. As research in correlation of IoT and the Sustainability Triangle is not replete and since this study aims to understand the intentions of the sample concerning this subject, the first phase is a qualitative exploration of the main hypothesis by collecting data from Greek farmers aiming to explore the subjects' view about the topic with the intention to investigate further the outcomes, by conducting personal interviews, in order to know the important variables and patterns of behavior of the participating group.

The questions of the semi-structured interviews that were audio recorded, derived from a review of the literature, aimed to cover a broad range of issues that are critical for the implementation of IoT in the farming sector; the participants are allowed to express their own point of view. Secondary research involves the reinterpretation of data, which have been primarily collected by someone, other than the user and is often used in the preliminary stages of a research process, in order to inform the research design (Suri, 2014). After the completion of the qualitative approach, the quantitative approach takes place in order to further study and obtain statistical data, with a larger sample of individuals. The data collected during the qualitative phase will be developed so that the main research question can be tested from a larger sample of farmers in order to obtain quantitative, statistical results.

At the end, the outcome of the secondary research of the literature review chapter is being combined with the outcomes from both qualitative and quantitative phase, aiming to corroborate the results of this research project. The attempt to cross-validate the findings of different methods in a single study is called triangulation (Creswell, 2003 pp. 217). This mixed method analysis is familiar to many researchers as it provides the advantage to result in well validated and substantiated outcomes while counteracting the weaknesses of each method.

3.3.1 Sample

Qualitative data are collected by conducting semi-structured interviews through telephone calls (Edwards and Holland, 2013). As the field of agricultural production is very broad, the first interviews are from several particular fields spanning various plant produce, greenhouse produce and livestock and bee keeping. It was instantly observed that each category had the potential to be examined individually due to its unique character and distinguishing characteristics which generate different needs. So at this point, a radical choice was made to limit the subjects on those who are related with plant production either outdoors or in a greenhouse, as they share more common characteristics, similar concerns and problems and consist of a homogenous sample. At first the convenience sampling method was used but in order to trace more relevant participants to the plant production, snowball sampling was used. Snowballing is reported as the method of growing the sample by asking one participant to recommend others for interviewing (Babbie, 2001; Crabtree & Miller, 1995).

Performing data-collection interviews stopped when the topic became saturated, specifically when the subjects introduced no new perspectives on the topic and responses were repeated. Groenewald (Groenewald, 2004) suggests that 2 to 10 participants or research subjects are sufficient to reach saturation and Creswell (2002) recommends using "long interviews with up to 10 people" for a phenomenological study, in our case due to the aforementioned inconsistency of agricultural field production (plants growing on the ground, trees, need of shoring etc.), so more participants were required to reach saturation point. Among the interviewees was a Quality and Phytosanitary Control Manager of the Department of Rural Economy and Veterinary in Orestiada, Greece. In the end, 21 interviews were required to reach saturation. The responders' age ranged from 22 to 72 years old from various regions around Greece.

Concerning the qualitative approach, an anonymous online survey was conducted. At first a convenient sample was used. In order to test the efficiency of the questionnaire design, the first 10 questionnaires were distributed as a pilot. No issues were reported so they were included in the final set. Due to the nature of farming jobs, participants in most cases did not have internet access. Thus, the snowball technique was used in order to move on the procedure. The questionnaires collected from the internet reached a sum of 132. At the same time, aiming to collect as many responses as possible, a systematic effort through telephone

calls was organized to collect another 100 responses. In total the sample consisted of 232 farmers from various regions across Greece.

3.3.2 Research Analysis

The methods that were implemented to analyze the results of qualitative and quantitative research outcomes that have been produced from the aforementioned research practices are presented in this chapter. The results from the qualitative phase that have been collected through semi-structured interviews are transformed from raw data into a standardized form, as Babbie (2001 p.304) stated, through an essentially coding operation called content analysis. Ryan et al. (2000) characterized content analysis as a method that includes techniques for reducing texts to "a unit-by-variable matrix and analyzing that matrix quantitatively to test hypotheses" while the researcher has the opportunity to create a matrix by applying a set of codes to a set of qualitative data. According to the aforementioned technique a Generic Content and Differential Analysis matrix is created in order to code the information from the interviews and transform the data into a measurable format.

Pursuant Burnard (1991) interview analysis follow certain stages. The procedure suggests taking notes during the interview in "memos" in order to distinguish the categories of the data. The next step requires the transcription of data in order to create the "open coding" categories that are freely generated based on interview data. In the fourth stage of the procedure the researcher is called to create more consistent categories by collapsing the similar ones in order to create the final list of categories at stage five. In the succeeding stages, a matrix is created with the first column stating the main topic of each category while the side one addressing the main subject briefly. The procedure concludes with the report of the counts in each category according to sex and age of the interviewee, forming the matrix which is substantiated from the research findings.

Qualitative data are analyzed through the Surveygizmo online software and are also being presented in the following chapter of results. A summary report of the results is extracted and available in Appendix III. Cross tab reports, also conducted through the Surveygizmo software, allow to cross tabulation at least two questions, one on the horizontal axis and one on the vertical, so a researcher can assess the degree of association between variables. The test that is used in that case is the chi-square (χ^2) test, most commonly used in sociology and

other fields that cope with descriptive variables. The chi-square (χ^2) test reveals if the differences between some of the cells are statistically significant (Davies and Hughes, 2014).

Finally, the outcomes of the qualitative and quantitative approaches are triangulated with the secondary research of the literature review chapter in order to obtain more validated data from the research procedure. Several past researchers suggest that the purpose of creating a form of triangulation by collecting data from three different kinds of informants aims to contrast the data and 'validate' the data when the generated findings are similar (Arksey & Knight, 1999; Bloor, 1997 ;).

3.4 Limitations

Although a mixed method approach was used to counteract the weaknesses of each method, there are still a few limitations surrounding this study. First of all, the survey received an approximate response rate of 53%, as 232 out of the total 572 participants took part. Also it should be noted that the demographic questions had responses from 216 people only. Furthermore, the majority of the responders were men, as only the 15% were women, thus outcomes were narrowed down to the sample's characteristics. Therefore, low response and diversity rates, can introduce bias into the findings and threaten the validity of the study.

4. Findings

The aim of this chapter is to present the results of the primary research outlined in the previous chapter. First, the results of the Qualitative phase are reported with the Quantitative results following suit. Both the interviews and the survey aim to answer the research questions by revealing the main challenges and opportunities affecting the environment, economy and society by applying IoT in the farming sector, and explore the dimensionality of the Sustainability Triangle.

4.1 Qualitative Results

To begin with the qualitative phase, after conducting the interviews with 3 women and 18 men, the answers that participants provided are categorized and presented in a Generic Content and Differential Analysis matrix. In the matrix that is available in the Appendix II section, the first result worth pointing out is an important characteristic that should be constantly checked in a cultivation. This constitutes of the diseases and pests that may affect production, which has a percentage of 76.2% that corresponds to 16 out of 21 participants for the diseases and 57.1% for pests. An important need that is not satisfied by current cultivation practices is weather control, as reported by 11 people. Production distribution is a valid concern reported by 6 people representing nearly one-fourth of the participants. Meanwhile, the most popular applications of IoT in farming smartification are considered to be automated irrigation with a percentage of 52.4%, followed by the control of the cultivation through smart devices with a percentage of 42.9%. Another trend that can be observed is that cultivation data collection for future planning and automated soil analysis tie by 8 responses each.

Concerning the challenges that would appear by the implementation of an IoT ecosystem in the farming sector, the most important reported ones are the high demand for capital gathering a percentage of 76.2%, followed by the lack of expertise of uneducated population in the technological field and the non tech savvy population in the farming sector with the percentages of 71.4% and 57.1% respectively. Furthermore, the lack of trust in innovative systems gathered 52.4% corresponding to the social challenges category.

The opportunities that may arise are divided in three categories: economic, environmental and social in accordance with the Sustainability Triangle pillars. The reduced cost of pesti-

cides, of water for irrigation and fertilizers, were reported equally by 16 people as important opportunities, corresponding to 76.2% while increased yield production seems to be reported almost from all the participants gathering 90.5%. Also worth noting is that environmental opportunities follow a similar pattern with 85.7% reporting that the decreased use of pesticides and water for irrigation are considered the most important opportunities followed by decreased use of fertilizers with 81.0%. As for the social opportunities. it is shown that the most reported ones are the increase of free time of the farmer with 61.9% and the reduced stress of the farmer with 52.4%.

Finally, other benefits except environmental, economic and social are reported by three participants that are the health benefits both for farmers and consumers. Three other respondents reported that the provincial population may show motivation and have the opportunity to be educated in new technologies. In addition, two of the participants mentioned that the image of the country will be improved gaining trust in the foreign markets. In the end it is noted by one participant that politics will be affected, demanding a new Common Agricultural Policy (CAP) in order to help farmers incorporate IoT farming systems in their cultivation.

4.2 Quantitative results

The results from the online survey were extracted from the Surveygizmo software. The statistics are analyzed and the main findings are presented in relation to our hypotheses. The data that correspond to the conducted survey are descriptive statistics, as well as a number of analyses of Pearson Chi-Square are integrated to extract possible correlation of the data. A summary report was created which is available in the Appendix IV section and the cross tab reports are available in the Appendix V.

4.2.1. Demographics

85% of the participants were men while only the 15% are women. The average age is estimated to be 34.3 years old. The majority of the responders were between 25-34 years old, followed by the age range of 35-44 marking 34.15% and 31.8% respectively. Also in the age range of 45-54 the percentage of participants was 20.5%, while there were no statistical significant percentages for ages below 24 and over 55. 36.6% of the participants appear to have a University degree or a Technical Institute degree and a 19.0% hold a master's degree. 14.8% have graduated from High School and 13% have a degree from a technical high

school. The average monthly salary level reaches 788.8 euros while the cluster of 501-1000 monthly salary level noted 36% and the cluster of 1001-1500 noted 21.8%. Regarding marital status, 45.4% of the participants appear to be single and 49.1% are married. Respondents spread across various regions around Greece, with the majority concentrated around the regions of Athens and Thessaloniki, are represented in the following map.

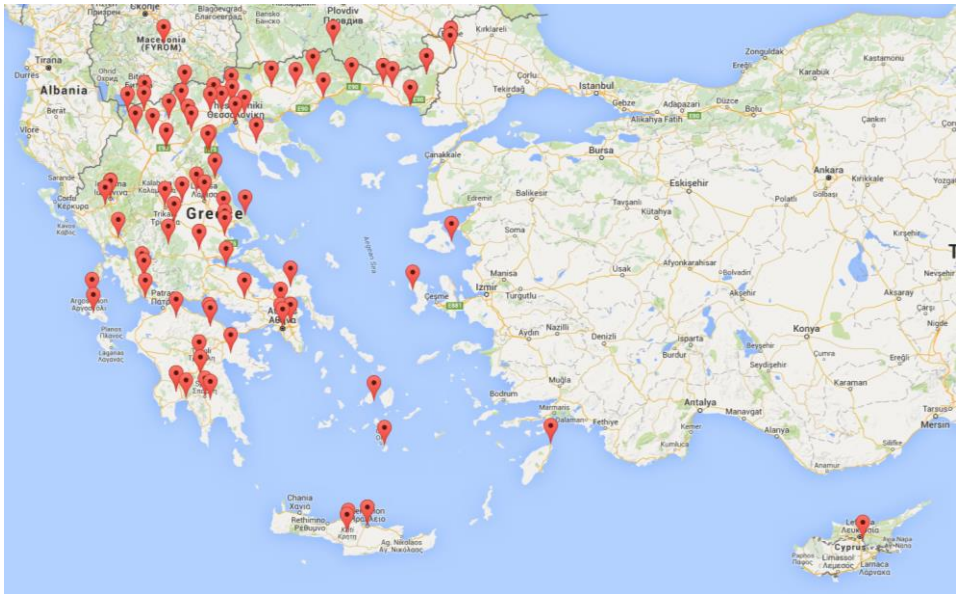

Figure 3: Geographic distribution of respondents across Greece

4.2.2. General information about the sample.

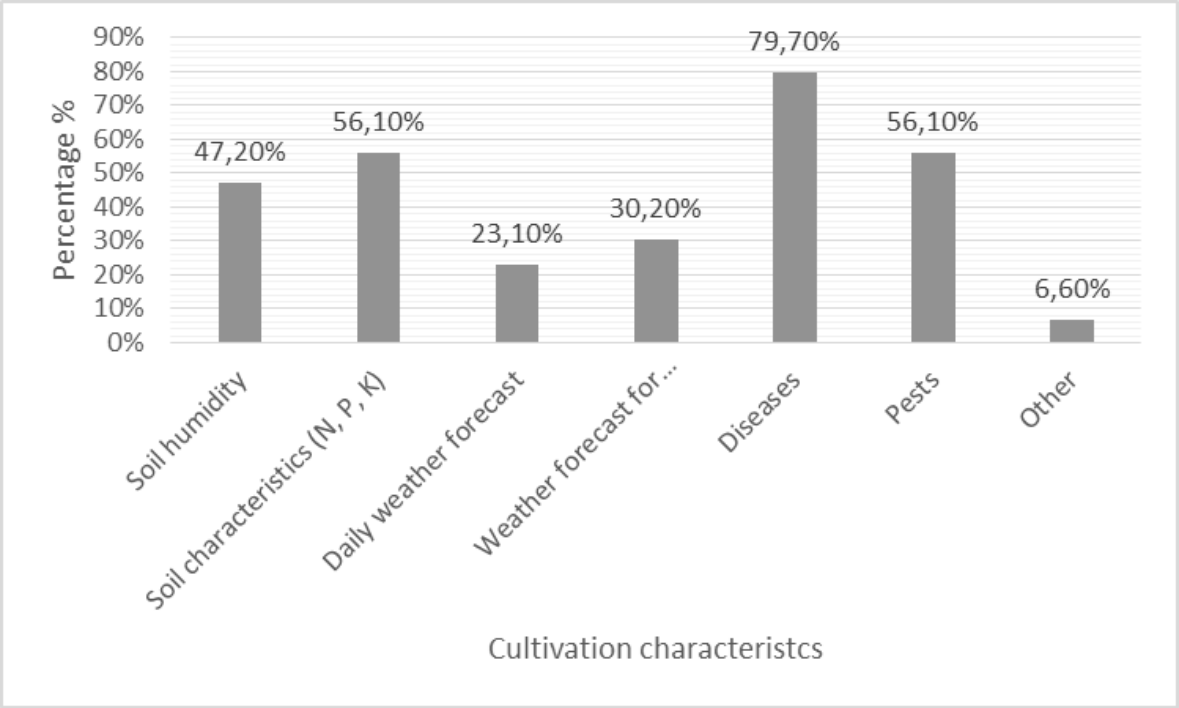

Table 1: Frequency table of the important characteristics that should be constantly checked in cultivation

As indicated in the summary report, 62.4% of the respondents apply conventional agricultural practices and 23.9% use organic farming. Table 1 reveals that 79.7% of all participants noted that diseases are the most important factor that should be constantly checked in a cultivation followed by 56.1% for the protection from pests and 47.2% for soil hymidity. Although 33.2% responded that production loss due to farming practices is around 10%, 59.3% declared that they are not satisfied with their applied agricultural practices. Also worth noting is that 63.7% answered that the major issue is production distribution.

In order to understand if the participants are willing to embed IoT application in their crop production in the conducted survey there are two similar questions that highlight the difference between the will and the need of the adjustment of such applications. In both questions the results are similar as 89.9% reported a general need of those applications in the farming sector and 90.4% indicated that such application will benefit their own cultivation.

4.2.3. IoT applications

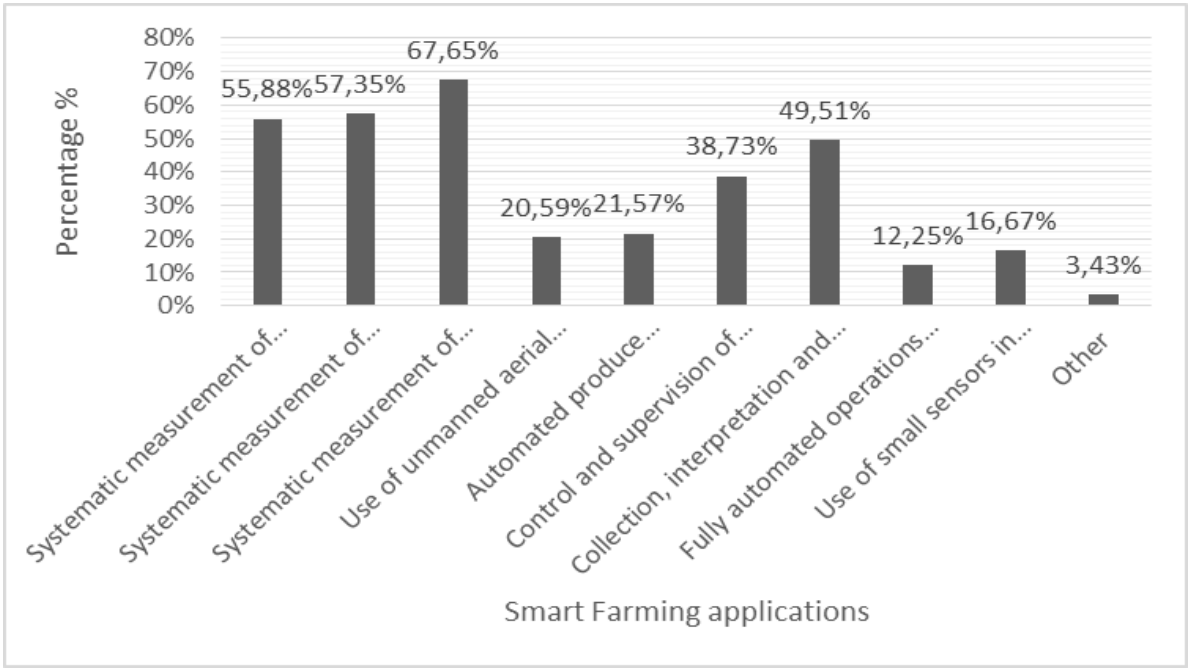

Table 2: Frequency table of the IoT application in farming smartification

Table 2 illustrates the frequency table of IoT applications in farming smartification. It can be observed that 67.7% of the participants are interested in an IoT application that provides systematic measurement of the conditions that reinforce the appearance of pests and diseases in order to cope with those conditions instantly when unsafe levels are detected. Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in required areas without having to water the entire cultivated area, and systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas at an appropriate amount required, noted almost equal percentages of 55.9% and 57.4% respectively. The least preferred application regarding crop cultivations are automated harvesting of production with automated machines not needing direct intervention by the farmer, which scored 21.6%, and spraying of the cultivation with the use of drones, which scored 20.6%. It should be noted that although the majority mentioned that there is need to apply IoT applications in the farming sector, 57.7% declared that they don't already use any similar application for their cultivation.

4.2.4 Challenges and opportunities of IoT in the economic, environmental and social pillars of the Sustainability Triangle

Regarding the implementation of IoT in the farming practices the participants noted that the most important economic benefits that would be generated are the yield increase with a percentage of 64%, the decreased cost of the use of water and fertilizers with 61.6% and 60.6% respectively, as long as there is a decreased cost on the use of pesticides. Concerning the environmental benefits, the participants reported that the decreased use of pesticides, water and fertilizers are important scoring 85.3%, 77.0% and 76.5% respectively. These answers are considered more important than the reduced consumption of electricity and petrol.

Regarding the social opportunities and challenges, the sample noted that the fatigue and stress levels of farmers would decrease, scoring 63.2% and 68.1% respectively, while at the same time highlighting that the major challenge concerning the social sector is the general lack of support from the state to the farming sector as a whole, with a percentage of 77.7%.

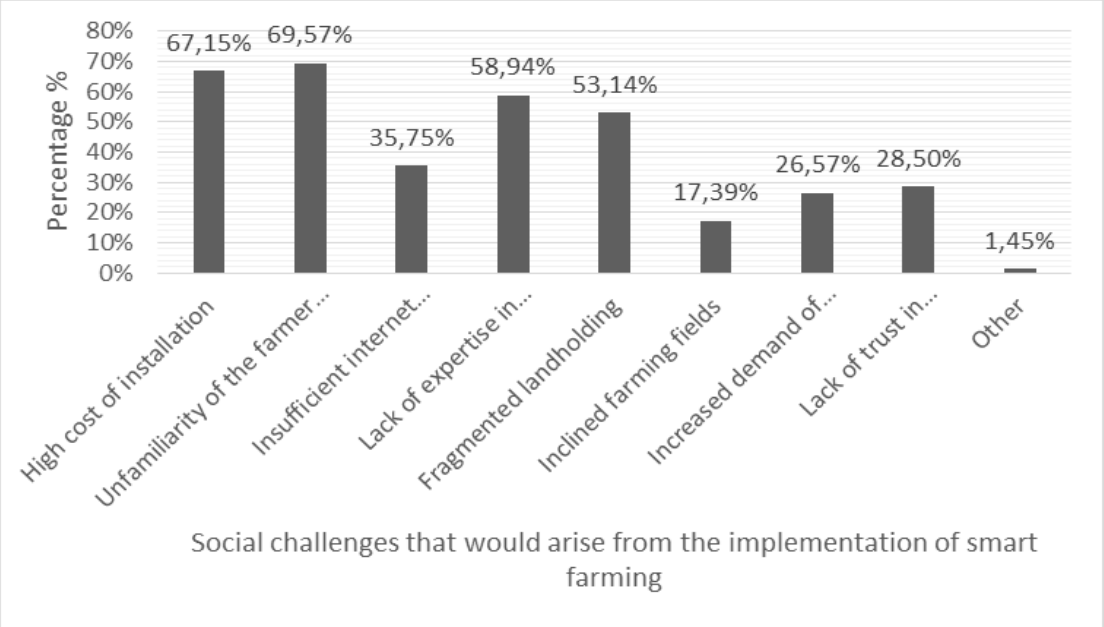

Table 3: Frequency table of the challenges of IoT application in the farming sector

Some interesting facts concerning the challenges that would arise from the implementation of farming smartification are revealed in Table 3. It can be observed that the two major challenges are that the population is unaccustomed to technological innovations in the farming sector, meeting 69.6%, and the high cost of the installation of an IoT system in crop production, reaching a 67.2%. Meanwhile, other challenges that can be observed are the

lack of expertise in technological systems with 58.9% and fragmented landholding with a percentage of 53.1%.

4.2.5 Exploring the dimensionality of the Sustainability Triangle

In an attempt to explore the dimensionality of the Sustainability Triangle, the participants in the survey noted adequately important, in a Likert scale from 1 to 5 (not at all, a little, adequately, a lot, very much) the contribution of IoT in health improvement for both farmers and consumers. The eventual opportunity of education in new technological systems in the province, the improvement of status and the trust increase of the country to foreign markets reach the percentages of 42.3%, 38.0% and 35.1% respectively. Finally, 78.7% declared that the application of IoT technology in the farming sector could not contribute in another sector except from economic, environmental and social of the Sustainability Triangle.

4.2.6 Cross tab reports

In order to correlate the findings of the survey, cross tab reports are generated (cited in the Appendix IV section). Tables 4, 5 and 6 indicate cross tab reports between the question of whether IoT application would benefit the cultivation practices of the farmer in correlation with age, education level and monthly income. With a p value > 0.05 the elements of the table are not likely correlated, indicating that age, education and monthly income don’t play a role in the decision of the participants.

Another cross tab report is created in order to correlate the IoT applications in the farming sector with the characteristics that are reported as most important from the participants. Table 7 demonstrates that the majority of those who reported that the most appealing IoT application is the automated irrigation system also reported that soil humidity is the most important characteristic that should be constantly checked in a cultivation, noted by 70.8%. As for those who chose the automated soil analysis application, also show their interest in soil characteristics with a percentage of 68.4. Moreover, 84.1% of those who preferred the application of automated control of pests and diseases were interested more in weather forecast prediction as the most important factor that affects the spread of diseases and pests. It can be noted that the choice of applications concurs with cultivation characteristics that have been chosen with a p-value equal to 0 (< 0.05) indicating a correlation between the variables in the table.

5. Discussion

This chapter presents findings interpretation of the primary and secondary research regarding the role of IoT in the Sustainability Triangle. More specifically the literature review findings will be triangulated with the findings of the qualitative and quantitative phase in order to produce more valid outcomes and answer the research questions which study the challenges and the opportunities that arise from the implementation of smart farming in the Sustainability Triangle, the intention of Greek farmers regarding the implementation of IoT technology in their cultivation practices and the extent to which Greek farmers are willing to use IoT application in their crop production. In the end the dimensionality of the Sustainability Triangle will be explored and a conceptual model corresponding with the findings will be presented.

5.1 The challenges and the opportunities that arise from the implementation of smart farming in the Sustainability Triangle

Literature review provided evidence about the opportunities and the challenges that arise from the implementation of smart farming. Environmental monitoring can provide useful information about the cultivation conditions and could assist the production with provident measures. Moreover, systems that save and arrange statistical data of the cultivation can help producers to overcome in a point the seasonal character of the crops providing timely information. The so called informatization could become a tool in managing the entire cultivation for current and future needs addressing to various benefits not only for the production but also for the local society. In addition, the available applications of smart devices can solve various instances immediately providing for the security of the cultivation, increasing the yield while protecting the environment and providing welfare to society.

The majority of the interviews in the qualitative research declared that various economic benefits derive from the implementation of smart farming. The potential yield increase and the decreased cost of pesticides, fertilizers, herbicides and water are undeniable. The moderate use of those compounds in combination with higher quality of the production and the decreased personnel required to cover cultivation needs can create a completely controlled and organized system that could become very competitive and profitable. More than 50% of the participants of the survey tend to agree with the subjects of the interviews suggesting

that yield increase is the most important economic opportunity that will emerge followed by decreased cost of pesticides, fertilizers, herbicides and water.

The reduced use and cost of the aforementioned crucial components of cultivation simultaneously entail the environmental benefits that emerge. Secondary research findings (FAO, 2012) indicate the augmented need of food while warning for a climate change where the temperature is expected to rise by 4 °C. Moreover, Foley et al (2011) underlines the need for world's future food security and sustainability needs, while supporting the agricultural field should manage and reduce significantly the environmental footprint. The reduced use of those chemical formulations can balance the long residence times that contaminate groundwater aquifers, restrict greenhouse emissions, reduce the negative effects of pesticides on biodiversity and protect natural resources (Bennett, 2014). The subjects of the interviews and survey participants seem to agree again but the second ones added that reduced petrol use is also important noting 50.5% in comparison with the interviewees, only 23.8% of whom considered petrol depletion. Sustaining a healthy ecosystem, policies and programs could balance the conservation of ecosystems and enhance local economies.

Using IoT applications for cultivation practices in collaboration with smart device applications, farming practices are easier to perform and the prediction of periodic phenomena that appear annually can be more accurate. Literature review findings indicate that real-time applications that operate using large datasets processed by the device or a cloud server give the advantage for instant decision making while optimizing systems and procedures. As per the interviews, the findings generally overlap with the results from the survey; 42.9% of interviewees and 38.7% of the survey participants are interested in using smart devices to control their production. Without doubt smartphone applications give the opportunity to supervise production from a distance. A female interviewee suggested that using smart device applications can control not only one field in a certain place or a certain type of cultivation but also different fields or types of crops.

Another interviewee mentioned that with the use of applications on smart devices you can better manage your daily program and also gain money from reduced petrol consumption that would be required for transportation to the field or to the warehouse. Gaining time in daily cultivation practices can be exploited for different reasons for each farmer. The participants of the survey noted that the most important social opportunities that may arise are the fatigue reduction of the producer and the reduced stress levels of the farmer concerning cul-

tivation threats, scoring 63.2% and 68.1 respectively. On the other hand, interview participants regard increased free time as a more important social benefit, marking it by 61.9%, although they don't believe that farmers will use the newly available time to educate themselves or expand their agribusiness detailing that there is a lack of culture in the farming regions around Greece something that makes producers incapable of recognizing opportunities and find motivation for self-improvement.

Although there are many opportunities from the implementation of smart farming, many challenges also arise. Secondary research findings point out that major issues of concern are data security, power supply, the reliability of wireless systems, the lack of experienced staff, low marginal cost and the proliferated job loss. Security issues don't seem to concern Greek farmers as none of the interview participants marked such an annotation. High demand of capital for installation of smart farming systems, the lack of educated farming population in technological systems and more specifically the unaccustomed population with those innovative systems are the major challenges reported from more than 57.1 percent of the interviewees. Survey participants tend to agree once more with the additional concerns about fragmented landholding in Greece. That means that the little acres that each farmer owns or rents to earn a living cannot produce a quantity capable to repay the initial capital that would have been invested.

The reliability of wireless systems does constitute a challenge noting 52.4% by the interviewees and 39.6% from the survey participants and it can be combined with the unfamiliar population with such systems reported from 57.1% of the interviewees and 69.6% by survey respondents. It can be implied that the aforementioned lack of expertise and the combination of lack of trust in IoT systems and unfamiliar population with those systems overlap creating a vicious cycle.

An important finding from the secondary research is that the World Economic Forum predicts that 5 million jobs will be lost while 2.1 million new job posts will be created for computer scientists, engineers and mathematicians. Industrie 4.0 does change the socioeconomic situation as it is known today. Both survey and interview participants marked approximately 35.0% that there will be job loss due to personnel restrictions. Developing cultivations in "smart" crop production, it could be alluded that the primary sector of economy would transform into the tertiary sector of economy. The farming sector will evolve from the production of raw materials into a service industry. There is a major concern from many

participants about the future, fearing that M2M communication will replace human activities. However, there is the side that supports that as the technology evolves the society should follow by adapting in the new demands and opportunities. The economy sector seems to overlap with social economy. Environment is connected with the possible financial tradeoffs in order to prevent for the environmental sustainability. Therefore, the sustainable development pillars of the triangle still are inextricably linked and interdependent at a certain point.

5.2 Do Greek farmers believe that IoT technology will benefit their cultivation practices?

According to the literature review research, several benefits that would compel farmers to embed IoT applications in their cultivation are noted, regardless of the agricultural practice that is already applied by each famer. The entirety of the interview participants declared that IoT applications will benefit their cultivation and the majority also stated that there is a general need for the improvement of crop production in Greece, using IoT applications to smartify the farming sector. The responses from the participants of the sample shed more light into those findings, with 89.9% noting that there is need for the implementation of those applications and 90.4% also reporting that IoT applications will benefit their cultivation practices. The role of those similar questions was to distinguish the meaning of the general need that might exist with the personal interests of the participant. The equivalent percentages indicate the identification of the general need with the personal interests of the farmers.

5.3 To what extent are Greek farmers willing to use IoT applications in their crop production?

Greek farmers clearly reported their interest about the implementation of an IoT system for farming smartification. But to what extend are they willing to apply such a system? Is there any relation between the basic needs that should be constantly checked in their cultivation with the preferences they had about the farming smartification applications? The interview participants considered automated irrigation, control of production and decision making of cultivation practices through smart devices, data collection for future use and planning of the cultivation, and automated soil analysis as the most appealing of applications.

The literature review chapter provided evidence that there is great variety of IoT applications that can support the entirety of the cultivation needs not only for the control of the cultivation with automated interventions by an accurately programmed system but also building and facilitate automation and traceability systems. Apostolos Chantziaggelakis (interview 21 cited in the Appendix I section), Quality and Phytosanitary Control Manager of Department of Rural Economy and Veterinary in Orestiada, suggests that although innovative technological systems regarding the Greek reality are needed, there are major obstacles that should be overcome before even considering of implementing smart agriculture. He also noted that farmers in Greece are not receptive to such systems as they don't have the demanded capital and even if they did, they would have preferred to spend that money on their personal projection within their local society, for example by buying new expensive cars. Fragmented landholding is also considered a major issue when trying to fulfill such an investment.

The survey respondents don't seem to disagree with the abovementioned point of view. The most popular IoT application chosen by the survey sample corresponds to the cultivation characteristics that they personally considered as most important. Smart farming applications are not equally likeable among participants, as they showed a preference in the simplest ones that are not perceived as intrusive to their personal work. To be more specific, the application concerning the systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in required areas without having to water the entire cultivated area and the systematic measurement of conditions capable to promote the spread of diseases garnered the rates of 55.9% and 67, 7% respectively. At the same time, the applications suggesting the use of drones for spraying the cultivation and the use of GPS for automated harvest without the need of the farmer gathered 20.6% and 21.6% respectively. That implies, in accordance with supplementary conversation with the participants of the survey that they need to feel that they contribute. It can also be noted that the size of their cultivation area may play an important role. If more farmers were cultivating larger fields and fatigue was greater, the percentage of those applications could be higher as they could deem them more helpful.

At this point, comparing the declaration of the lack of trust in automated systems can support even more the notion that Greek farmers are not totally ready to accept such systems

although 64.0% of the sample acknowledge the fact that the yield of their production can significantly increase.

5.4 Exploring the dimensionality of the Sustainability Triangle

Analyzing the question of the qualitative and the quantitative phases « Do you believe that farming smartification can contribute to another sector besides economy, environment and society? » the majority of the participants in both interviews and surveys answered that there is no other field, except from three respondents that answered they could be benefited from a smart farming system. Although, 78.8% of the survey participants and 12 out of 21 interviewees suggested that there is no other sector, it is interesting to analyze the responses of the minority.

At first three interviewees mentioned the health of both farmers and consumers will ameliorate as the spraying procedures of the cultivation could be done by drones and the farmer himself will not inhale chemical concoctions. The products will not absorb those compounds and as a result the consumers will be more protected. Other three interviewees noted that the population of the province may have the motivation to educate themselves, first and foremost in order to use such systems themselves and at the same time to have the opportunity or chance to explore other knowledge fields. Thus, the educational level of this population will improve, affecting also their status quo. The third element reported from two interviewees was the image of the country in the foreign markets. This implies that by using more sophisticated systems for the control of cultivation, the goods will have better quality and better tracing during their life cycle, creating a more competitive production while promoting the country's market trust.

Testing those three categories in the surveys using a Likert scale from 1 to 5 representing the importance of three suggestions regarding the health, the education and the image of the country the sample concentrated 42.3%, 38.0% and 35.1% respectively for each category corresponding to the middle choice «adequately». However, the participants also suggested some other elements, such as exports, productivity, control of the quality, higher values of final products that can reach better markets, new job vacancies, foreign policy, tourism, welfare in general, dignity, education and psychology.

Another interviewee suggested that the Common Agricultural Policy (CAP) should be changed in order to include articles capable to promote farmers trust and security in order to

have the confidence to import smart farming applications in their practices. A participant of the survey agrees with that point of view noting that “The CAP must be adjusted. Taking into account the subsidies to reduce cultivation costs, and if the IoT system could have in any way reduced production costs, the funds must be differently distributed.” Apostolos Chantziaggelakis confirmed the existence of akin articles but Greek farmers will maladminister funding, incapable to reclaim their agribusiness.

Although these suggestions do not depict the opinion of the majority, it should be mentioned that people in the farming sector declare that they confront more serious problems concerning their survival. For that reason, those suggestions should be treated with respect and will be used in order to underline some particular subsections of the dimensionality of the Sustainability Triangle in the model that is presented in figure 4.

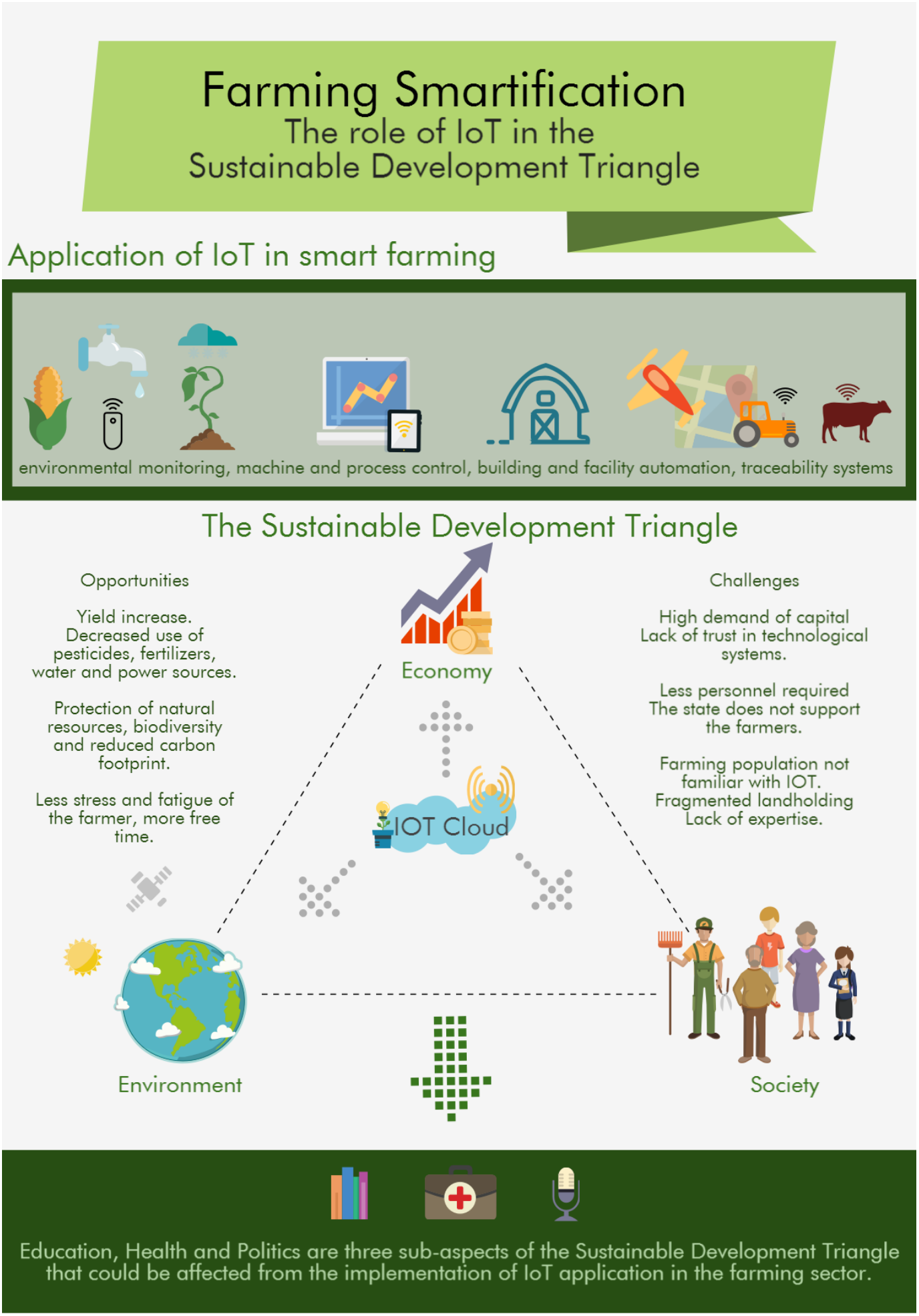

Figure 4: Farming Smartification model

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6. Conclusions

The aim of the study was to explore the Internet of Things in the framework of the Sustainability Triangle in the agricultural field, to understand cultivation needs and smart farming applications, explain the challenges and opportunities that arise from the implementation of an IoT ecosystem in the field of Agriculture, while further exploring the dimensionality of the Sustainability Triangle. This chapter is going to revisit each of these objectives and provide a summary of the methodology and the main findings of the research. In the end, further recommendations that derived from the limitations of the study will be reported.

The secondary research revealed the most commonly applied agricultural practices and the precision farming system that is intended both for conventional and organic crop production and can be corroborated by IoT technologies. Additionally, IoT technologies and smart farming applications were presented in order to understand the feasibility of those technological innovations. The literature review findings also shed light to the emerging challenges and opportunities from the application of smart farming regarding the administration of collected, interpreted and analyzed data gathered from the environment with the use of sensors and transmitted from various systems such as RFID tags. Lastly, the main pillars of the Sustainability Triangle were examined providing a stepping stone on which the methodology of the research could proceed.

Utilizing a phenomenological research approach to explore the true intentions of the sample and applying quantitative and qualitative research methods, the main subjects were examined through three hypothetic sub questions. The aim was to examine further, by triangulating the finding of primary and secondary research, the challenges and the opportunities that arise from the implementation of smart farming in the Sustainability Triangle, the intention of Greek farmers about the implementation of IoT technology in their cultivation practices and the extent to which Greek farmers are willing to use IoT applications in their crop production and in the end to explore the dimensions of the Sustainability Triangle.

Overall, the implementation of IoT technologies in the farming sector does provide significant opportunities but at the same time alludes to challenges that should be considered carefully. Regarding the Sustainability Triangle pillars, smart farming contributes to all three of them, economy, environment and society. Administrating the whole cultivation practices

with precision and control through a computing cloud, the precise agriculture practices can go a step further. Subsequently, production will significantly be increased while reducing the environmental pollution and in the same time various social opportunities will emerge giving the opportunity to a more integrated smart farming ecosystem. Although Greek farmers declared their interest about the implementation of a smart farming system, they aren't completely ready for a full integration. Furthermore, exploring the dimensionality of the Sustainability Triangle, sub aspects of the main pillars can be highlighted as education, health and politics.

6.1 Suggestions for further research and improvement of the study

The first thing that should be considered for improvement of this study is the size of the sample of the survey. The online survey was completed 232 times, in contrast with the total number of 572 participants. Farmers are spread in various regions and they are not accessible when they work in the fields, so a wider timeframe could provide more responses to the survey. Moreover, a great percentage of the older (over 45 years old) farming population don't have access to the internet.

Finally, it should be noted that 85% of the participants are men, a reasonable percentage as farming activity is mainly a «laborer's job». The implementation of smart farming applications could tip the scales and cause the cultivation practices to be more appealing to women. A question that may arise from that implication refers to the willingness of women, to involve themselves with farming as a job, if it is easier to handle heavy labor activities.

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Appendices

Appendix I

Qualitative method: Interviews

Participant Information **(**orally)

Title of the study: Farming Smartification. The role of IoT in Sustainability Triangle

My name is Katerina Chioteli and I am currently doing my Masters in Strategic Product Design at the International Hellenic University, in Thermi, Thessaloniki. This interview is part of my dissertation and aims to explore the dimensionality of Sustainability Triangle. You are asked to take part in a 15 min interview and your participation is completely voluntary. You have the right to withdraw your answers from this study anytime without detriment.

This interview will be audio-recorded. All the information that you will provide, will remain confidential and will be only used for the purposes of this study. The data will be collected and coded to ensure anonymity and will be then immediately destroyed. There is no way that your answers can be identified individually. All answers will be analyzed and will become part of the "findings" section of my research report.

If you are willing to be involved in this project, we can now proceed to the interview.

The conclusions drawn from the research conducted and the full report can available to you upon your request. In that case you will be asked to provide your e-mail address.

If you have any questions/concerns, during or after the investigation, or wish to contact an independent person to whom any questions may be directed or further information may be sought from, please contact:

Chioteli Katerina +0030 6974514139

Interview 1

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   I grow 2 different varieties of clinging beans, and I also have cattle for meat production (limousine breed). (St. Germanos, Prespes)

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Currently I follow conventional farming practices but a few years ago I had some acres with organic farming practices applied. Yes I am satisfied. I think I don't need anything more.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   I conduct soil analysis once in 3 years, I am mainly interested for the pH levels of the soil. During the plants lifespan I look out for diseases and pests. I don't care much about soil humidity because of the field's location.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   I lose approximately 15-20% of my production during the harvest period due to heavy and old machinery.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

   Concerning conventional farming I don't have any uncovered needs. My plant production is set in rows and I can control my cultivation, but I spend a lot of money to support the clinging beans. I want new machinery but they are too expensive for me. I guess this is not a necessity, as I can do my job with the current ones.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   Generally, we always want something better but I think I am satisfied taking into consideration my capital. The state does not support us, the farmers. Although I want to do something better I believe that the risk is forbidden.

7. **Are you familiar with the term IoT (Internet of Things)?**

   The what? No I am not?

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

   Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.

g. Fully automated functions and accurate control of the conditions in a greenhouse environment.

h. Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

There is need of course. Because technology evolves but there are many "buts" and "ifs".

8. Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?

I would be interested in all of them except from the one for the greenhouse obviously but I don't think that I want to apply them on my production. I love my job and I am very happy in the fields. I have fun going out and doing my job out there.

9. Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)

No I don't. First of all I didn't know about those systems but I also don't have enough money to invest in a system like that.

10. Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?

The production rate will increase. Generally those systems can help to solve famine problems around the word. For example in Africa.

11. Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?

Smartphone. It would be easier of course to check my production through my smartphone but I strongly believe that «the field needs you». If you are not present to see with your own eyes the stages of the plant growth the production will be ruined.

12. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

As I already mentioned the famine and the yield increase are the main opportunities. Also there are benefits for the environment and maybe the farmers will be less stressed.

If by challenges you mean disadvantages, I believe that farming overall is related with tradition. If you change the traditions as a nation we will lose our legacy concerning moral codes etc.

Also about older farmers, it is impossible to apply those practices. They cannot use easily the remote control of the television. A system like that with the use of computer, smartphone and other devices will be impossible for them to get used to it and they will lose their income.

13. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

The cost is forbidden. I believe that I don't really want to lose my contact with earth. The only reason that I might consider it is the yield increase but I am already satisfied with my current practices. Also in Greece we don't have so many acres to make such an investment.

14. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

Economic: yield increase without doubt and decrease of costs of water, pesticides and fertilizers.

Environmental: less use of water, fertilizers and pesticides. Maybe less electricity for the heaters in the field during the winter.

Social: I cannot find benefits. Maybe less stress for the farmer. We will lose contact with each other. We will only communicate through smartphones. People will be lonely.

15. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    I care for the environment but sometimes the «bread on my table» is more important.

16. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    No

17. **Sex** Male

18. **Age** 26

19. **Educational level** University

20. **Monthly income** Medium

21. **Marital status** Single

Interview 2

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   I have a greenhouse with flowers. (Patra)

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Hydroponic system. I am very satisfied. I don't have many expenses and waste of fertilizers.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

The conditions in the greenhouse are more or less fully controlled. The main characteristics that I have to check for my particular production are the temperature in the greenhouse daily, the amount of fertilizers in the system and of course diseases and pests.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   I don't have important loses, around 10% mainly due to the diseases. But if I don't do something at the right time my production might vanish.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

   I cannot control the temperature very well, heat for the winter and cooler temperatures for the summer. Also the greenhouse is old and there are several problems concerning the heat loss in the winter and to maintain cooler temperatures during summer months.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   Why not? I just need money.

7. **Are you familiar with the term IoT (Internet of Things)?**

   No I am not.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. **Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.**

g. **Fully automated functions and accurate control of the conditions in a greenhouse environment.**

h. **Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)**

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

There is need of course. You can save a lot of money and time.

9. **Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?**

I would like to have a fully automated system in my greenhouse. I don't have the need of irrigation due to the hydroponic system but generally I would like to have a more accurate system to feel more secure.

10. **Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)**

    I didn't know about the IoT systems but I also don't have the capital. The greenhouse has many automated systems and I also use a particular program for greenhouses on the computer to keep statistics.

11. **Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?**

    Yes of course, I will save a lot of money.

12. **Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?**

    I use a Smartphone. I could control my production through the smartphone and I will also save money by paying less people.

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: In our field, an important role is the quality of the flower in order to hit higher values in the market. So in a system like that I will have better control of my production, so higher quality and better prices. I have to train a few people to control the systems, young people will have work, so I will gain money from the monthly salaries.

    Challenges: Money, money, money. There is no available capital and maybe my father could not get used to those systems easily. Also less job positions, which is bad for other people but good for «my pocket».

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

The only problem is the lack money. There is no other reason to discourage me.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Economic: yield increase without doubt, higher quality in my filed, less salaries to pay.

    Environmental: Less use of water, fertilizers and pesticides. Less electricity or petrol for the temperature.

    Social: Jobs for younger educated people although some may lose their jobs but life is difficult, you have to adapt. Also I will have more free time to develop other aspects of my life and business and I will feel more secure if I could control the production through my mobile phone.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    I care for the environment as long as I don't pay from my pocket.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    No

18. **Sex** Male

19. **Age** 25

20. **Educational level** University

21. **Monthly income** Low

Interview 3

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   I have poultry for eggs and meat. Grapes for wine and berries for processing.

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Organic farming. My production is not very large so I can control it with organic farming practices.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   Soil humidity, diseases and fertilizers. It depends on the weather and the stage of growth for the crops. For the poultry the things are a little different.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   I don't have many losses. Mainly from the pruning and grafting.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

   The weather is a serious problem. In our region, Ioannina, most of the days it's raining and during hot months we face serious problems in our production due to hail falls.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   Why not? But not yet. I am going to grow aromatic plants.

7. **Are you familiar with the term IoT (Internet of Things)?**

No I am not.

IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. **Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.**

g. **Fully automated functions and accurate control of the conditions in a greenhouse environment.**

h. **Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)**

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

There is need of course. Do these applications really exist or is it still in an experimental stage?

9. **Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?**

   All these applications sound interesting but I can imagine a system for the hail. For example, a sensor that observes the weather and automatically deploys a net that covers the field in order to protect the production.

10. **Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)**

    I didn't know about these systems but I also don't have enough money. I have installed an automated irrigation system but in our region it rains a lot so it is not necessary.

11. **Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?**

    Of course everything will be easier. I think that it is possible to have another field somewhere else and control both of them.

12. **Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?**

    I use a smartphone. I could control my production through the smartphone and as I mentioned I can also have another cultivation somewhere else so I can double my income.

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: The farmer gains time and money of course. They also have the opportunity to educate themselves, although the majority is not willing to be educated.

Challenges: In our country the fields are not very large and most of them are inclined. The population is not educated in such systems and that needs time. The cost I believe is very high.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    Lack of capital will discourage me. I generally like it.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Economic: yield increase, less salaries to pay.

    Environmental: less use of water, fertilizers and pesticides.

    Social: education and the image of our country abroad.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    I care for the environment a lot.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    Education as I told. Greece will be more trustworthy.

18. **Sex** Female

19. **Age** 22

20. **Educational level** University

21. **Monthly income** Low

22. **Marital status** Single

Interview 4

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   Olive trees for oil production.

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Organic farming. It sufficient to produce a good production.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   Fertilizers and diseases! 3 times per year we must check the soil and concern ourselves with the diseases for olive trees 2 times before and after summer.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   My production is traditional as I don't have the money to buy machinery. I collect the olives by hand.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

   In our region (Nauplion) I am lucky and I don't have special needs. In other regions there are serious problems with pests. Also olive tree production is not a demanding one. The only need is for K that is organic product either way. I can say that my needs are covered.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   No I am not because the markets that my products are forwarded to, are interested in organic ones and in the same time I want to care as much as I can for the environment, and for my health using organic practices. I feel good and responsible.

7. **Are you familiar with the term IoT (Internet of Things)?**

   No I am not.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. **Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.**

g. **Fully automated functions and accurate control of the conditions in a greenhouse environment.**

h. Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

Generally there is need.

9. Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?

The irrigation system sounds good, I don't need it in Nauplion because in south Greece water is cheap, but I will use it for environmental reasons to irrigate only when it is needed and where it is needed. The fertilization systems will help me gain money as the organic fertilizers are very expensive. I already have my own excel sheets to report inputs and outputs, fiscal status etc. so I think I need an automated system. I tried to use an existing application for android devices but I didn't find it convenient. Me excel sheet is more customized for my needs. I also use applications for the weather through my smartphone.

10. Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)

(Already answered from the above so the question was skipped.)

11. Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?

Yes of course.

12. Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?

(Already answered from the above so the question was skipped.)

13. What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?

Opportunities: The opportunities will appear in my opinion if an application somewhere can control everything in advance, in order to check everything before. There is the need of an application that includes information from the soil to the stock market. It is important to understand both your needs in the field and the prices in the world market.

Challenges: The greatest challenge is the uneducated population of farmers both in general education and also in technology field. The applications for the smart devices must be very simple and easy to use from everybody. The user interface is very important.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    I could decrease the prices of my products and be more competitive in the market, decrease the footprint in the environment (e.g. carbon footprint from the fertilizer production). Maybe the high cost will discourage me.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Economic: already responded from the above.

    Environmental: already responded from the above.

    Social: the social benefits are directly depended on the economic and environmental benefits. I cannot separate them.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    I care for the environment a lot that's why I apply organic production. The main goal is to produce and protect at the same time the environment.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

No

18. Sex male

19. Age 28

20. Educational level Master's degree in agriculture

21. Monthly income Medium

22. Marital status Engaged

Interview 5

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   Olive trees for oil production in Serres.

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Traditional organic farming.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   Diseases, fertilization, irrigation, pests. I cannot say exactly when. It depends.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   I believe 15%

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

I cannot protect my production from pests.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   Why not, but in organic farming to increase yield and more easy farming practices.

7. **Are you familiar with the term IoT (Internet of Things)?**

   No I am not.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.

g. Fully automated functions and accurate control of the conditions in a greenhouse environment.

h. Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

Generally, there is a need.

9. Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?

I would like to grow my cultivation, use more modern machinery and generally apply modern farming practices. I would apply maybe all of them, also for environmental reasons.

10. Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)

No I am not. I don't have the money.

11. Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?

Yes of course. I would gain money and time. I could also care for the environment will less water consumption, pesticides etc.

12. Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?

Yes in both questions.

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: money, time and environmental. The specialization in each type of production. More targeted production.

    Challenges: Uneducated population. The customization of the program depending on the cultivation.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    The only reason I could think is the cost if it is big.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Economic: Less use of pesticides, fertilizers, water and the specialization in each type of production will increase yield.

    Environmental: Less use of pesticides, fertilizers, water.

    Social: Increase of production and decreased cost. More people could be fed and farming could be accessible to more people. Poor people could be fed and occupied. More job vacancies in some sectors, some jobs will be lost but that's life. We cannot have blacksmiths crafting swards. Society evolves. Also the farmers won't be so tired all the time.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    I care. We should all pay attention to the exhausting character of agriculture.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    Education but I thing that is included in societal aspects.

18. Sex male

19. Age 36

20. Educational level University

21. Monthly income Low

22. Marital status Single

Interview 6

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   Olive trees for oil production in Creta

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Conventional farming but due to the crisis, it resembles organic as we don't have the money for fertilizers etc. All the money goes to taxes.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   Not responded (complains about the taxes).

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   Not responded (complains about the taxes).

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

Not responded (complains about the taxes).

6. **Are you interested to change your current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   Sometimes we lose the 50%. Generally around 30% (complains about the taxes)

7. **Are you familiar with the term IoT (Internet of Things)?**

   No I am not.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.

g. Fully automated functions and accurate control of the conditions in a greenhouse environment.

h. Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

Generally there is need of advanced techniques. If I had the money, I would invest the capital for a more professional outcome. The majority of our farmers sit all day in cafes. They don't want to work. Partnerships must be developed in order to take loans.

9. Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?

Not responded (complains about the taxes)

10. Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)

No I am not. I don't have the money. (Complains about the taxes)

11. Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?

Not responded (complains about the taxes)

12. Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?

Not responded (complains about the taxes)

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: Yield increase.

    Challenges: Uneducated population. (Complains about the taxes)

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    We don't know where to distribute our production. Half of the production is going to waste.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Not responded (complains about the taxes)

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    Not responded (complains about the taxes)

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    Not responded (complains about the taxes)

18. **Sex** male

19. **Age** 66

20. **Educational level** University

21. **Monthly income** Low

22. **Marital status** Married

Interview 7

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   Olive trees for oil production in Crete and a vineyard.

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Conventional farming.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   Diseases, pests, irrigation.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   Approximately 20%

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

   I am satisfied

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   Why not?

7. **Are you familiar with the term IoT (Internet of Things)?**

   No I am not.

IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. **Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.**

g. **Fully automated functions and accurate control of the conditions in a greenhouse environment.**

h. **Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)**

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

I thing is over our needs and expectation. But in a theoretical level yes of course there is a need.

9. **Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?**

   I don't have the money but I also believe it is not for me.

10. **Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)**

    No I don't have the need and the money

11. **Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?**

    Easier to predict somethings and gain time

12. **Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?**

    Yes I use smart devices. Why not?

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: Yield increase, more free time, evolution of the society through discussion

    Challenges: Lack of expertise and some closed societies in some villages may not be interested to hear about such systems, they don't trust technology.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    The cost discourages me.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Economic: less use of pesticides, fertilizers, water and yield increase.

    Environmental: less use of pesticides, fertilizers, water.

    Social: (already answered)

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    I care.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    No

18. **Sex** male

19. **Age** 37

20. **Educational level** IEK

21. **Monthly income** Medium

22. **Marital status** Married

Interview 8

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

    Fruit, vegetables and olive trees in Mytilene.

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Conventional farming. Satisfied in general am but not completely.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   Irrigation, pests, diseases and take care of the production in general.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   Approximately 30%, it depends on the weather. When the weather is bad maybe the 50% is destroyed.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

   There are some practices like hoeing that are not fully effective

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   Yes why not. If my life will be easier

7. **Are you familiar with the term IoT (Internet of Things)?**

   No I am not.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. **Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.**

g. **Fully automated functions and accurate control of the conditions in a greenhouse environment.**

h. **Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)**

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

There is the need but personally I cannot apply those practices. I don’t have the knowledge to apply them. I need someone to help me.

9. **Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?**

   The irrigation system is basic for the vegetables and fruits. And the system for the diseases.

10. **Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)**

    No I don't and also I don't have a wide area of production.

11. **Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?**

    Yes, it could.

12. **Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?**

    No. I am trying to learn how to use the laptop

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: the production is easier and quicker.

    Challenges: Lack of expertise and there isn't any help / instructions to understand the functionality of such systems.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    The lack of expertise is the main problem for me.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

Economic: Less use of pesticides, fertilizers, water and yield increase.

Environmental: Less use of pesticides, fertilizers, water.

Social: If you protect the environment and have a good production your life is better and you gain time.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    I care as much is it possible. I use the least possible amounts of pesticides etc.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    No I cannot think of something now.

18. **Sex** male

19. **Age** 72

20. **Educational level** University

21. **Monthly income** Medium

22. **Marital status** Married

Interview 9

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   Aromatic plants.

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Organic. I care for the environment. For the aromatic plants, the practices are not very intensive and the demands of the production are covered by using an organic farming practice.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   For my production, soil characteristics, irrigation, although aromatic plants don't need much water, pests, diseases and of course the weather. Weather is the most important factor.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   It depends on the weather. If it doesn't rain, I have to spend a lot of money to irrigate the field as it doesn't have an automated irrigation system. Also the neighboring field affects my production approximately 20% because I cannot sell those plants as organic and the selling prices are lower.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

   I cannot control pests and diseases without spraying plant protection mixes and I have to do it manually.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   Yes of course.

7. **Are you familiar with the term IoT (Internet of Things)?**

   I have read an article online but tell me more.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actu-

ators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. **Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.**

g. **Fully automated functions and accurate control of the conditions in a greenhouse environment.**

h. **Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)**

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

Of course there is the need.

9. **Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?**

   The irrigation system, soil analysis, statistics, control of the budget. Generally, all of them except from the greenhouse and livestock applications.

10. **Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)**

    I don't have the information to feel secure to apply such a system.

11. **Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?**

    Yes and I would feel more safe but I don't know if it is worth it.

12. **Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?**

    Yes, in both questions.

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: I could control better my production, environmental protection.

    Challenges: most of the farmers won't understand the benefits. They don't know how to use devices not only smart ones. They have to understand and moderate the use of pesticides etc. Many old people will lose their jobs if they cannot apply it. The evolution of the technology cannot be predicted. Also the systems are not tested in Greece. I believe it requires a big capital to invest.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

The cost. It is new and expensive and I believe that it will benefit large farm companies. It is like smartphones: When smartphones were released to the market not everyone could afford them and they were not user friendly at the beginning.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Economic: Less use of pesticides, fertilizers, water and yield increase, control of the production and the money.

    Environmental: Less use of pesticides, fertilizers, water.

    Social: Less stress as you can check the production, you have more free time and you can make other businesses, for example if you have oranges you can also make orange juices and jams.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    (Already answered from the above).

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    A system like that can help in evolution in general.

18. **Sex** female

19. **Age** 27

20. **Educational level** Master's degree

21. **Monthly income** Medium-Low

22. **Marital status** Single

Interview 10

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   I grow cherries and peach trees in Veroia.

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Conventional farming. All the systems have extra needs but generally it's ok.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   Soil characteristics, the specific kind of the tree according to the soil, diseases, pests, fertilizers at the appropriate time.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   It depends on the weather. Last year the hail destroyed the 70% but in normal situations 15-20%.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

   The weather is important.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   Yes. Some years ago we applied precision agriculture farming.

7. **Are you familiar with the term IoT (Internet of Things)?**

   Yes.

IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. **Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.**

g. **Fully automated functions and accurate control of the conditions in a greenhouse environment.**

h. **Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)**

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

Of course.

9. **Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?**

   All of them are interesting.

10. **Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)**

    Precision Agriculture as I told before. We gathered the extra water to send it in a field that could not be irrigated.

11. **Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?**

    Yes.

12. **Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?**

    Yes in both questions

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: You gain time and money and you can share data.

    Challenges: Farmers are not familiar with technology, it cannot be applied in every type of cultivation, for example it is more difficult when dealing with trees than with an open field.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    The cost is the problem.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Economic: Less use of pesticides, fertilizers, water and yield increase, production control and money.

    Environmental: Less use of pesticides, fertilizers, water.

    Social: Improved quality of the product, you add extra value to expertise, maybe more free time.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    I care as much as the farming practices let me. I cannot risk my production.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    No those are the basics.

18. **Sex** male

19. **Age** 31

20. **Educational level** university

21. **Monthly income** Medium

22. **Marital status** Single

Interview 11

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

Olive trees and grapes in Crete.

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Conventional farming.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   The diseases.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   It depends on the weather. Rain can ruin the whole production.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

   The weather is important. Distribution also is a big problem.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   No.

7. **Are you familiar with the term IoT (Internet of Things)?**

   No I am not.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. **Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.**

g. **Fully automated functions and accurate control of the conditions in a greenhouse environment.**

h. **Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)**

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

No.

9. **Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?**

   I am not interested.

10. **Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)**

    No.

11. **Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?**

    No. I don't trust those systems.

12. **Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?**

    No

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: I cannot see any opportunities.

    Challenges: we don't trust those systems.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    The cost is the problem.

    He abandoned the procedure

15. **Sex** male

16. **Age** 37

17. Educational level IEK

18. Monthly income Low

19. Marital status Married

Interview 12

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   I have a greenhouse with tomatoes and lettuce.

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Hydroponic cultivation.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   The use of fertilizers is automated so I care only about diseases and pests.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   Maximum 10%.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

   I would like cheaper fertilizers.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

No.

7. **Are you familiar with the term IoT (Internet of Things)?**

   Yes I already apply IoT applications in my greenhouse.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. **Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.**

g. **Fully automated functions and accurate control of the conditions in a greenhouse environment.**

h. **Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)**

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

Of course.

9. **Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?**

Already answered.

10. **Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)**

No.

11. **Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?**

No. I don't trust those systems.

12. **Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?**

No

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

Opportunities: In collaboration with hydroponics you can care for the environment and you can gain money from preventing structural damage of the greenhouse (by monitoring your greenhouse). Also you don't need money for the maintenance of the system. There are no updates as it is customized for your needs. The updates are only for add-ons if you like. Also you can predict the next year's production as you keep the statistics for plant growth, for example in relation with the temperature or the humidity.

Challenges: Less personnel are required that is good for the producer but not good for the people who will lost their jobs. Especially those who are not educated they will be ruined. Also it is a new system for Greek population and people are not ready for something like that. An important problem is also the absence of internet connection in the fields. I created a system that functions with 3G but it is not sufficient e.g. in Larissa. But In a greenhouse you can have easily an internet line.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    There is nothing to discourage me. The good thing is that the prices in Greece are the same with the rest of the Europe, although in most cases in our country technological components are more expensive.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Economic: Everything is controlled so you save energy and money from every detail. Less use of pesticides, fertilizers, water. You can prevent diseases, pests etc. or a leakage (applications on smartphone informs you instantly). You spend also less money for locomotion.

    Environmental: The same with economics.

    Social: Less stress and more free time due to automated systems.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    Already answered.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    No.

18. Sex male

19. Age 27

20. Educational level Master's degree

21. Monthly income Medium

22. Marital status Single

Interview 13

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   I am a beekeeper in Ioannina mostly but I move the hives in different places all around Greece. The state does not support the organic beekeepers.

2. **What is the percentage of your production that cannot be exploited, creating loss of you capital, regarding the practice you follow?**

   It depends. In our field the quantity of the production is important. Each hive produces 10kg in average. One year some hives gave me approximately 40kg, some other times 0kg.

3. **Are you interested to change you current practice with a more effective one? If yes/no could you please tell me the reason?**

   Yes, why not?

4. **Are you familiar with the term IoT (Internet of Things)?**

   No I am not.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

5. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. **Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.**

g. **Fully automated functions and accurate control of the conditions in a greenhouse environment.**

h. **Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)**

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

There is need but people in Greece are not honest and they cheat. We use electronic scales. Also this is a very expensive system for the majority of the beekeepers.

There are also automated hives that gather the honey production on their own

Those systems are for the movies and fairytales. We cannot apply them because we don't trust them. And they are very expensive. Here in Ioannina there are many bears and many of us use electric systems that send messages on smart devices to inform us that the bears are attacking the hives. Also there are GPS systems in case someone steals someone else's hive.

6. **Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?**

   Yes and some friends of mine have the scale systems. One buys the system and the rest of us use it (roughly 10 people).

   What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?

   Opportunities: You could feel secure for your production. When you know the place and quantity of the honey secretions you don't move the hive without reason and you gain money.

   Challenges: The cost is a problem. If we install antennas etc. we will destroy the environment more.

7. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

   No.

8. **Sex** male
9. **Age** 36
10. **Educational level** IEK
11. **Monthly income** Medium
12. **Marital status** Married

Interview 14

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   I have cotton production near Sofico village in Orestiada.

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Conventional farming. I believe that I cannot take advantage of the whole production due to losses.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   Irrigation, pests, diseases, soil characteristics and productivity.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   15-20%.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

   Many salaries for workers to irrigate the production as we don't have irrigated fields, great cost regarding the total income. I cannot fully control my production.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   Yes, but I don't know how.

7. **Are you familiar with the term IoT (Internet of Things)?**

   No.

IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. **Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.**

g. **Fully automated functions and accurate control of the conditions in a greenhouse environment.**

h. **Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)**

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

Yes of course.

9. **Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?**

   I don't know about livestock but I like the control of the production through smartphone. Also the system that holds the statistics can be used from another person who is not necessarily a farmer or an agriculturist. Using such systems you decrease the risk. I suggest that those systems can make further suggestions for improvements, and not only to notify the farmers for a potential problem.

10. **Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)**

    No. I didn't know about them.

11. **Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?**

    Yes I will gain money, time, less fatigue.

12. **Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?**

    Yes. We use smart devices for communication and amusement why not for our jobs?

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: I believe that such systems can attract more young people to find a job in the production field. You can control your production from distance, increase yield, less fatigue for the farmer, more free time.

    Challenges: The cost is a problem. The majority of the population in the farming sector are not ready to apply such systems, they don't trust technology and due to their age, they are not willing to learn how to use them.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    I don’t know the cost and these systems are not tested yet. Also I believe that the state should give subsidies for the installation of such systems in order to attract the interest of the farmers.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Economic: Yield increase that means more annual income, less use of pesticides etc., less personnel required, better control of the cultivation expenses.

    Environmental: The same with economics.

    Social: Less stress and fatigue and more free time for the farmer to educate himself or spend time with his family. Maybe those systems could be a motivation for people to be educated in new technologies. The country will be better represented in foreign markets. Such systems give an opportunity to take advantage of the local characteristics e.g. good climate conditions for a variety of productions, also the field could be enforced with young people. Farmers are not inferior to other businessmen. They just don’t have the support from the state to evolve in their field.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    As much as I could, depending on the production risks.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    Education. New farmers will be more educated in order to cope with technological innovations. Also our country will be more competitive in other markets.

18. **Sex** female

19. Age 36

20. Educational level Master's Degree

21. Monthly income Medium

22. Marital status Engaged

Interview 15

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   I have oil and almond tree productions and wheat production. (Near Serres)

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Conventional farming. It is ok.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   The wheat needs rain to begin to sprout. So the weather is very important both for wheat and the tree productions. I don't have irrigated field so I depend on the rain to water my plants.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   Around 20%.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

The distribution of the production is a problem. The state does not support the farmers. Everything is very expensive, the seeds, the fertilizers the whole production cost is enormous.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   Yes, why not?

7. **Are you familiar with the term IoT (Internet of Things)?**

   No.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.

g. Fully automated functions and accurate control of the conditions in a greenhouse environment.

h. Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

Generally yes but without the support of the state there is no hope. The taxes ruin our possibilities. I also believe that those systems benefit big agricultural companies in other European countries, or America etc.

9. Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?

All of them sound interesting but everything depends on the cost. Theoretically the irrigation system, is the easiest to use and I believe it is quite simple but you have to own fields near a water source.

10. Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)

No. I didn't know about them.

11. Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?

Yes I will gain money, time, less fatigue and feel more secure about my production.

12. Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?

Yes. Yes I am still young, I think I could handle it.

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: You can gain a lot of money from pesticides, water, fertilizers, the yield will increase and in the same time you provide for the environment while gaining money.

    Challenges: The cost. The majority of the population in the farming sector are not educated in such systems and they cannot understand and afford them. Many people will lose their jobs. The state should support us. Also the fields in Greece are small and most of them are in inclination, only in Larissa lowland everything is flat.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    Only the cost. I am young and educated and I can handle it concerning the innovation aspects.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Economic: Already answered.

    Environmental: Already answered.

    Social: Everything will be easier in less time and as the products will become more competitive the farmer will have the confidence of a successful person.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    As much is it possible without taking risks as the organic farmers.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    The whole scenery of politics maybe will be changed. I don’t know.

18. Sex male

19. Age 46

20. Educational level University

21. Monthly income Medium

22. Marital status Married

Interview 16

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   I have wheat and cotton production. (Near Giannitsa)

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Conventional farming. I cannot fully control my cultivation

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   The time until and after the sprout, pests, diseases and irrigation especially during summer months. We also check soil characteristics but not so often.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   Around 10% from the machinery and up to 50% when the weather is extremely bad.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

We need to have greater production with the minimum cost.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   Yes, why not?

7. **Are you familiar with the term IoT (Internet of Things)?**

   No.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.

g. Fully automated functions and accurate control of the conditions in a greenhouse environment.

h. Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

Generally yes. We have many needs that should be covered before that, but generally systems like this will help.

9. Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?

All of them sound interesting. I liked most the automated harvesting. But I still believe that someone should be there to check with his own eyes.

10. Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)

Automated irrigation and also I keep some statistics.

11. Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?

Yes my life could be easier. I will be more refreshed, less stressed and more confident about my production.

12. Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?

Yes for both questions

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: As I told everything will be easier. Also both farmers and consumers will be healthier while consuming less pesticides. Of course there is a positive impact to the environment with decreased use of pesticides etc. You can have better results with less cost.

    Challenges: The cost of establishment. The job positions will be diminished.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    Only the cost. I am young and educated and I can handle it concerning the innovation aspects.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Economic: Already answered.

    Environmental: Already answered.

    Social: Less job positions.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    Yes as much as I can.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    The politics about farmer should be changed. The CAP (common agricultural policy) should be adapted in those new systems.

18. **Sex** male

19. Age 24

20. Educational level University

21. Monthly income Medium

22. Marital status Single

Interview 16

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   Grapes for wine and tsipouro production. (Kozani) I also have a winery.

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Conventional farming because if I applied organic farming the costs would be tremendously huge regarding the income.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   The weather because diseases and pests depend on the weather conditions. Also sometimes to check soil characteristics.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   Hail can damage from 10-70% of the cultivation and powdery mildew around 5% if we act quickly.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

Machinery is too expensive and also our fields are not irrigated.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   Yes, why not?

7. **Are you familiar with the term IoT (Internet of Things)?**

   Yes.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.

g. Fully automated functions and accurate control of the conditions in a greenhouse environment.

h. Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

Generally, yes but I believe that you have to be there to make the decisions. In Greece the fields are small. I moved for a while in Australia where one farmer had really many acres. In Australia by having 20-50 acres you are considered as a small time farmer. The majority of the farmer that earn their living by farming have at least 1.500 acres. The company I used to work has 50.000 acres in total.

9. Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?

None of them particularly.

10. Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)

No due to the cost.

11. Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?

Yes. The precision and the control in the inputs are important benefits.

12. Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?

Yes but only for the basics. You cannot have the control you just know what is going on in the field.

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: You can save money from almost everything.

    Challenges: The farmers are not familiar with technology. They have to be educated.

    If you don't know how to use the system the cost will increase as you have to pay someone else to do that stuff for you.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    Less stress as you will be able to control some aspects.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Economic: Already answered.

    Environmental: Less waste of water, energy, pesticides, herbicides, fertilizers etc.

    Social: I cannot thing something.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    I don't use many pesticides and herbicides. Some organic ones but when my whole production is endangered I use chemicals.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

Maybe the quality of the product.

18. Sex male

19. Age 30

20. Educational level University

21. Monthly income Medium

22. Marital status Single

Interview 17

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   I grow wheat and triticum diccocum and poultry. (Lagadas)

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Conventional farming. I cannot earn more money from organic farming practices. No it is not sufficient.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   I don't pay much attention. My grandfather taught me to control the conditions with «the eye». Also my fields are not irrigated.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

I also have some grinding mill equipment, so lower quality of production translates to lower quality flours for example. We produce premium flours and the normal kind too. I have some loses from machinery, about 10%. I use the leftover seed parts to feed poultry.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

   We are not satisfied from the outcome. If I didn't have the grinding mill I could not survive by growing wheat. I don't sell the wheat as plant, I sell my products as pasta or flour.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   Only for something environmental friendly.

7. **Are you familiar with the term IoT (Internet of Things)?**

   No.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. **Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.**

g. **Fully automated functions and accurate control of the conditions in a greenhouse environment.**

h. **Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)**

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

Generally, yes but I don't like such systems. Farmers just drink coffee and whisky. They don't work much for cultivations like wheat, corn etc.

9. **Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?**

I would like to check the soil. For the rest I prefer to apply the practices manually. No I don't trust those systems. Also in Greece the field are small and inclined.

10. **Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)**

No I didn't know about them. By what I learned so far I believe that the cost is forbidden.

11. **Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?**

Generally yes but I don't trust them.

12. **Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?**

    Yes. I would like to have the ability to manage my production from afar. From satellite photos for example.

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: You can save money but only if the production would increase.

    Challenges: The cost and the trust are the main concerns. Also the state does not support the farmers.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    Less stress maybe.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Economic: Only yield increase.

    Environmental: If you already use the pesticides correctly according to the guidelines you already prevent damage to the environment. So I don't know if it really helps the environment. If the antennas do more damage, there is no point.

    Social: I cannot think of something. The farmers drink coffee, smoke and sit all day at the cafes. They buy new cars to show off in the village. So maybe they will buy more cars.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    I care for the environment but as I can see around me when you care you become an idiot. I won't save the planet on my own.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    There are many dangers with those systems. It is like the google car. How can I trust systems that require constant internet connection? The state should support the society.

18. **Sex** male

19. **Age** 34

20. **Educational level** High school

21. **Monthly income** Low

22. **Marital status** Married

Interview 18

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   I grow apple trees near Kozani.

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Conventional. I am generally but always things can become better

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   The weather plays an important role. If it is cold we use heaters. Also the humidity of the soil, pests, diseases.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   It depends on the weather, around 10-20%.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

   You cannot predict many things, so as to be organized and prepared for the next stage of the cultivation. The weather forecasts are not so accurate.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   I would like to apply precision agriculture practices but I don't have the capital.

7. **Are you familiar with the term IoT (Internet of Things)?**

   No.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. Use of drones for cultivation detection or spraying of formulation products.

e. Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.

f. Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.

g. Fully automated functions and accurate control of the conditions in a greenhouse environment.

h. Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

Yes of course. Farmers could really control the use of pesticides, fertilizers, water etc. and really save time and money. And for my tree production I believe it is feasible and easy to apply. I am not sure if I have to put sensors also inside the foliage.

(Note: this interviewee processed all this new information in seconds and he had questions about the location of the sensors, the route the drones could follow and where they could be stored. He also made rough calculations concerning the money he could save from labor expenses regarding the spraying applications of the cultivation. It was an extended conversation about those systems. The descriptions of the functionality of IoT systems are omitted as they don't have direct interest for the study.)

9. Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?

All of them sound interesting. I would like automated production from hail if it possible! The farmers could do amazing things with the support of those systems.

10. **Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)**

    I had automated irrigation but not anymore.

11. **Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?**

    Of course without question! First of all my cultivation will be more integrated and more productive.

12. **Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?**

    Yes. I tried one last year but I was not completely satisfied.

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: the opportunities are obvious. Every application that you mentioned has positive impact directly to our pockets and in the environment. You can save money from the use of pesticides, fertilizers, herbicides, pests and diseases. You also can save money and energy from electricity and petrol consumption. In our region winter has some very cold days and we have to protect the apples. Less stress due to the constant information. Also the producers can save time to invest in other factors. Not only to expand the agribusiness but also to have time with their families. They would also have the opportunity to study for those systems so the whole farming population will start becoming educated. Not university like educated but they will start to read books and newspapers not only for the gossip and the politics.

    Challenges: The only concerns I have is about the acres and the inclination of the field. The land holding is fragmented as you agriculturists say. Some people will lose their labor jobs but it is normal, some other will open for young educated people. We have to say that the majority of young people in Greece have some kind of degree.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    The cost is the only reason.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Already answered in the previous monologue he didn't wanted to add something.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    I care but I don't do really much. If I grow organic the farmer of the neighbor field will ruin my cultivation with spraying.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    The health of course. Both for the farmers and consumers. The farmer will inhale less pesticides and the consumer will eat less "poisoned" fruits and vegetables. Even the fibers of our cotton t-shirts will be healthier!

18. **Sex** male

19. **Age** 28

20. **Educational level** IEK

21. **Monthly income** Medium

22. **Marital status** Single

Interview 19

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   I grow tomatoes and peppers in a greenhouse in Ierapetra.

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Both hydroponic and conventional farming practices. I am satisfied but there is always room for improvement.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   I keep statistics in general for air hydration, for the soil cultivation I measure soil conductance. I check characteristics every day. I can understand with eye witnessing what are the needs. But as I have a greenhouse most of the parameters are automatically checked by systems.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

   The waste of biomass is given to other organizations for compost. The main issue is that it is a serious problem with the distribution of the product. Around the month of May, the plants are very productive while the prices change and many times we cannot sell the production and we throw the products away. I cannot say a specific number.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

   It would be good if a public organization existed and we had more specific weather information. We are following online pages for the weather but every region has different needs. Also we would like to be informed more about the dangers of the production that currently change.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   I would like to transform the whole production in hydroponic practices but the cost of establishment is very high.

7. **Are you familiar with the term IoT (Internet of Things)?**

   No.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.

g. Fully automated functions and accurate control of the conditions in a greenhouse environment.

h. Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

Yes the cultivation practices would be applied easier. You would have the opportunity to rest on Sunday. The Greenhouses have the need to be visited even in Christmas. But I am not sure because chips are breaking often.

9. Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?

We use similar systems for greenhouses but they are not adjusted to Greek conditions. The human presence is more suitable for Greece. They are good for Holland, America, Germany but they are not developed for Greece.

10. Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)

Already answered.

11. Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?

Already answered

12. Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?

Yes. Yes why not.

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: Older people can adapt with the help of a younger one who could possibly find a job opportunity.

    Challenges: The cost first of all. The accuracy and the validity of the values that are given from the program. Should we trust such systems? This is the major issue I believe.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    The cost will discourage me.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Economic: Less use of water and fertilizers. Yield increase and better quality of the product. Automatically if the plant grows on a healthy environment you don't need to apply pesticides or other formulas for the diseases. The product will be healthier.

    Environmental: The same with economics.

    Social: More free time for the farmer. Less personnel witch is good and bad in the same time. The labor expenses are very important for a greenhouse budget.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    I work consciously following the global CAP directions. So I care as much as I can for the environment. I won't save the world by my own. If the state supported the farmer, I could do more. If you produce in a conventional way your product is cheaper while you don't have so many expenses.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    Evolution of the farming industry.

18. **Sex** male

19. **Age** 28

20. **Educational level** University

21. **Monthly income** Medium

22. **Marital status** Single

Interview 20

1. **What is the type of your production? Crops or animal production? If crops, what kind of production do you have?**

   Last year I grew onions and now I grow beans and cumin. I do experiments to see new cultivations. Some years ago I planted potatoes and it was a total disaster. (Kilkis)

2. **What type of agricultural practices do you follow (conventional, organic etc.)? Are you satisfied with your current agricultural practice? If yes/no could you please provide the reason?**

   Conventional. Generally yes.

3. **What are, in your opinion, the main characteristics that should be checked and how often there is a need for examining each one?**

   The weather and the diseases.

4. **What is the percentage of your production that cannot be exploited, creating capital loss, regarding the agricultural practice you follow? (For example, the use of tractors, the use of pesticides that harm the neighboring plants, extreme weather conditions etc.)**

As I told you I don't grow only one type for many years. It depends on the cultivation and the unexpected weather conditions.

5. **Are there any needs, in your opinion, that are not covered by the current agricultural practice you apply?**

   The information is not good. Agriculturists don't know about other plants. They know only those that are growing in the regions that they work. I asked them to help me with the onions that had diseases and they told me that the onions are ok. And then I sent a photograph to an agriculturist in Thiva, where the farmers grow many onions and he told me to tell them that they don't know anything. Also we don't know where to deploy our production and of course you can never predict the weather.

6. **Are you interested to change you current agricultural practice with a more effective one? If yes/no could you please provide the reason?**

   Yes why not?

7. **Are you familiar with the term IoT (Internet of Things)?**

   No.

   IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

8. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. **Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.**

g. **Fully automated functions and accurate control of the conditions in a greenhouse environment.**

h. **Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)**

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

Does it really exist or is still on an experimental level?

Yes it is a reality.

Ok, that's nice but… To make this system feasible that means that the field has electricity, water etc. It is possible to use it only in dynamic cultivation e.g. corn, cotton etc. But the main question is when my capital investment will depreciate? It sounds good but there are many buts...

9. **Which one of the aforementioned applications would you like to use in your production? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?**

The irrigation system sounds more feasible.

10. **Do you apply any similar system in your production? If yes, which one and how satisfied you are? If you do not apply any similar system please provide the reason (For example the high cost, the lack of information etc.)**

    No I didn't know.

11. **Do you believe that IoT applications can benefit your production? If yes/no could you please specify how?**

    Yes everything will be easier and the production more safe.

12. **Do you use smart devices? If yes, would you be interested in controlling your production through an application from your smartphone (or tablet)?**

    Yes. Yes of course.

13. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

    Opportunities: (He didn't answer).

    Challenges: Your acres are all gathered in one place or you have them divided? In Larissa it is easy to use something like that. Everything is depending on the price you can sell your products. Distribution is difficult and the storage for the species differs. Everything depends on the infrastructure and there is no money.

14. **What are the reasons that will encourage you to use an IoT ecosystem in your production and what are the reasons that will discourage you?**

    The cost.

15. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

    Economic: Less use of everything more money in the pocket.

Environmental: First of all you can save resources. The water under the soil doesn't get polluted. We destroyed the Lagada Lake because we didn't know how to protect the lake. The lake died from eutrophication. We didn't know. Now we know.

Social: Lack of information. The farmers are lost, they know nothing. They don't know what to do, where to ask.

16. **How much are you interested in a system that will not only increase your production rate but it will also contribute to environmental sustainability while promoting the local welfare of the society?**

    Already answered.

17. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    Product distribution. You will have standard production, standard income.

18. **Sex** male

19. **Age** 36

20. **Educational level** IEK

21. **Monthly income** Medium

22. **Marital status** Single

<u>Interview 21</u>

1. **What type of agricultural practices do the majority of the farmers follow (conventional, organic etc.)?**

   The majority of the farmers use conventional farming.

2. **Are you familiar with the term IoT (Internet of Things)?**

No.

IoT can be defined in many ways. Briefly it is a «cloud» ecosystem comprised of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects. For the field of farming I will give you some examples in order to understand better.

3. **Hereby I will mention some popular applications of IoT in the Agricultural field, in order to help you understand how an IoT ecosystem can be applied in your production area:**

a. **Systematic measurement of soil moisture in various strategic points of the field providing automatic irrigation only in the required areas without having to water the entire cultivated area**

b. **Systematic measurement of the chemical properties of the soil providing automated fertilization in the required areas with the appropriate amount that is required**

c. **Automated production harvest using automated machines without the need of direct intervention of the farmer**

d. **Use of drones for cultivation detection or spraying of formulation products.**

e. **Collection, interpretation and analysis of the collected data (data such as the aforementioned: soil/foliage humidity, soil characteristics, environmental conditions capable to promote diseases, initial appearance of pests etc.) in order to better control the current production while preventing and organizing it based on future demands according to statistical analysis.**

f. **Control and supervision of the production through smart devices such as smartphones or tablets in helping with instant decision making.**

g. **Fully automated functions and accurate control of the conditions in a greenhouse environment.**

h. **Use of small sensors in livestock to fully control health and animal productivity (automated feeding in the required quantity, animal positioning system through satellites)**

Do you believe that there is a need to apply such methods? If yes/no could you please provide the reason?

Before, there are more substantial needs than those practices. The state does not support the farmers the farmers don't know how to use innovative equipment. Fragmented land holding is a serious problem. The majority of the farmers are not even real farmers. They should be informed but I don't think it is the current need of Greek farmers. Also the cost is an important factor to consider. Generally, there is the need for such systems but... there is a great 'but' concerning the Greek farmers.

4. **Which of the aforementioned application would you like to follow/promote? Which are in your opinion the needs that could be covered with those applications? Do you have any further suggestions?**

   All of them are interesting but as I already told you there are other needs to cover before that. These practices can increase the production and help farmers save money from various aspects like pesticides etc.

5. **Do you believe that IoT application will benefit production? If yes/no could you please tell me how?**

   You can control the use of pesticides etc. and be constantly informed for the weather. If a farmer in Greece has 1000 acres he is considered as a big-land farmer but in other countries, he is an amateur. We also have to create partnership associations. Greece is not an organized country. What is the point to produce more and better quality without having an appropriate distribution net?

6. **What are, in your opinion, the challenges and the opportunities of applying an IoT ecosystem in the field of agriculture?**

   We need to be organized first in many other fields. I cannot tell at this point about opportunities and challenges.

7. **Which are the reasons that will urge you to use/promote an IoT ecosystem in your production and which are the reasons that will discourage you?**

There is the danger to let everything be taken care of by using automated systems and afterwards what? Farmers with clean shoes are not farmers and don't forget that they don't trust such systems.

8. **Do you believe that applying an IoT system in farming will cause any economic, environmental or social benefits? If yes/no could you please provide the reason? Could you give some examples?**

   Economic: Yield increase.

   Environmental: The decreased use of pesticides etc., water, energy.

   Social: Support in evolution of the country in general.

9. **How much are farmers interested in a system that not only increase production rate but also prevents for the environmental sustainability while promoting the local welfare of the society?**

   Everybody according to personal information and education care more or less for the environment.

10. **Do you believe that applying an IoT system in farming will have a contribution on any other field except from the aforementioned? (Economic, environmental and social)? If yes could you please describe which one?**

    No I cannot think something else. The new CAP has articles for new technological systems but Greek farmers will use these money to buy new cars.

11. **Sex** male

12. **Age** 56

13. **Educational level** University

14. **Monthly income** Low

15. **Marital status** Married

Appendix II

Generic Content and Differential Analysis Matrix

					sex				age range							
Categories	**Definition**	**Subcategories**	**sum**		**M**		**F**		**18-24**		**25-34**		**35-54**		**55+**	
1.0 Cultivation caracteristics	The characteristics that should be checked during cultivation practices	Daily weather conditions	9	42,9%	4	19,0%	1	4,8%	1	4,8%	5	23,8%	3	14,3%		0,0%
		Extreme weather conditions	3	14,3%	2	9,5%	1	4,8%	1	4,8%	1	4,8%	1	4,8%		0,0%
		Diseases	16	76,2%	12	57,1%	3	14,3%	1	4,8%	6	28,6%	7	33,3%	1	4,8%
		Pests	12	57,1%	8	38,1%	3	14,3%	1	4,8%	5	23,8%	3	14,3%	1	4,8%
		Soil humidity	8	38,1%	5	23,8%	3	14,3%	2	9,5%	2	9,5%	3	14,3%	1	4,8%
		Soil caracteristics	8	38,1%	6	28,6%	2	9,5%	2	9,5%	5	23,8%	2	9,5%		0,0%
2.0 Uncovered needs	The needs that cannot be covered from the current cultivation practices	Control of cultivation	5	23,8%	3	14,3%	2	9,5%	1	4,8%	2	9,5%	1	4,8%	1	4,8%
		Control of the weather	11	52,4%	9	42,9%	1	4,8%	2	9,5%	3	14,3%	4	19,0%		0,0%
		Control of the use of pesticides	2	9,5%	1	4,8%	1	4,8%		0,0%	1	4,8%	1	4,8%		0,0%
		Production distribution	6	28,6%	6	28,6%		0,0%		0,0%	1	4,8%	3	14,3%	2	9,5%

					sex				age range							
Categories	**Definition**	**Subcategories**	**sum**		**M**		**F**		**18-24**		**25-34**		**35-54**		**55+**	
3.0 Applications	Applications of IoT in Agriculture that the interviewee would apply for his/hers production	Automated irrigation	11	52,4%	9	42,9%	2	9,5%	1	4,8%	5	23,8%	3	14,3%	1	4,8%
		Automated use of herbicides, fungicides, insecticides	7	33,3%	5	23,8%	2	9,5%	1	4,8%	4	19,0%	1	4,8%	1	4,8%
		Use of drones for automated spraying	6	28,6%	4	19,0%	2	9,5%	1	4,8%	4	19,0%	1	4,8%		0,0%
		Data collection for future use and planning of the cultivation	8	38,1%	5	23,8%	3	14,3%	1	4,8%	5	23,8%	2	9,5%		0,0%
		Automated soil analysis	8	38,1%	6	28,6%	2	9,5%	1	4,8%	6	28,6%	1	4,8%		0,0%
		Control of the production and decision making of the cultivation practices through smart devices	9	42,9%	6	28,6%	3	14,3%	1	4,8%	6	28,6%	2	9,5%		0,0%
		Fully automated practices in Greenhouses	7	33,3%	5	23,8%	1	4,8%	1	4,8%	6	28,6%		0,0%		0,0%
		Use of sensors for the localization and health control of livestock	4	19,0%	3	14,3%	1	4,8%	1	4,8%	3	14,3%		0,0%		0,0%
		Automated production collection	7	33,3%	5	23,8%	2	9,5%	2	9,5%	4	19,0%	1	4,8%		0,0%
4.0 Already used applications	Applications of IoT or similar applications (more simple) already used	Automated irrigation	5	23,8%	4	19,0%	1	4,8%	2	9,5%	3	14,3%		0,0%		0,0%
		Applications for smart devices	4	19,0%	3	14,3%	1	4,8%		0,0%	3	14,3%	1	4,8%		0,0%
		Fully automated practices in Greenhouses	3	14,3%	3	14,3%		0,0%		0,0%	3	14,3%		0,0%		0,0%
		Data collection and analysis through other programs	6	28,6%	6	28,6%		0,0%	1	4,8%	5	23,8%		0,0%		0,0%

					sex				age range							
Categories	**Definition**	**Subcategories**	**sum**		**M**		**F**		**18-24**		**25-34**		**35-54**		**55+**	
5.0 Challenges	The challenges that would appear in the field of Agriculture from the use of an IoT ecosystem.	High demand of capital	16	76,2%	13	61,9%	2	9,5%	2	9,5%	8	38,1%	3	14,3%	1	4,8%
		Insufficient Internet connection	1	4,8%	1	4,8%	3	14,3%		0,0%	1	4,8%	2	9,5%		0,0%
		Uneducated population/Lack of expertise	15	71,4%	12	57,1%	3	14,3%	1	4,8%	8	38,1%	5	23,8%	1	4,8%
		Fragmented land holding	6	28,6%	5	23,8%	1	4,8%	1	4,8%	2	9,5%	1	4,8%	1	4,8%
		The majority of the farmers are not familiar with technological applications	12	57,1%	9	42,9%	3	14,3%	2	9,5%	6	28,6%	2	9,5%	2	9,5%
		Increased use of antennas and electricity demands	2	9,5%	2	9,5%		0,0%		0,0%	1	4,8%	1	4,8%		0,0%
		Not tested systems	4	19,0%	2	9,5%	2	9,5%		0,0%	2	9,5%	2	9,5%		0,0%
		Inclined farm fields	5	23,8%	4	19,0%	1	4,8%	1	4,8%	2	9,5%	1	4,8%	1	4,8%
6.0 Economic Opportunities	The economic opportunities that would appear in the field of Agriculture from the use of an IoT ecosystem	Decreased cost of pesticides	16	76,2%	13	61,9%	3	14,3%	2	9,5%	8	38,1%	5	23,8%	1	4,8%
		Decreased cost of water for irrigation	16	76,2%	13	61,9%	3	14,3%	2	9,5%	8	38,1%	5	23,8%	1	4,8%
		Decreased cost of fertilizers	16	76,2%	13	61,9%	3	14,3%	2	9,5%	8	38,1%	5	23,8%	1	4,8%
		Increased yield of production	19	90,5%	16	76,2%	3	14,3%	1	4,8%	10	47,6%	5	23,8%	3	14,3%
		Decreased cost of electricity	4	19,0%	4	19,0%		0,0%		0,0%	3	14,3%	1	4,8%		0,0%
		Ameliorated quality of the product	8	38,1%	8	38,1%		0,0%		0,0%	6	28,6%	1	4,8%	1	4,8%
		Less personnel required	7	33,3%	5	23,8%	2	9,5%	2	9,5%	3	14,3%	1	4,8%		0,0%
		Opportunity to expand agribusiness	3	14,3%	1	4,8%	2	9,5%	1	4,8%	2	9,5%		0,0%		0,0%
		Control of the budget	8	38,1%	6	28,6%	2	9,5%		0,0%	6	28,6%	2	9,5%		0,0%

					sex				age range							
Categories	**Definition**	**Subcategories**	**sum**		**M**		**F**		**18-24**		**25-34**		**35-54**		**55+**	
7.0 Environmental opportunities	The environmental opportunities that would appear in the field of Agriculture from the use of an IoT ecosystem	Decreased use of pesticides	18	85,7%	14	66,7%	3	14,3%	2	9,5%	8	38,1%	5	23,8%	2	9,5%
		Decreased use of water for irrigation	18	85,7%	15	71,4%	3	14,3%	2	9,5%	9	42,9%	5	23,8%	2	9,5%
		Decreased use of electricity	6	28,6%	5	6,0%		0,0%		0,0%	5	23,8%	1	4,8%		0,0%
		Moderated use of fertilizers	17	81,0%	14	66,7%	3	14,3%	2	9,5%	9	42,9%	5	23,8%	1	4,8%
		Decreased use of petrol	5	23,8%	5	23,8%		0,0%		0,0%	3	14,3%	2	9,5%		0,0%
8.0 Social opportunities	The social opportunities that would appear in the field of Agriculture from the use of an IoT ecosystem	More free time	13	61,9%	10	47,6%	3	14,3%	2	9,5%	6	28,6%	4	19,0%	1	4,8%
		Less stress due to the more secure production	11	52,4%	8	38,1%	3	14,3%	2	9,5%	6	28,6%	3	14,3%		0,0%
		More job vacancies for young people	5	23,8%	3	14,3%	2	9,5%	1	4,8%	2	9,5%	2	9,5%		0,0%
		Decreased fatigue	7	33,3%	6	28,6%	1	4,8%	1	4,8%	2	9,5%	3	14,3%	1	4,8%
9.0 Social challenges	The social challenges that would appear in the field of Agriculture from the use of an IoT ecosystem	Less personnel required	8	38,1%	7	33,3%	1	4,8%	2	9,5%	5	23,8%	1	4,8%		0,0%
		Lack of trust in technological systems	11	52,4%	9	42,9%	2	9,5%		0,0%	6	28,6%	4	19,0%	1	4,8%
		Solitude/unsociability	1	4,8%	1	4,8%		0,0%		0,0%	1	4,8%		0,0%		0,0%
		The state does not support farmers	6	28,6%	6	28,6%		0,0%		0,0%	2	9,5%	2	9,5%	2	9,5%

					sex				age range							
Categories	**Definition**	**Subcategories**	**sum**		**M**		**F**		**18-24**		**25-34**		**35-54**		**55+**	
10.0 Other benefits	Other benefits that the participants of the interviews reported as not considered in the framework of the economic, social and environmental opportunities	Health benefits both for farmers and consumers	3	14,3%	3	14,3%		0,0%	1	4,8%	2	9,5%		0,0%		0,0%
		Opportunity to educate the population of province in new technologies	3	14,3%	1	4,8%	2	9,5%	1	4,8%		0,0%	2	9,5%		0,0%
		Politics will change creating new CAP (Common Agricultural Policy).	1	4,8%	1	4,8%		0,0%			1	4,8%		0,0%		0,0%
		Opportunity the improve the "image" of the country in the field of agriculture gaining trust and respect from other markets	2	9,5%		0,0%	1	4,8%	1	4,8%		0,0%	2	9,5%		0,0%

Appendix III

Questionnaire presentation

Farming Smartification

This survey is part of a research project of the MSc in Strategic Product Planning of the International Hellenic University. The purpose of the questionnaire is to collect information from Greek farmers to apply new technologies in agriculture, in the context of a diploma thesis.

This survey is anonymous and completely confidential. The information that you give will be only used for the purposes of this project and there is no way that your answers can be identified individually. The data will be collected and analyzed, and the findings will become part of a research report. All data will be destroyed after the completion of this study.

Your participation is completely voluntary and you have the right to withdraw your answers from this study at any time, without giving any explanation. If you are willing to participate, you can now start completing the online questionnaire. The process of filling out the questionnaire will need approximately 7 minutes.

Thank you in advance for your time and cooperation.

---

1) What is your current cultivation method?

( ) Crop production

( ) Crop and livestock production

( ) Greenhouse production

( ) Other: _____

2) Is farming activity your main source of income?

( ) Yes

( ) No

3) What kind of agricultural practice or system do you apply in your production?

( ) Conventional Farming

( ) Organic Farming

( ) Precision Agriculture

( ) Hydroponic System in a Greenhouse

( ) Other: _____

4) What in your opinion are the main cultivation characteristics that need constant attention in your production?

(You can choose more than one answer)

[ ] Soil humidity

[ ] Soil characteristics (N, P, K)

[ ] Daily weather forecast

[ ] Weather forecast for extreme phenomena

[ ] Diseases

[ ] Pests

[ ] Other: _____

5) What is the percentage of your production that cannot be exploited, damaging your capital, regarding the agricultural practice you follow? (Use of machinery equipment, use of pesticides, limited control of weather conditions etc.)

( ) 0-10%

( ) 11-15%

( ) 16-20%

( ) 21-25%

( ) >25%

6) Do you believe that your current cultivation practice is satisfactory?

( ) Yes

( ) No

7) If not, what are the cultivation needs that are not covered by your current practice?

(You can choose more than one answer)

[ ] Cultivation control

[ ] Controlling weather conditions

[ ] Control of the pesticide or fertilizer usage

[ ] Production distribution

8) Are you interested in changing your current cultivation system with a more efficient one?

( ) Yes

( ) No

9) Do you use smart devices? (Smartphone, tablet etc.)

( ) Yes

( ) No

10) In what extend do you believe that you contribute to the protection of the environment with your current applied cultural practices?

( ) Not at all ( ) A little ( ) Adequately ( ) A lot ( ) Very much

The "Internet of Things" (IoT) is an emerging innovative technology platform that utilizes a device network with embedded sensors that communicate with each other, to collect physical environment data while analyzing and managing them, with a goal to provide useful services to individuals, businesses and the society in general. IoT is used in various fields such as the health sector, industry, tourism, agriculture etc.

Listed below are some examples of applications of such a system, specifically for the field of agriculture.

11) Which of the following smart applications are you interested in embedding on your cultivation?

(You can choose more than one answer)

[ ] Systematic measurement of soil moisture in various strategic points of the field, providing automatic irrigation only in the required areas without having to water the entire cultivated area.

[ ] Systematic measurement of the chemical properties of the soil, providing automated fertilization in the required areas with the appropriate required amount.

[ ] Systematic measurement of conditions that favor the appearance and spread of diseases and pests, to instantly deploy the needed amount of chemical pesticides.

[ ] Use of unmanned aerial vehicles (drones) for automated crop spraying

[ ] Automated produce harvesting using GPS, skipping the farmers direct intervention.

[ ] Control and supervision of the production through smart devices such as smartphones or tablets, contributing to instant decision making.

[ ] Collection, interpretation and analysis of the cultivation data in order to efficiently control the current production, while self-regulating future needs of the production according to statistical data.

[ ] Fully automated operations and accurate control of the conditions in a greenhouse environment.

[ ] Use of small sensors in livestock to fully control health and animal productivity conditions (automatic feeding in the required amount, animal positioning service via satellite).

[ ] Other: _____

12) Do you believe that there is a need of the implementation of smart farming applications?

( ) Yes

( ) No

13) Do you believe that smart farming applications would benefit your cultivation practices?

( ) Yes

( ) No

14) Do you already apply any similar system to your cultivation?

(You can choose more than one answer)

[ ] Automated irrigation

[ ] Smart device applications

[ ] Fully automated conditions in a greenhouse environment

[ ] Collection and interpretation of cultivation data through computer programs

[ ] No, I don't apply any similar application

[ ] Other: _____

15) Which are in your opinion the most important economic benefits that could arise from the implementation of a smart farming system?

(You can choose more than one answer)

[ ] Yield increase

[ ] Reduced cost from the use of fertilizers

[ ] Reduced cost from the use of pesticides

[ ] Reduced cost from the use of water

[ ] Reduced cost from the use of electricity

[ ] Improved production quality

[ ] Reduced personnel expenses

[ ] Facility to expand the agribusiness

[ ] Control of the capital

[ ] Other: _____

16) Which are in your opinion the most important environmental opportunities that would arise from the implementation of a smart farming system?

(You can choose more than one answer)

[ ] Decreased use of pesticides

[ ] Decreased water consumption

[ ] Decreased use of electricity

[ ] Decreased petrol consumption

[ ] Moderated use of fertilizers

[ ] Other: _____

17) Which are in your opinion the most important Social benefits that would arise from the implementation of a smart farming system?

(You can choose more than one answer)

[ ] Increased producer leisure time

[ ] New job vacancies for young people in primary production

[ ] Reduced fatigue levels of the farmer

[ ] Reduced farmer stress levels for the cultivation

[ ] Other: _____

18) Which are in your opinion the most important challenges that would arise from the implementation of a smart farming system?

(You can choose more than one answer)

[ ] High cost of installation

[ ] Unfamiliarity of the farmer with smart farming applications

[ ] Insufficient internet coverage in farming areas

[ ] Lack of expertise in technological systems

[ ] Fragmented landholding

[ ] Inclined farming fields

[ ] Increased demand of infrastructures (antennas etc.)

[ ] Lack of trust in technological systems

[ ] Other: _____

19) Which are in your opinion the most important social challenges that would arise from the implementation of a smart farming system?

(You can choose more than one answer)

[ ] Reducing job vacancies

[ ] Lack of trust in technological systems

[ ] Insufficient support of the farmers by the state

[ ] Other: _____

How important do you consider the following specific benefits that probably arise from the application of a smart produce system?

20) How much, in your opinion, smart farming systems contribute to the health of both farmers and consumers?

( ) Not at all ( ) A little ( ) Adequately ( ) A lot ( ) Very much

21) How much, in your opinion, smart farming systems contribute to the education on new technological systems of province population

( ) Not at all ( ) A little ( ) Adequately ( ) A lot ( ) Very much

22) How much, in your opinion, smart farming systems contribute to the image and the trust of Greece in foreign markets

( ) Not at all ( ) A little ( ) Adequately ( ) A lot ( ) Very much

23) Do you believe that farming smartification can contribute to another sector except from economy, environment and society? If yes, which one?

( ) Yes: _____*

( ) No

Demographics

24) Sex

( ) Male

( ) Female

25) Age

( ) 18-24

( ) 25-34

( ) 35-44

( ) 45-54

( ) 55+

26) Educational level

( ) Elementary

( ) Middle school

( ) Technical high school

( ) Vocational schools

( ) High school

( ) University – Technical institute

( ) Master's degree

( ) Doctoral

27) Gross monthly income

( ) 0-500 euro

( ) 501-1000 euro

( ) 1001-1500 euro

( ) 1501-2000 euro

( ) >2000 euro

28) Marital status

( ) Single

( ) Married

( ) Divorced

( ) Widowed

29) Area of activity

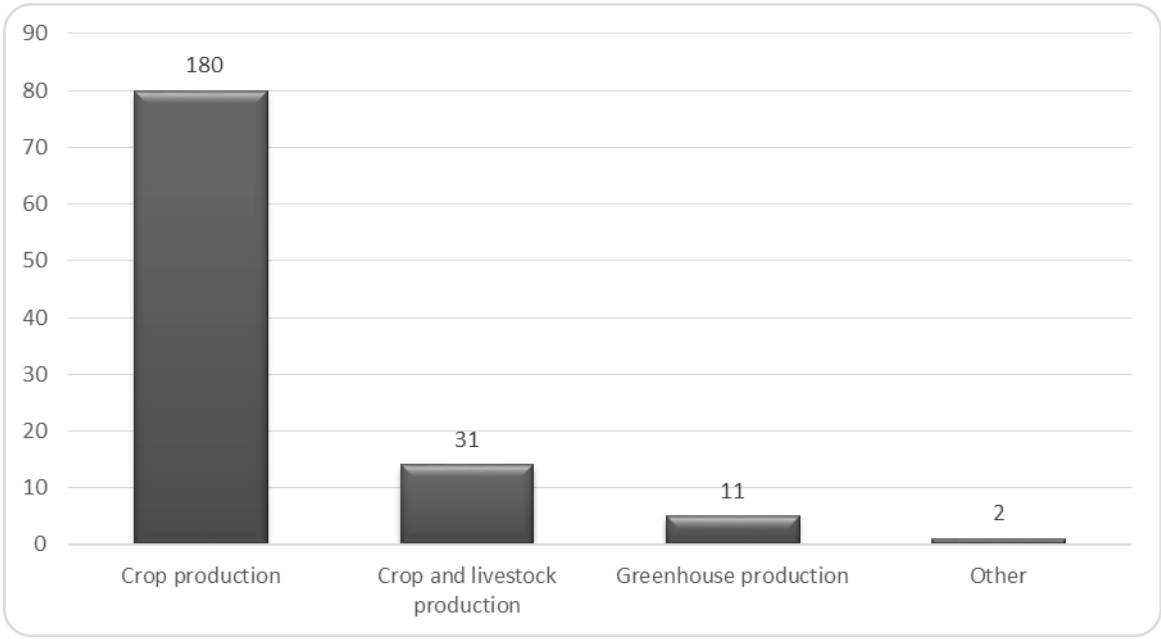
_____

Thank you for your time!

Appendix IV

Quantitative method: Summary Report

1. What is your current cultivation method?



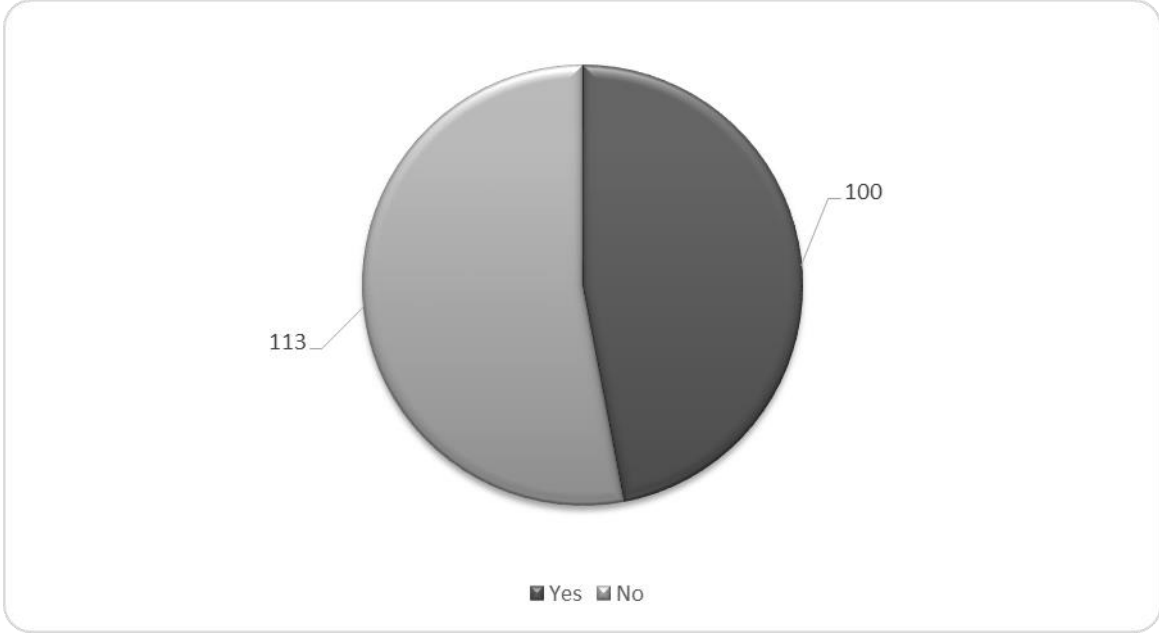
Value	Percent	Count
Crop production	80.36%	180
Crop and livestock production	13.84%	31
Greenhouse production	4.91%	11
Other	0.89%	2
Total		224

Statistics

Total Responses	224
Skipped	8
Unanswered	8

Responses "Other"	Count
Left Blank	231
Inappropriate content	1

2. Is farming activity your main source of income?

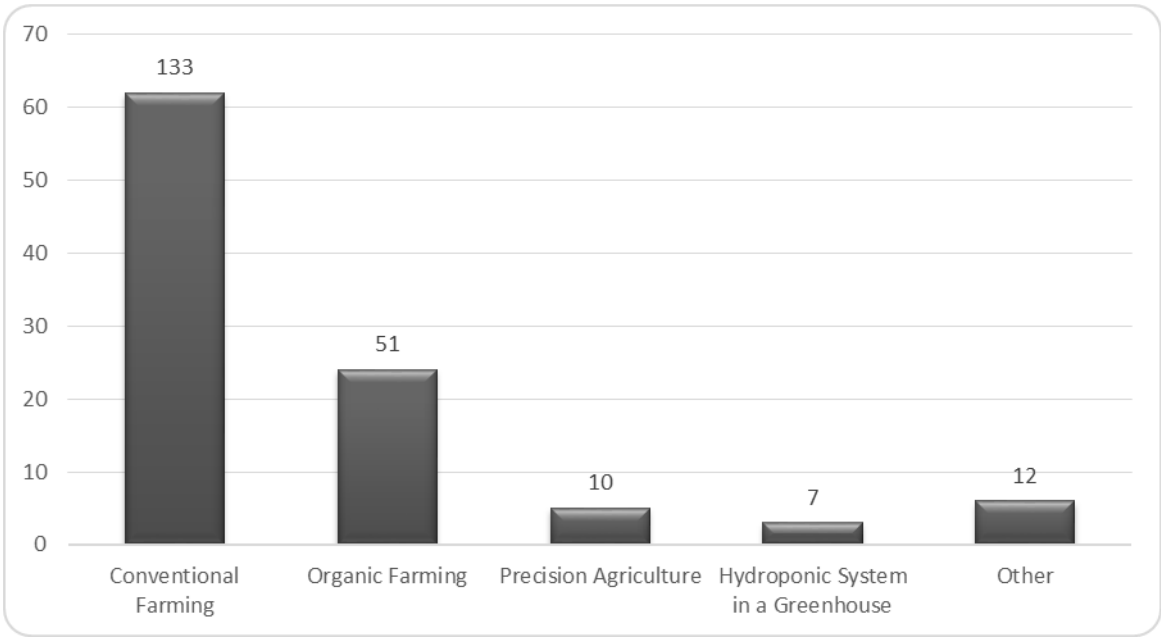


Value	Percent	Count
Yes	46.95%	100
No	53.05%	113
Total		213

Statistics

Total Responses	213
Skipped	19
Unanswered	19

3. What kind of agricultural practice or system do you apply in your production?



Value	Percent	Count
Conventional Farming	62.44%	133
Organic Farming	23.94%	51
Precision Agriculture	4.69%	10
Hydroponic System in a Greenhouse	3.29%	7
Other	5.63%	12
Total		213

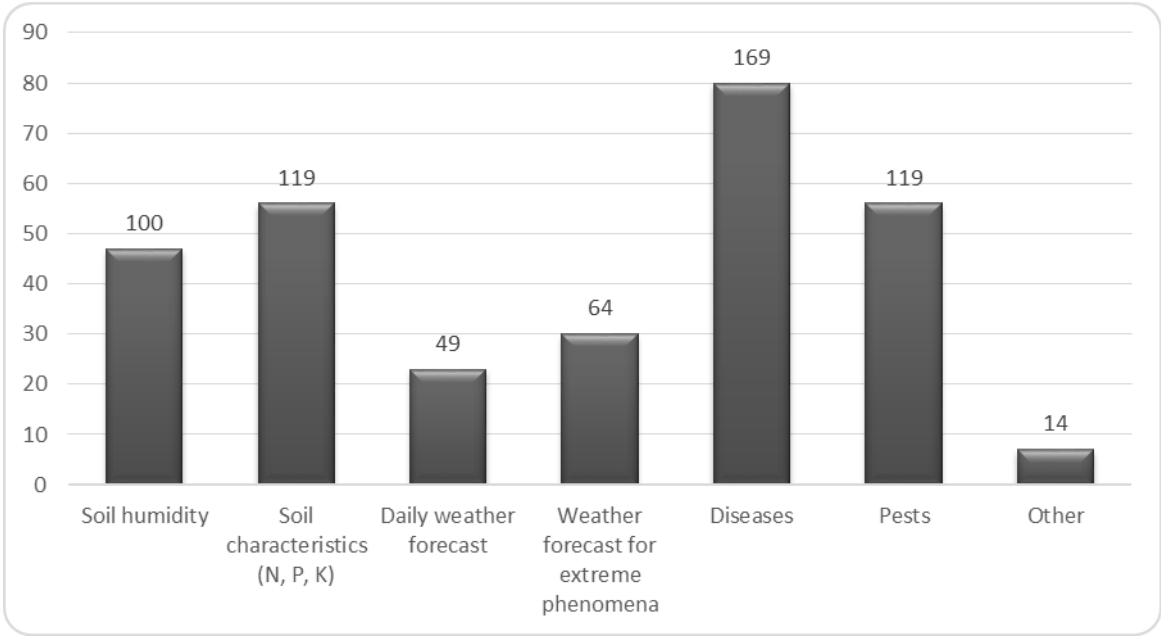
Statistics

Total Responses	213
Skipped	19
Unanswered	19

Responses "Other"	Count
Left Blank	220
Combination of organic farming with permacultura and foukouo-ka method.	2
Certified conventional farming	2

Traditional farming	2
Tree production	1
Both conventional and organic farming	1
fukuoka	3

4. What in your opinion are the main cultivation characteristics that need constant attention in your production? (You can choose more than one answer)



Value	Percent	Count
Soil humidity	47.17%	100
Soil characteristics (N, P, K)	56.13%	119
Daily weather forecast	23.11%	49

Weather forecast for extreme phenomena	30.19%	64
Diseases	79.72%	169
Pests	56.13%	119
Other	6.60%	14
Total		212

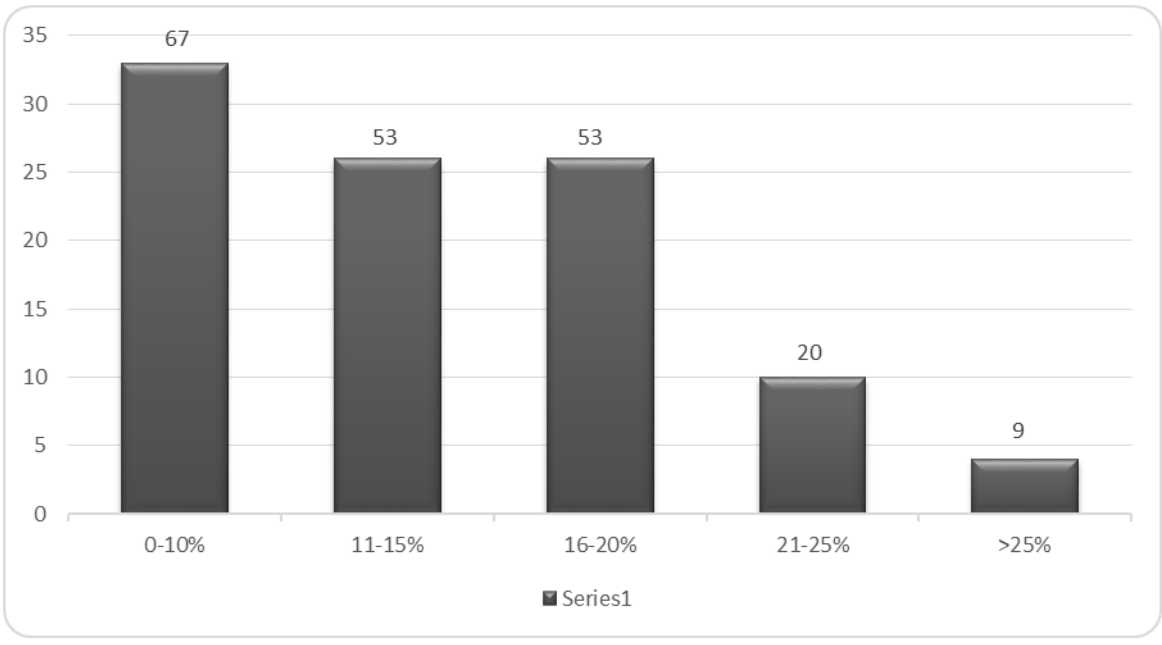
Statistics

Total Responses	212
Skipped	20
Unanswered	20

Responses "Other"	Count
Left Blank	218
All the above	4
microbial, bacterial flora, beneficial fungi etc.	1
Quality, to be possible to exceed the competition	1
Weeding	2

TIMELY troubleshooting	1
Inappropriate content	1
Foliage humidity	1
Financial indices	1
Cultivation practices in general	1
Percentage of soil cover (with mostly herbaceous plants)	1

5. What is the percentage of your production that cannot be exploited, damaging your capital, regarding the agricultural practice you follow? (Use of machinery equipment, use of pesticides, limited control of weather conditions etc.)

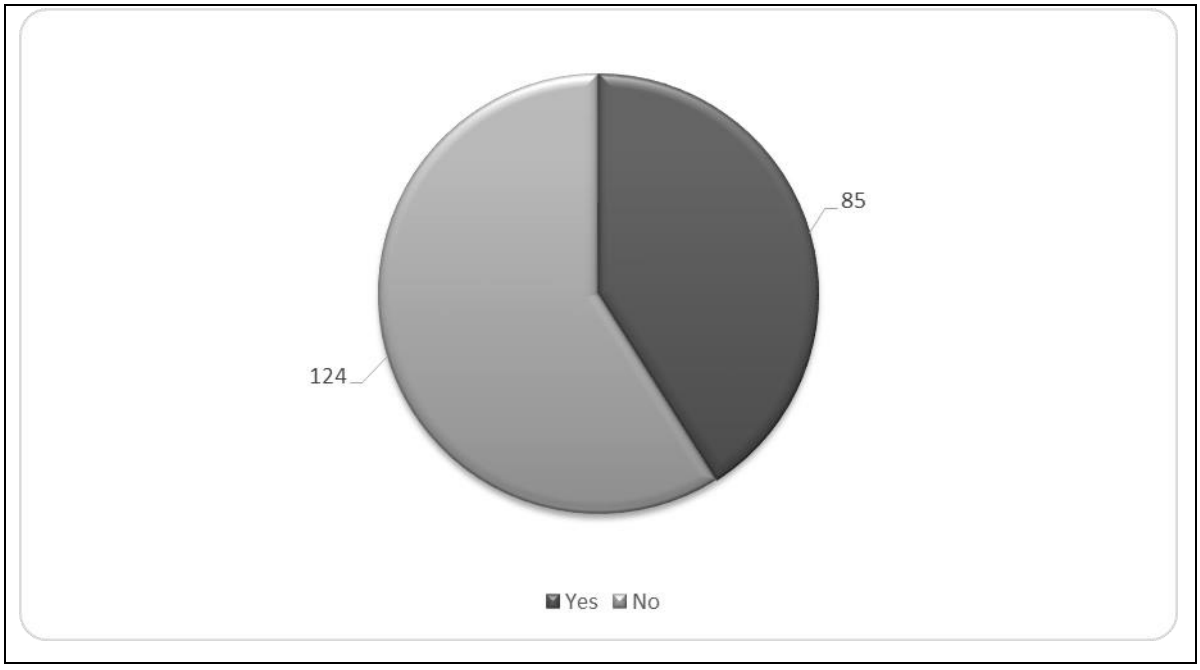


Value	Percent	Count
0-10%	33.17%	67
11-15%	26.24%	53
16-20%	26.24%	53
21-25%	9.90%	20
>25%	4.46%	9
Total		202

Statistics

Total Responses	202
Sum	1,851.00
Average	14.69
StdDev	3.57
Min	11.00
Max	21.00
Skipped	30
Unanswered	30

6. Do you believe that your current cultivation practice is satisfactory?

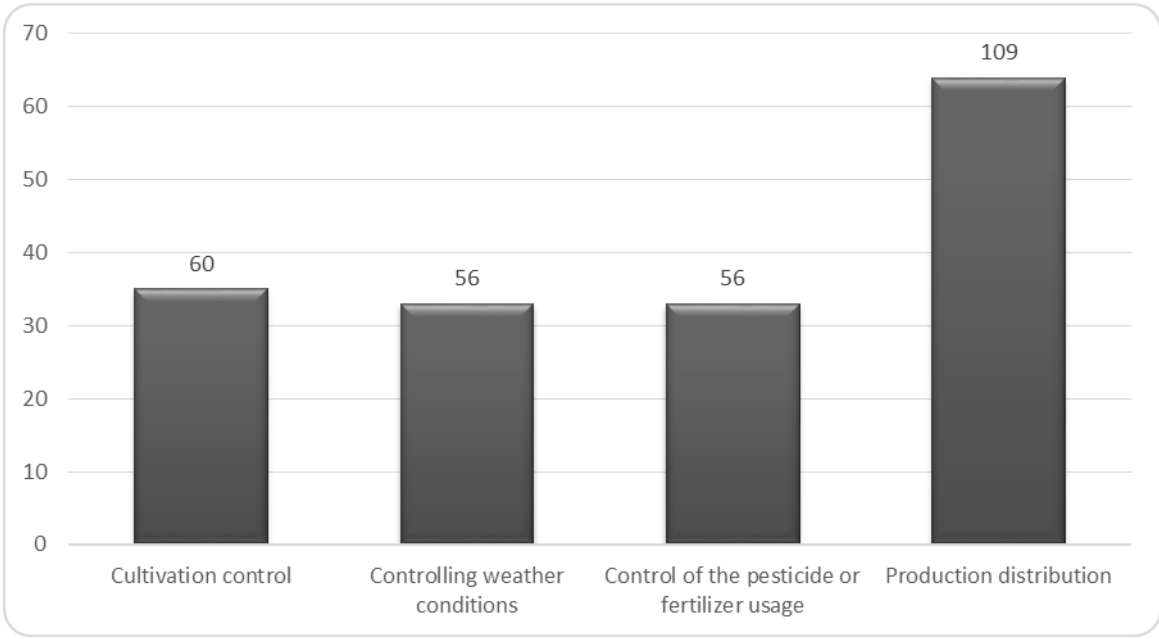


Value	Percent	Count
Yes	40.67%	85
No	59.33%	124
Total		209

Statistics

Total Responses	209
Skipped	23
Unanswered	23

7. If not, what are the cultivation needs that are not covered by your current practice? (You can choose more than one answer)

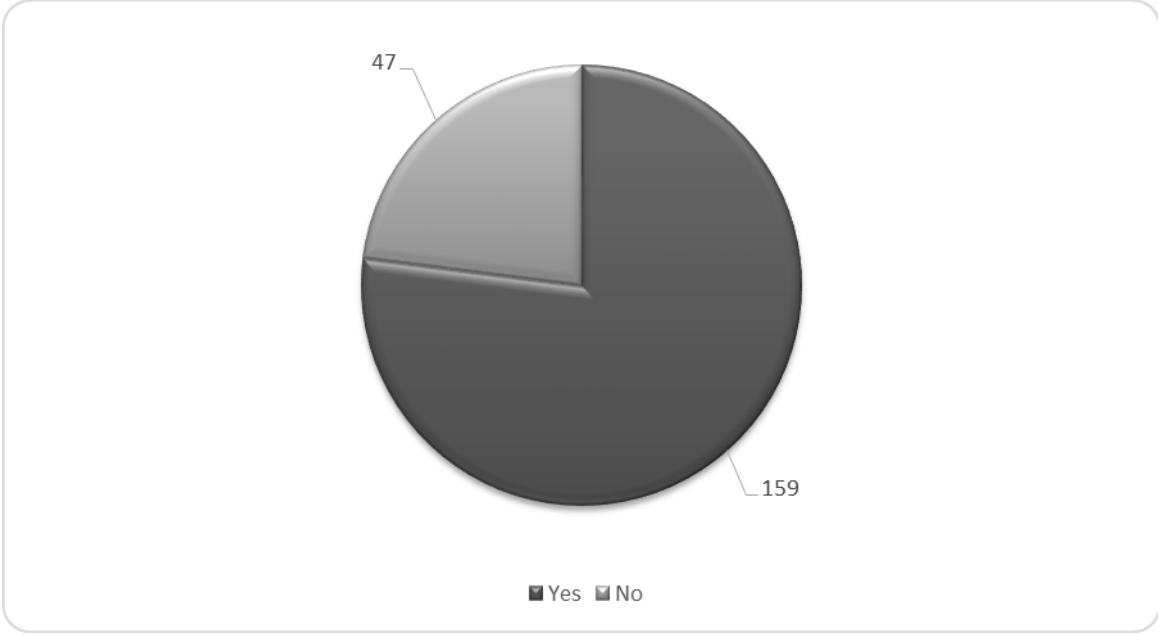


Value	Percent	Count
Cultivation control	35.09%	60
Controlling weather conditions	32.75%	56
Control of the pesticide or fertilizer usage	32.75%	56
Production distribution	63.74%	109
Total		171

Statistics

Total Responses	171
Skipped	61
Unanswered	61

8. Are you interested in changing your current cultivation system with a more efficient one?



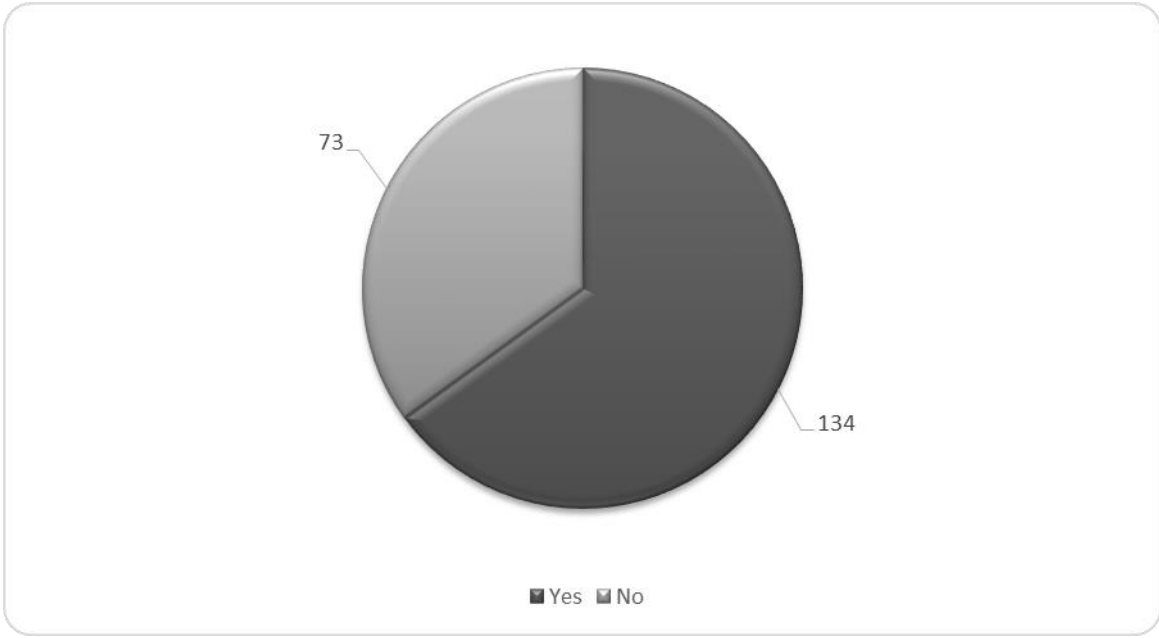
Value	Percent	Count
Yes	77.18%	159
No	22.82%	47

Total		206

Statistics

Total Responses	206
Skipped	26
Unanswered	26

9. Do you use smart devices? (Smartphone, tablet etc.)



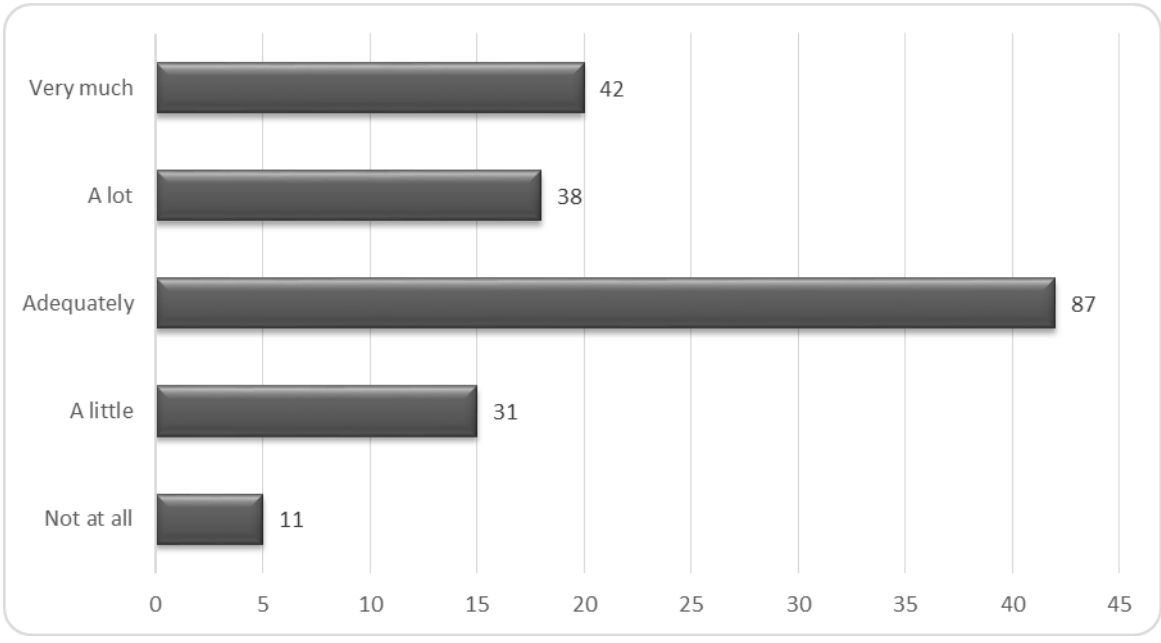
Value	Percent	Count
Yes	64.73%	134
No	35.27%	73

Total		207

Statistics

Total Responses	207
Skipped	25
Unanswered	25

10. In what extend do you believe that you contribute to the protection of the environment with your current applied cultural practices;



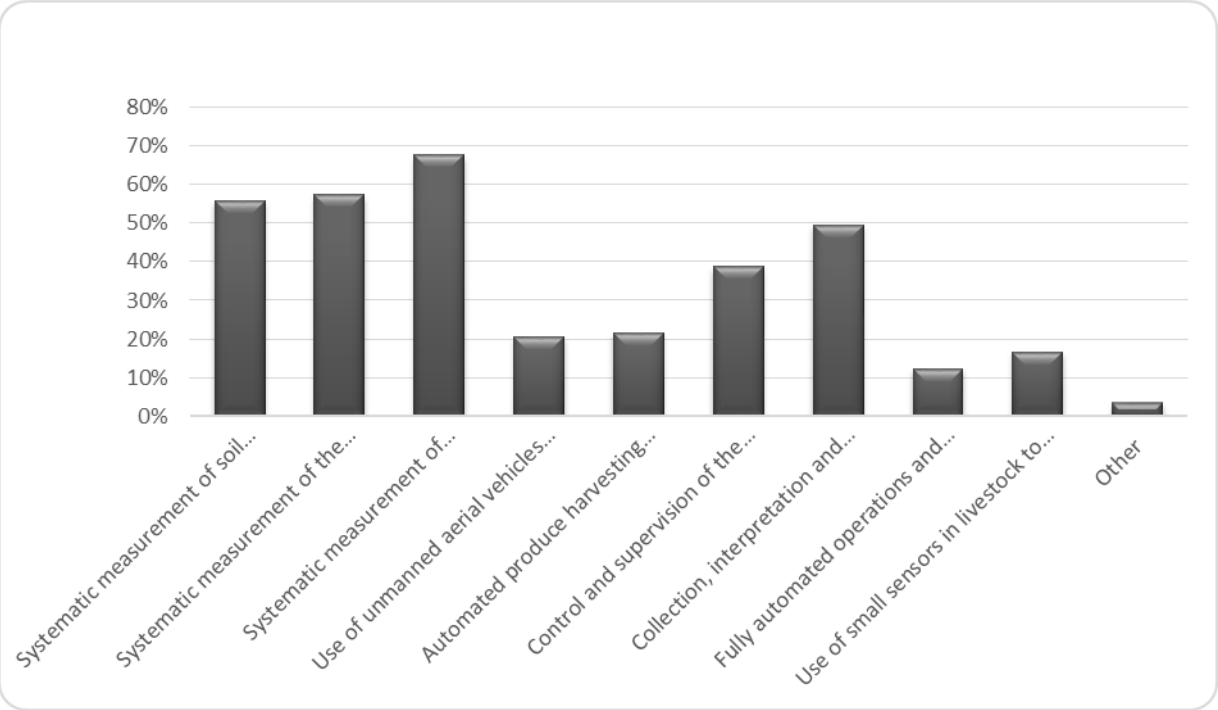
Value	Percent	Count

Not at all	5.26%	11
A little	14.83%	31
Adequately	41.63%	87
A lot	18.18%	38
Very much	20.10%	42
Total		209

Statistics

Total Responses	209
Skipped	23
Unanswered	23

11. Which of the following smart applications are you interested in embedding on your cultivation? (You can choose more than one answer)

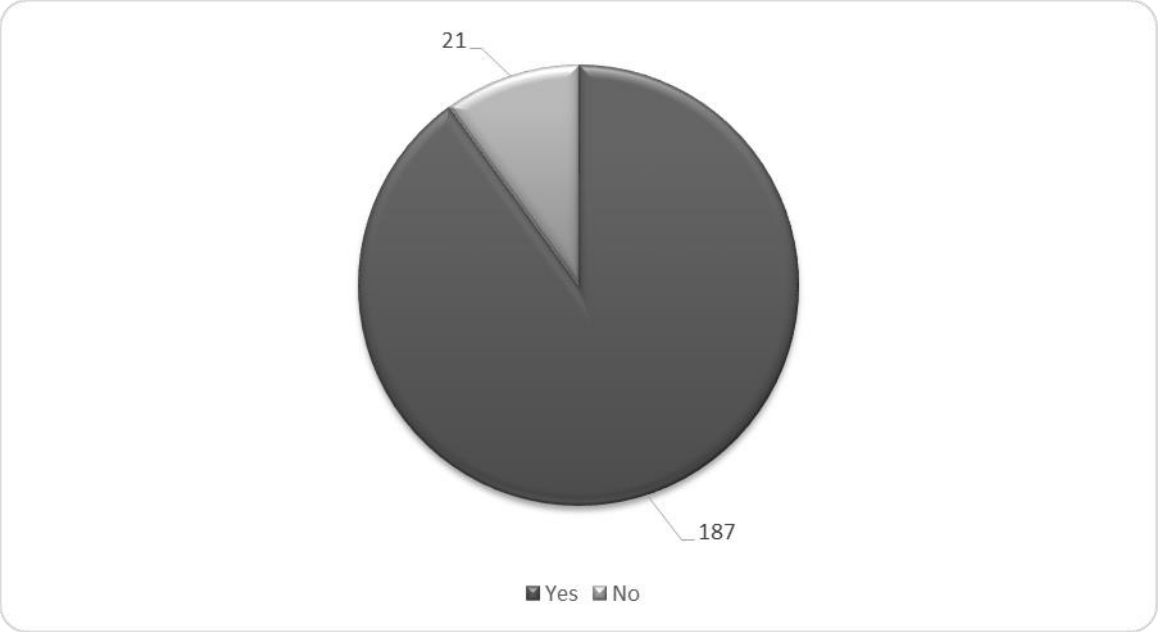


Value	Percent	Count
Systematic measurement of soil moisture in various strategic points of the field, providing automatic irrigation only in the required areas without having to water the entire cultivated area.	55.9%	114
Systematic measurement of the chemical properties of the soil, providing automated fertilization in the required areas with the appropriate required amount.	57.4%	117
Systematic measurement of conditions that favor the appearance and spread of diseases and pests, to instantly deploy the	67.7%	138

needed amount of chemical pesticides.		
Use of unmanned aerial vehicles (drones) for automated crop spraying	20.6%	42
Automated produce harvesting using GPS, skipping the farmer's direct intervention.	21.6%	44
Control and supervision of the production through smart devices such as smartphones or tablets, contributing to instant decision making.	38.7%	79
Collection, interpretation and analysis of the cultivation data in order to efficiently control the current production, while self-regulating future needs of the production according to statistical data.	49.5%	101
Fully automated operations and accurate control of the conditions in a greenhouse environment.	12.3%	25
Use of small sensors in livestock to fully control health and animal productivity conditions (automatic feeding in the required amount, animal positioning service via satellite).	16.7%	34
Other	3.4%	7
Total		204
Responses "Άλλο"		Count
Left Blank		227

Site like best price	1
notice for precise harvest date to estimate the maturity of the fruit before thedelivery time to the consumer (unripe or too mature)	1
Inappropriate content	1
Better prices	1
None of them. All jobs should be done manually.	1

12. Do you believe that there is a need of the implementation of smart farming applications?



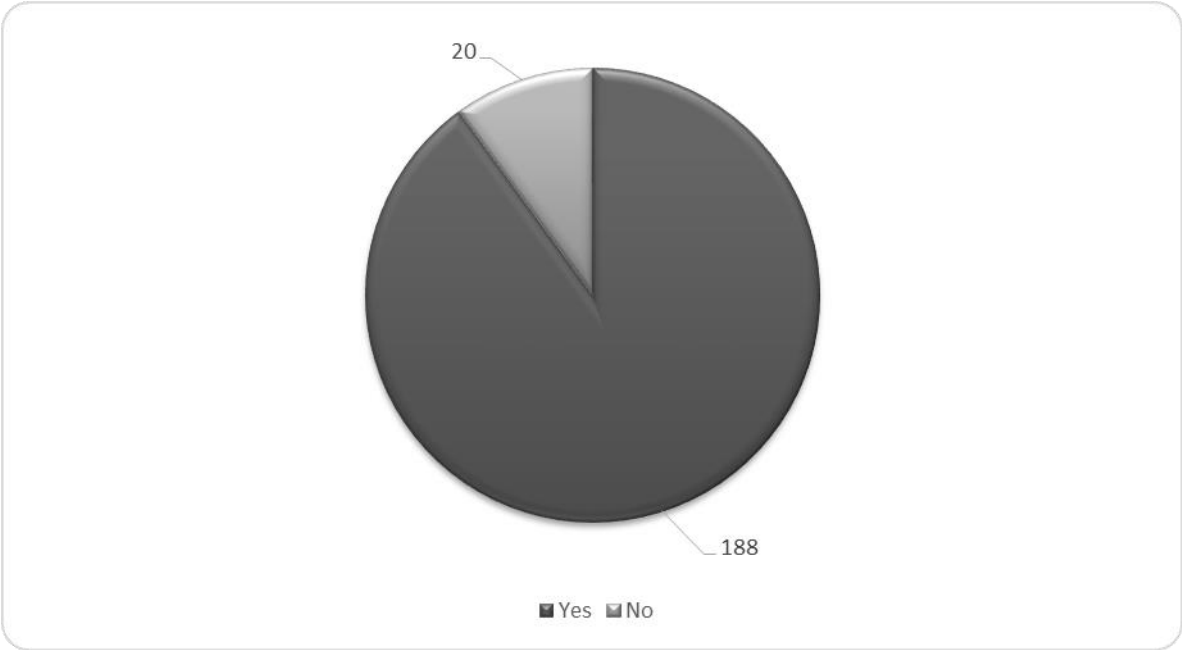
Value	Percent	Count
Yes	89.90%	187
No	10.10%	21

Total		208

Statistics

Total Responses	208
Skipped	24
Unanswered	24

13. Do you believe that smart farming applications would benefit your cultivation practices?



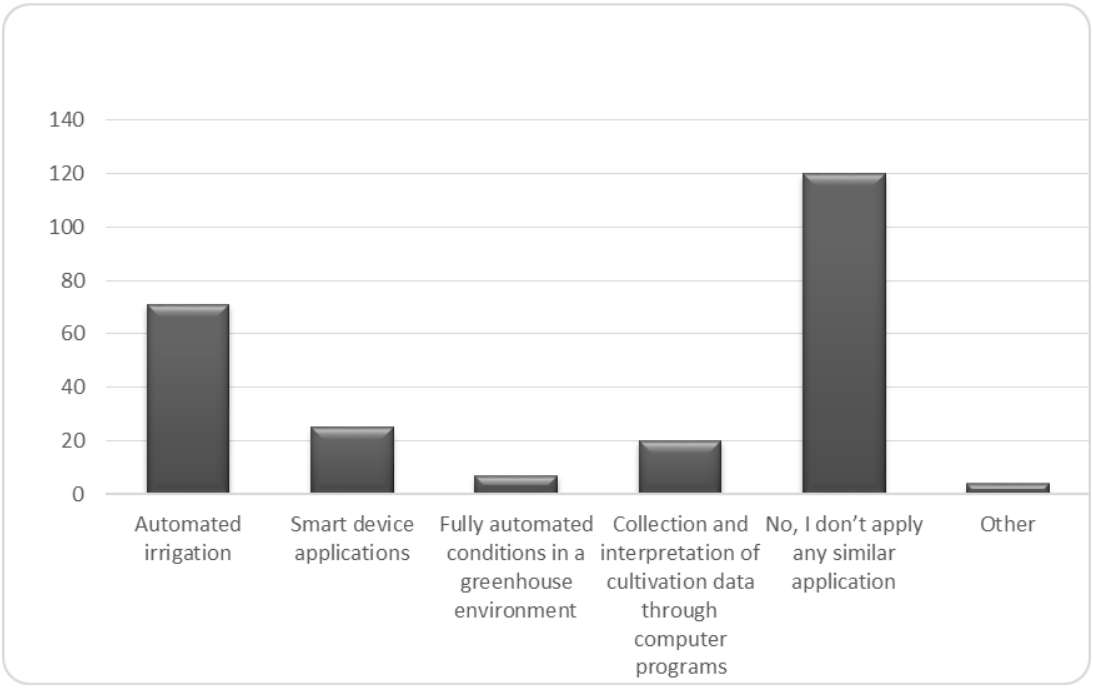
Value	Percent	Count
Yes	90.38%	188
No	9.62%	20

Total		208

Statistics

Total Responses	208
Skipped	24
Unanswered	24

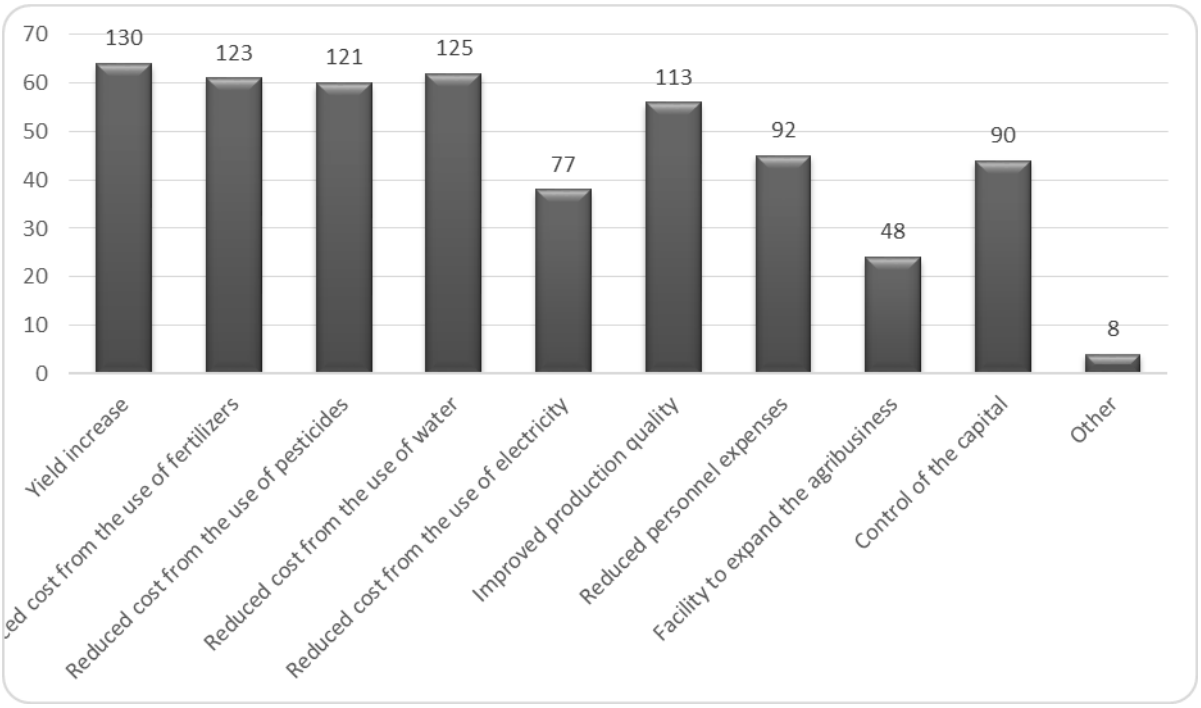
14. Do you already apply any similar system to your cultivation? (You can choose more than one answer)



Value	Percent	Count
Automated irrigation	34.1%	71
Smart device applications	12.0%	25

Fully automated conditions in a green-house environment	3.4%	7
Collection and interpretation of cultiva-tion data through computer programs	9.6%	20
No, I don’t apply any similar application	57.7%	120
Other	1.9%	4
Total		208
Responses "Other"		Count
Left Blank		228
We have also a meteorological station		1
Use of GPS and night vision cameras		1
Not any more		1

15. Which are in your opinion the most important economic benefits that could arise from the implementation of a smart farming system? (You can choose more than one answer)



Value	Percent	Count
Yield increase	64.04%	130
Reduced cost from the use of fertilizers	60.59%	123
Reduced cost from the use of pesticides	59.61%	121
Reduced cost from the use of water	61.58%	125
Reduced cost from the use of electricity	37.93%	77
Improved production quality	55.67%	113
Reduced personnel expenses	45.32%	92

Facility to expand the agribusiness	23.65%	48
Control of the capital	44.33%	90
Other	3.94%	8
Total		203

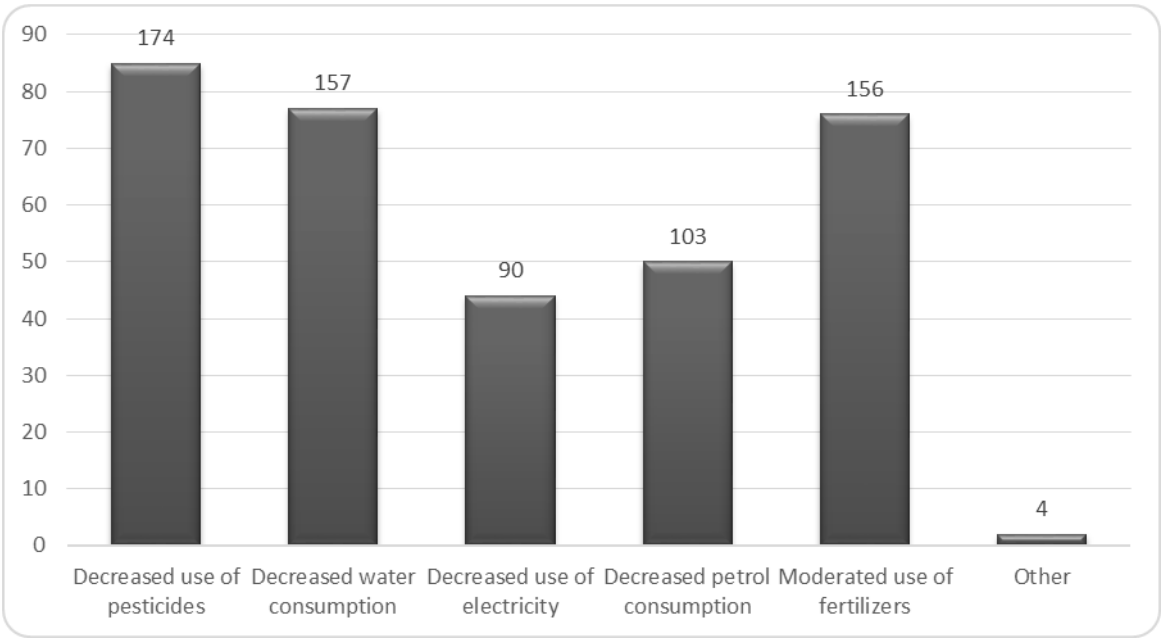
Statistics

Total Responses	203
Skipped	29
Unanswered	29

Responses "Other"	Count
Left Blank	226
Protection of the environment due to reduced use of pesticides and electricity	1
Sustainability. Natural Resource Management. Smart Management. Harbinger of integrated management.	1
Such automated systems are referred only to large areas and productions, not small crops with the wide variety of plants. Therefore, the model of your research, is aimed essentially to very few farmers or to other countries countries.	1

Protection of the environment	1
I am sorry but it is a waste of money	1
hahahaha	1

16. Which are in your opinion the most important environmental opportunities that would arise from the implementation of a smart farming system? (You can choose more than one answer)



Value	Percent	Count
Decreased use of pesticides	85.29%	174
Decreased water consumption	76.96%	157

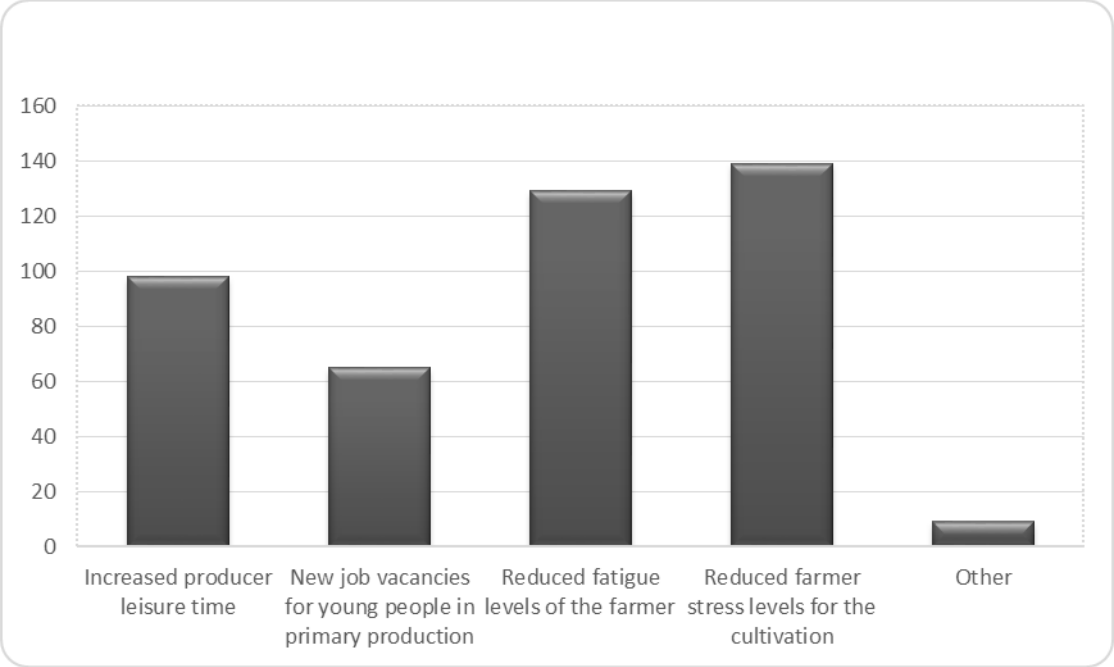
Decreased use of electricity	44.12%	90
Decreased petrol consumption	50.49%	103
Moderated use of fertilizers	76.47%	156
Other	1.96%	4
Total		204

Statistics

Total Responses	204
Skipped	28
Unanswered	28

Responses" Other"	Count
Left Blank	229
Maintaining good conditions e.g. in the soil for survival of useful microorganisms. General easiest design of environmentally friendly cultivation due to accuracy	1
I only care about money	1
What other do when we need them?	1

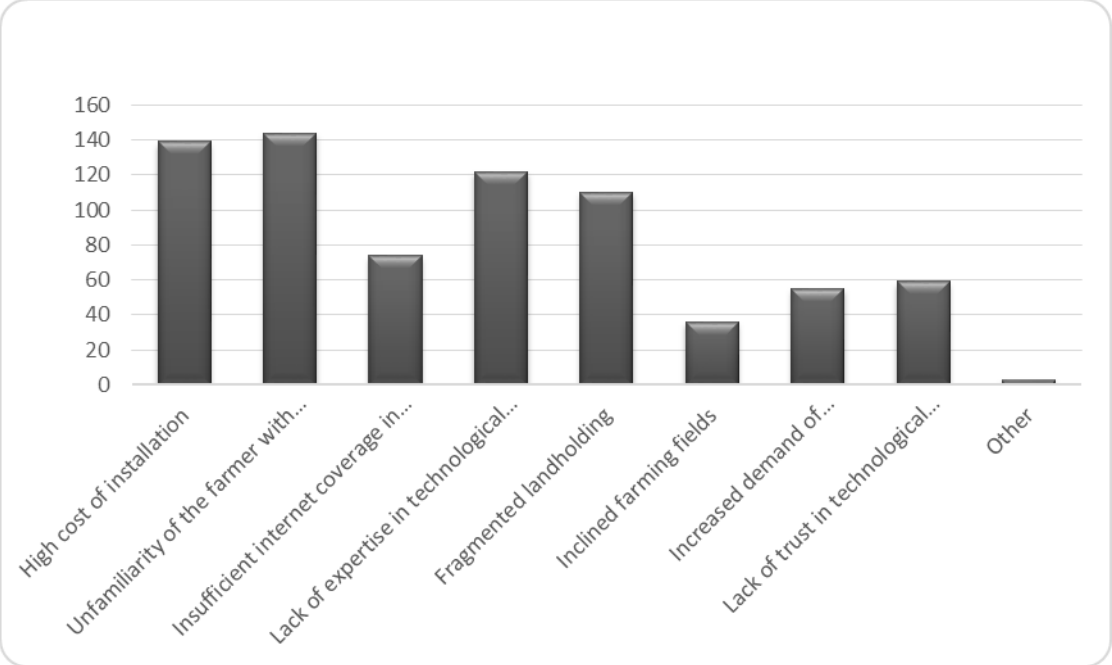
17. Which are in your opinion the most important Social benefits that would arise from the implementation of a smart farming system? (You can choose more than one answer)



Value	Percent	Count
Increased producer leisure time	48.0%	98
New job vacancies for young people in primary production	31.9%	65
Reduced fatigue levels of the farmer	63.2%	129
Reduced farmer stress levels for the cultivation	68.1%	139
Other	4.4%	9
Total		204
Responses "Other"		Count
Left Blank		224

The automation requires increased technological investment. Typically, this increases the producer's stress, because most of them don’t know how to use applications on tablets etc.	1
Cheaper products more affordable for poorer groups	1
Allows young professionals of various specialties to add and derive value from primary production	1
Social mentality will be changed, more sustainable approaches	1
Inappropriate content	1
Reduced production cost	1
Environmental benefits	2

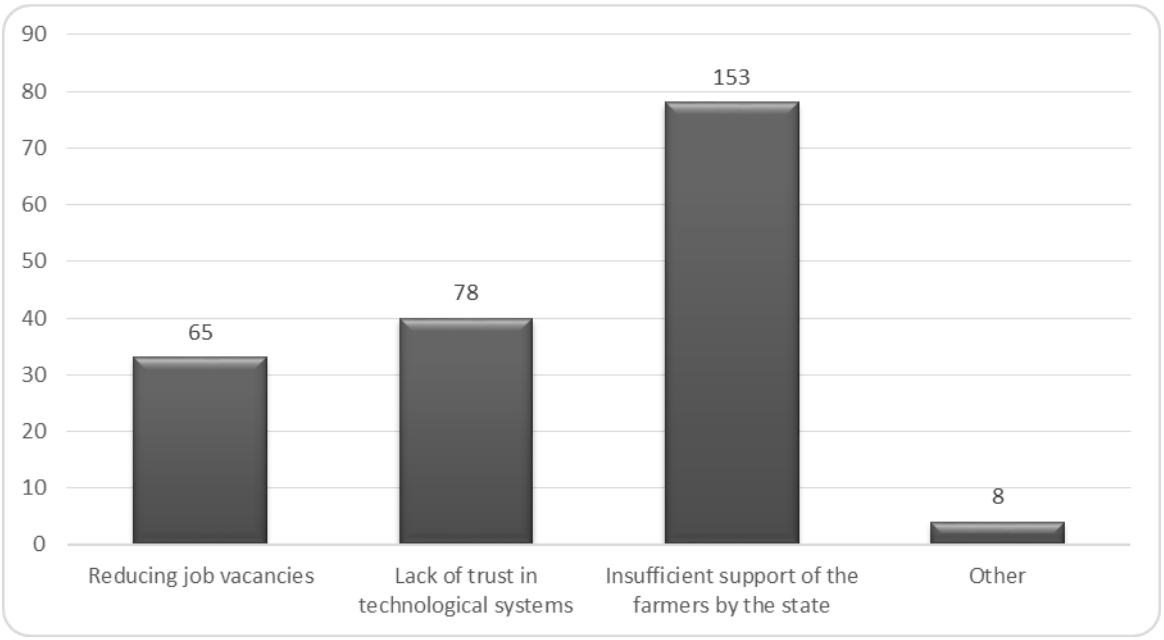
18. Which are in your opinion the most important challenges that would arise from the implementation of a smart farming system? (You can choose more than one answer)



Value	Percent	Count
High cost of installation	67.2%	139
Unfamiliarity of the farmer with smart farming applications	69.6%	144
Insufficient internet coverage in farming areas	35.8%	74
Lack of expertise in technological systems	58.9%	122
Fragmented landholding	53.1%	110
Inclined farming fields	17.4%	36
Increased demand of infrastructures (antennas etc.)	26.6%	55
Lack of trust in technological systems	28.5%	59
Other	1.5%	3
Total		207

Responses "Other"	Count
Left Blank	230
The state does not support the farmers	1
Rented fields	1

19. Which are in your opinion the most important social challenges that would arise from the implementation of a smart farming system? (You can choose more than one answer)



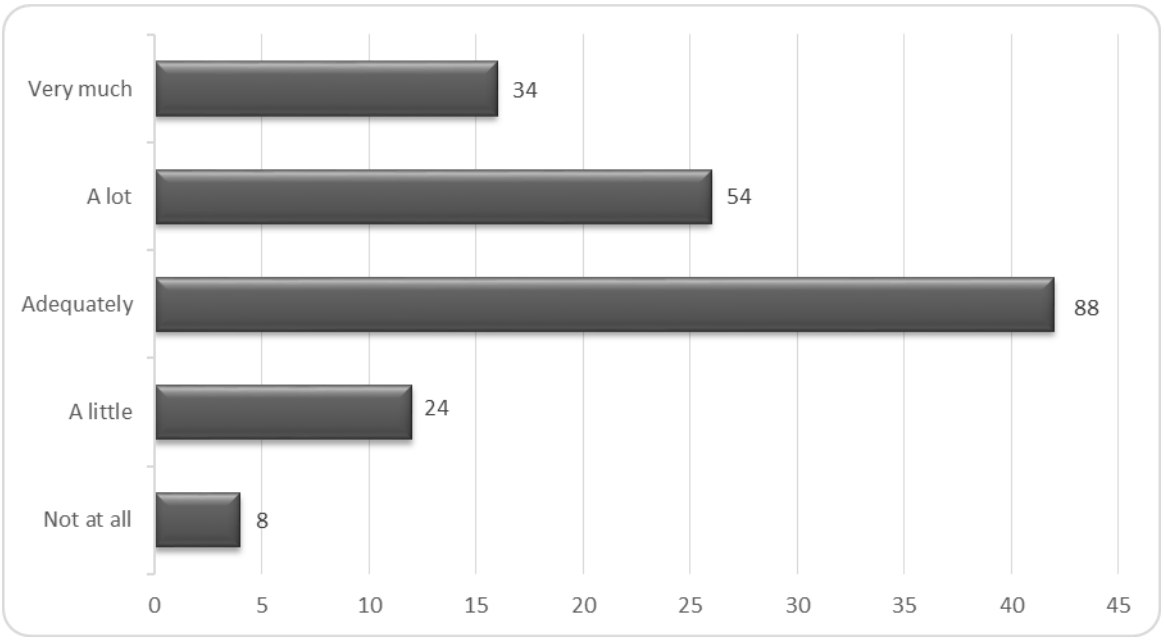
Value	Percent	Count
Reducing job vacancies	32.99%	65
Lack of trust in technological systems	39.59%	78
Insufficient support of the farmers by the state	77.66%	153
Other	4.06%	8
Total		197

Statistics

Total Responses	197
Skipped	35
Unanswered	35

Responses "Other"	Count
Left Blank	228
There are more important issues to be solved. The agronomists have insufficient knowledge or the serve large agrochemical companies interests. The product distribution system is destructive. Recording of production is absent. Compensation systems etc. are unacceptable. The Electronics-communication functionality of rural services (e.g. OPEKEPE, kepyel, OGA) does not exist. What we are discussing now dear girl!	1
The shrinkage of the rural population due to failure of installation of such systems and, consequently, the unsustainability due to competition.	1
Thefts and general loss of equipment	1
lack of cultivation culture	1

20. How much, in your opinion, smart farming systems contribute to the health of both farmers and consumers?

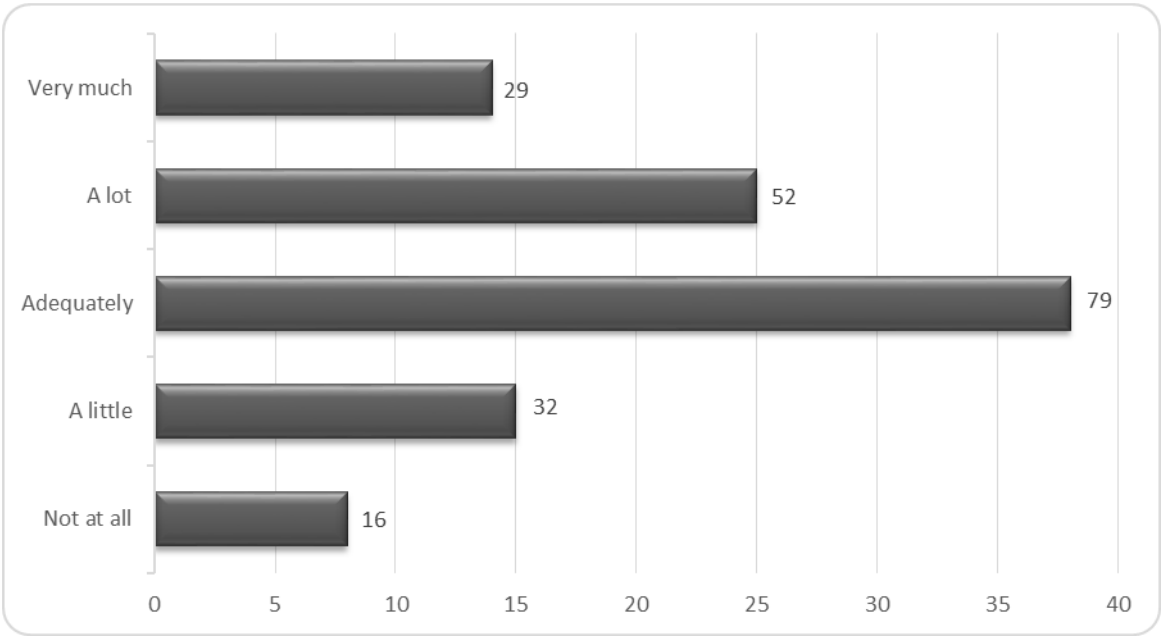


Value	Percent	Count
Not at all	3.85%	8
A little	11.54%	24
Adequately	42.31%	88
A lot	25.96%	54
Very much	16.35%	34
Total		208

Statistics

Total Responses	208
Skipped	24
Unanswered	24

21. How much, in your opinion, smart farming systems contribute to the education on new technological systems of province population



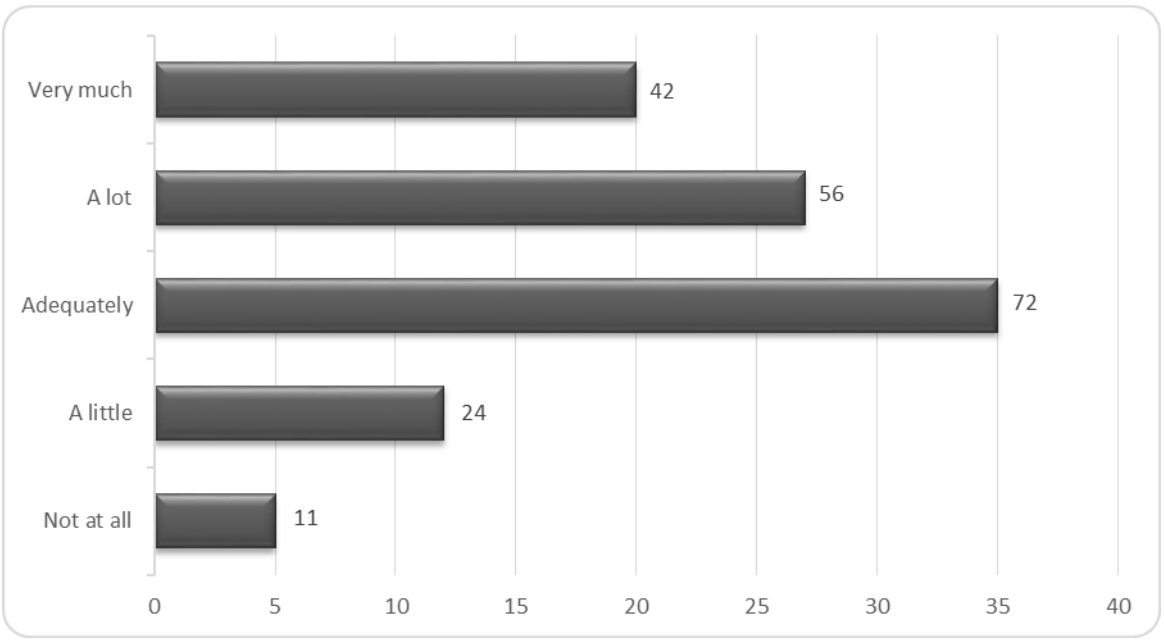
Value	Percent	Count
Not at all	7.69%	16
A little	15.38%	32

Adequately	37.98%	79
A lot	25.00%	52
Very much	13.94%	29
Total		208

Statistics

Total Responses	208
Skipped	24
Unanswered	24

22. How much, in your opinion, smart farming systems contribute to the image and the trust of Greece in foreign markets

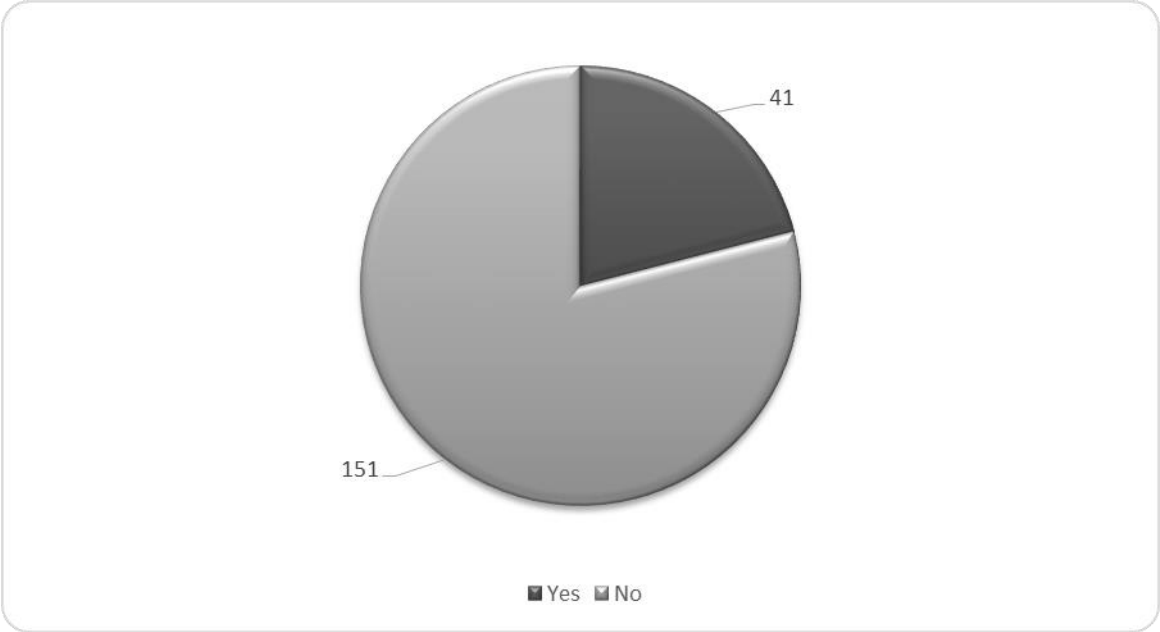


Value	Percent	Count
Not at all	5.37%	11
A little	11.71%	24
Adequately	35.12%	72
A lot	27.32%	56
Very much	20.49%	42
Total		205

Statistics

Total Responses	205
Skipped	27
Unanswered	27

23. Do you believe that farming smartification can contribute to another sector except from economy, environment and society? If yes, which one?



Value	Percent	Count
Yes	21.35%	41
No	78.65%	151
Total		192

Statistics

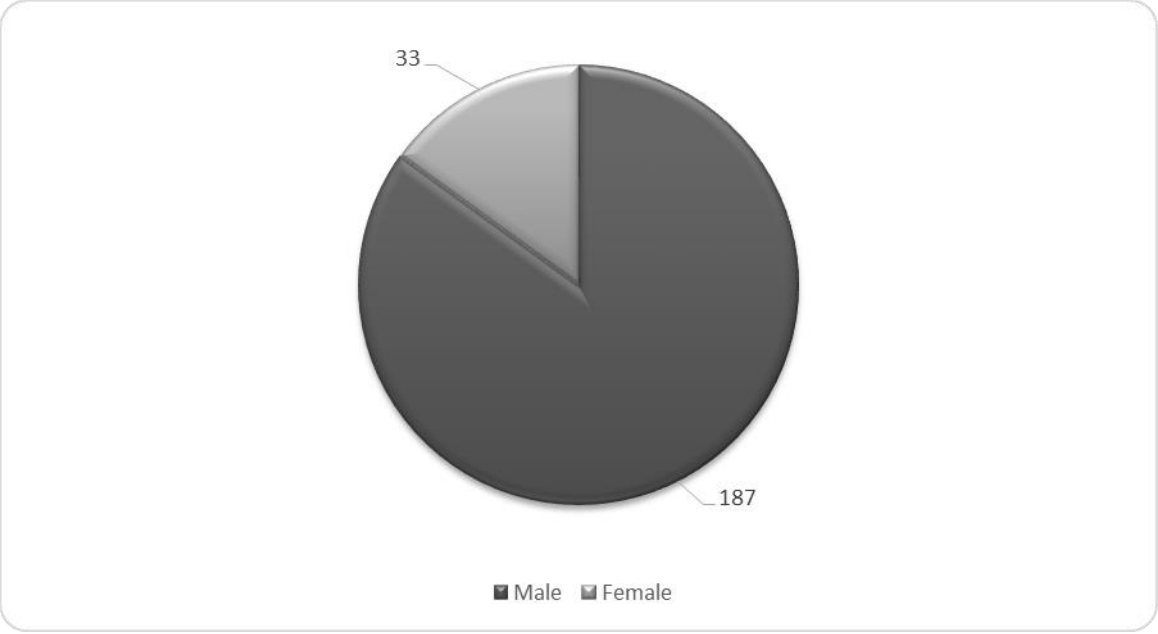
Total Responses	192
Skipped	40
Unanswered	40

Responses "Yes"	Count
Left Blank	191
Exports	1
Productivity	2
As I said, the date of harvest. Optimized plan of planting dates. Connect with MIRC systems for traffic management and inventory. Automated harvesting system with direct packaging of sensitive products. Automatic quality control.	1
Political field: an adjustment of the CAP (common agricultural policy) should be done. If we take as a given that the subsidies is to reduce the cost of farming, and provided that with the above system the production cost will be reduced, so the funds must be distributed differently	1
The creation of a new kind of an agricultural company with a strong point. This will be the highest final product quality. This can give an easy path to the foreign food markets.	1
Scientific fashion (and those who win from it). If all these "smart" scientific interventions were for good, then why more and more land each year is deserted?	1
To the farmer himself, those systems contribute to development of a businessman farmer rather amateur. He learns how to work and be correctly informed, not acting by experience that some-	1

times can be dangerous	
Foreign policy	1
Science	1
New job vacancies	1
Economy	3
Economy and environment	2
Rational management	1
Environment	2
Quality of life	1
Politics	2
To us	1
Technological development, prosperity, global economy	1
Tourism	1
I support the permaculture	1
Dignity	1
Education	2

Education of young people in new technologies	1
Economy, environment, society, health	1
Computer science, networks	1
Information systems	1
technology	2
health	4
psychology	1

24. Sex



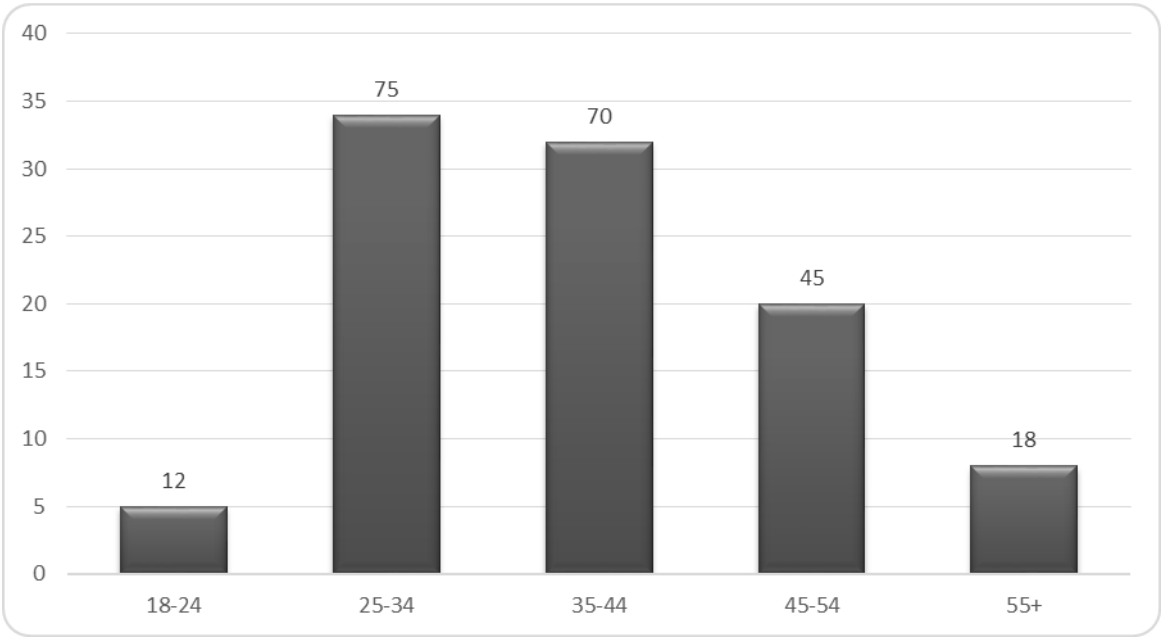
Value	Percent	Count
Male	85.00%	187

Female	15.00%	33
Total		220

Statistics

Total Responses	220
Skipped	10
Unanswered	12

25. Age



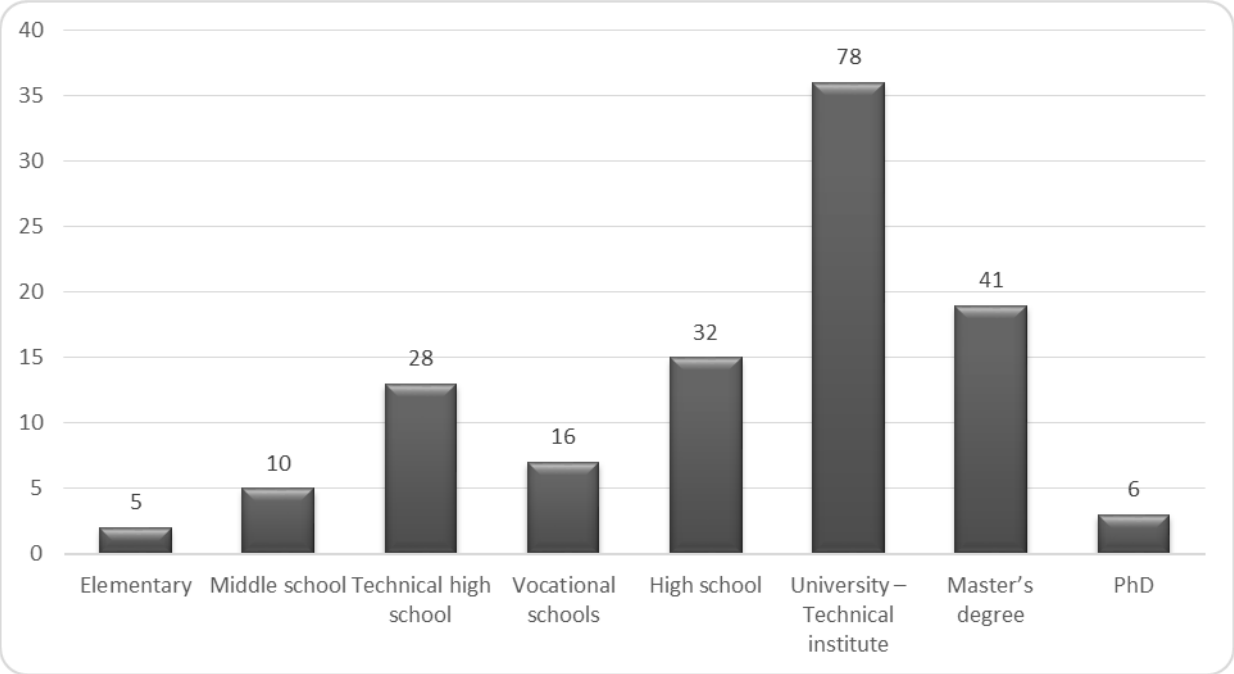
Value	Percent	Count
18-24	5.45%	12

25-34	34.09%	75
35-44	31.82%	70
45-54	20.45%	45
55+	8.18%	18
Total		220

Statistics

Total Responses	220
Sum	7,556.00
Average	34.35
StdDev	10.13
Min	18.00
Max	55.00
Skipped	10
Unanswered	12

26. Educational level



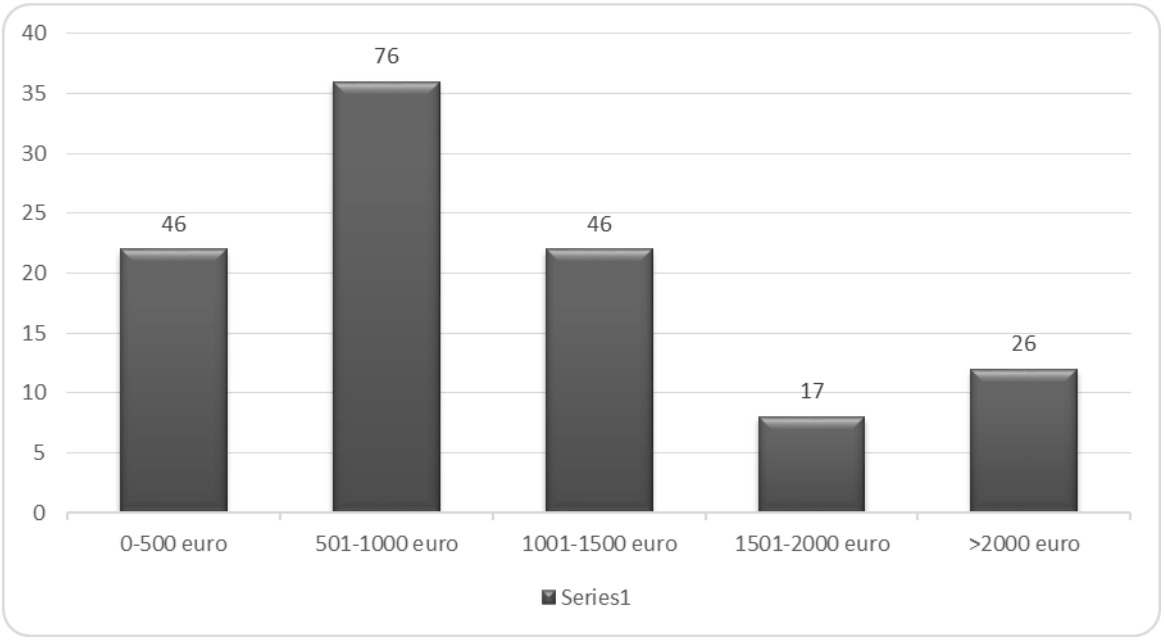
Value	Percent	Count
Elementary	2.31%	5
Middle school	4.63%	10
Technical high school	12.96%	28
Vocational schools	7.41%	16
High school	14.81%	32
University – Technical institute	36.11%	78
Master's degree	18.98%	41

PhD	2.78%	6
Total		216

Statistics

Total Responses	216
Skipped	14
Unanswered	16

27. Gross monthly income



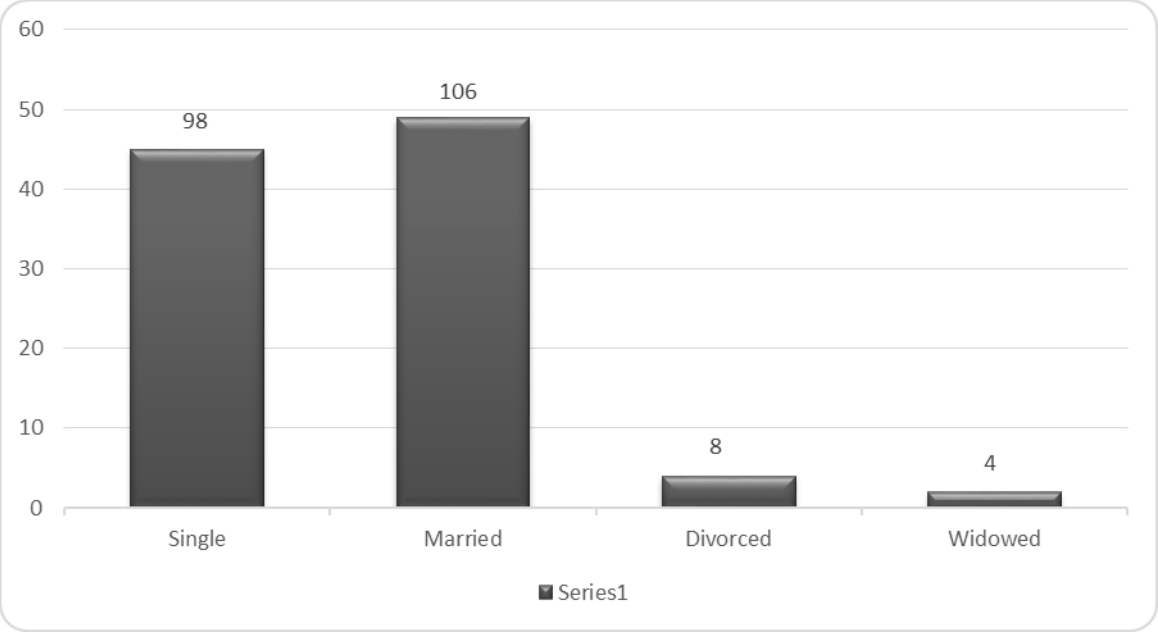
Value	Percent	Count

0-500 €	21.80%	46
501-1000 €	36.02%	76
1001-1500 €	21.80%	46
1501-2000 €	8.06%	17
>2000 €	12.32%	26
Total		211

Statistics

Total Responses	211
Sum	109,639.00
Average	788.77
StdDev	349.61
Min	501.00
Max	1,501.00
Skipped	19
Unanswered	21

28. Marital status

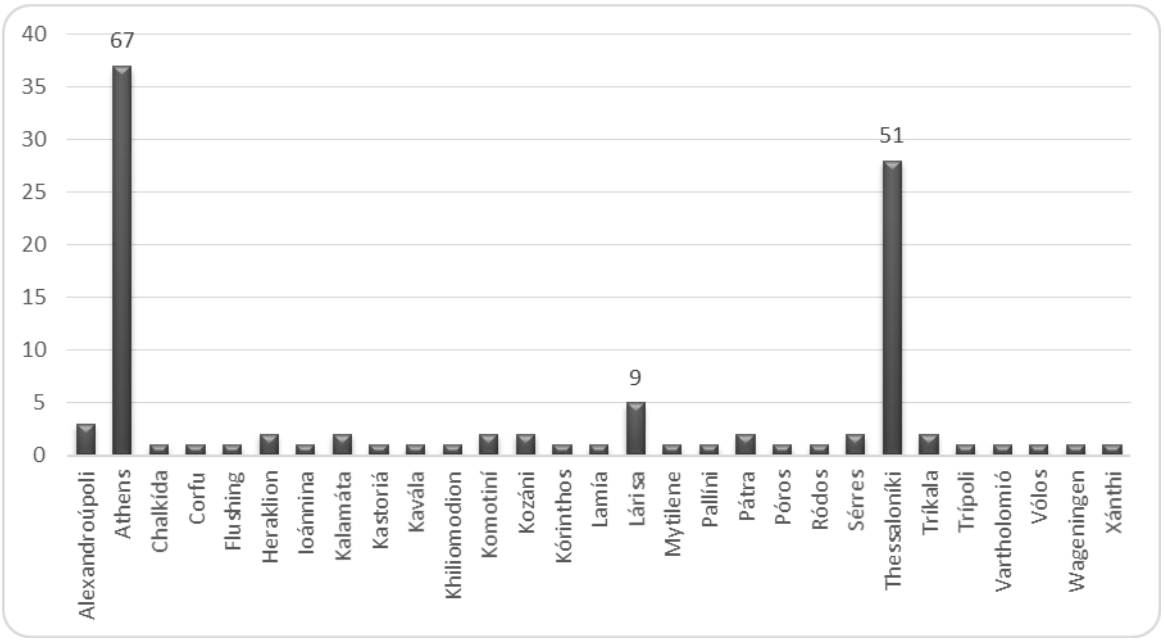


Value	Percent	Count
Single	45.37%	98
Married	49.07%	106
Divorced	3.70%	8
Widowed	1.85%	4
Total		216

Statistics

Total Responses	216
Skipped	14
Unanswered	16

Source Cities



Statistics

Total Responses	179
Skipped	0
Unanswered	53

Appendix V

Cross Tab reports

	Age range					
	18-24	**25-34**	**35-44**	**45-54**	**55+**	**Total**
Do you believe that smart farming applications would benefit your cultivation practices?						
Yes	**10** 83.3%	**68** 94.4%	**58** 89.2%	**36** 87.8%	**15** 88.2%	**187** 90.3%
No	**2** 16.7%	**4** 5.6%	**7** 10.8%	**5** 12.2%	**2** 11.8%	**20** 9.7%
Total	**12** **5.8%**	**72** **34.8%**	**65** **31.4%**	**41** **19.8%**	**17** **8.2%**	**207**

Pearson Chi-Square	2.5444
Degrees of Freedom	4
p-Value	0.6367 (> 0.05, not likely correlated)

	Educational level								
	Elementary	**Middle school**	**Technical high school**	**Vocational schools**	**High Scholl**	**University-Technical institute**	**Master's Degree**	**Doctoral**	**Total**
Do you believe that smart farming applications would benefit your cultivation practices?									
Yes	**3** 75.0%	**7** 87.5%	**26** 96.3%	**12** 85.7%	**30** 96.8%	**69** 89.6%	**36** 90.0%	**4** 66.7%	**187** 90.3%
No	**1** 25.0%	**1** 12.5%	**1** 3.7%	**2** 14.3%	**1** 3.2%	**8** 10.4%	**4** 10.0%	**2** 33.3%	**20** 9.7%
Total	**4** **1.9%**	**8** **3.9%**	**27** **13.0%**	**14** **6.8%**	**31** **15.0%**	**77** **37.2%**	**40** **19.3%**	**6** **2.9%**	**207**

Pearson Chi-Square	7.9681
Degrees of Freedom	7
p-Value	0.3354 (> 0.05, not likely correlated)

	Gross monthly income					
	0-500 €	**501-1000 €**	**1001-1500 €**	**1501-2000 €**	**>2000 €**	**Total**
Do you believe that smart farming applications would benefit your cultivation practices?						
Yes	**37** 82.2%	**67** 91.8%	**43** 95.6%	**16** 100.0%	**21** 87.5%	**184** 90.6%
No	**8**	**6**	**2**	**0**	**3**	**19**

	17.8%	8.2%	4.4%	0.0%	12.5%	9.4%
Total	**45** **22.2%**	**73** **36.0%**	**45** **22.2%**	**16** **7.9%**	**24** **11.8%**	**203**

Pearson Chi-Square	7.0835
Degrees of Freedom	4
p-Value	0.1315 (> 0.05, not likely correlated)

	What in your opinion are the main cultivation characteristics that need constant attention in your production? (You can choose more than one answer)							
	Soil humidity	**Soil characteristics (N, P, K)**	**Daily weather forecast**	**Weather forecast for extreme phenomena**	**Diseases**	**Pests**	**Other**	**Total**
Which of the following smart applications are you interested in embedding on your cultivation?								
Systematic measurement of soil moisture in various strategic points of the field, providing automatic irrigation only in the required areas without having to water the entire cultivated area.	**68** 70.8%	**71** 60.7%	**32** 66.7%	**39** 61.9%	**91** 55.5%	**69** 59.5%	**6** 54.5%	**114** 18.5%

Systematic measurement of the chemical properties of the soil, providing automated fertilization in the required areas with the appropriate required amount.	**63** 65.6%	**80** 68.4%	**30** 62.5%	**41** 65.1%	**95** 57.9%	**67** 57.8%	**6** 54.5%	**117** 19.0%
Systematic measurement of conditions that favor the appearance and spread of diseases and pests, to instantly deploy the needed amount of chemical pesticides.	**67** 69.8%	**84** 71.8%	**36** 75.0%	**53** 84.1%	**120** 73.2%	**86** 74.1%	**8** 72.7%	**138** 22.4%
Use of unmanned aerial vehicles (drones) for automated crop spraying	**20** 20.8%	**29** 24.8%	**14** 29.2%	**18** 28.6%	**33** 20.1%	**25** 21.6%	**1** 9.1%	**42** 6.8%

Automated produce harvesting using GPS, skipping the farmers' direct intervention.	**26** 27.1%	**28** 23.9%	**12** 25.0%	**18** 28.6%	**30** 18.3%	**23** 19.8%	**2** 18.2%	**44** 7.2%
Control and supervision of the production through smart devices such as smartphones or tablets, contributing to instant decision making.	**38** 39.6%	**52** 44.4%	**25** 52.1%	**35** 55.6%	**67** 40.9%	**52** 44.8%	**5** 45.5%	**79** 12.8%
Collection, interpretation and analysis of the cultivation data in order to efficiently control the current production, while self-regulating future needs of the production according to statistical data.	**55** 57.3%	**64** 54.7%	**31** 64.6%	**37** 58.7%	**91** 55.5%	**68** 58.6%	**5** 45.5%	**101** 16.4%
Fully automated operations and	**11**	**15**	**7**	**8**	**22**	**18**	**1**	**25**

accurate control of the conditions in a greenhouse environment.	11.5%	12.8%	14.6%	12.7%	13.4%	15.5%	9.1%	4.1%
Use of small sensors in livestock to fully control health and animal productivity conditions (automatic feeding in the required amount, animal positioning service via satellite).	**18** 18.8%	**21** 17.9%	**8** 16.7%	**16** 25.4%	**31** 18.9%	**23** 19.8%	**1** 9.1%	**34** 5.5%
Other	**3** 3.1%	**5** 4.3%	**1** 2.1%	**1** 1.6%	**6** 3.7%	**5** 4.3%	**1** 9.1%	**7** 1.1%
Total	**96** **15.6%**	**117** **19.0%**	**48** **7.8%**	**63** **10.2%**	**164** **26.7%**	**116** **18.9%**	**11** **1.8%**	**204**

Pearson Chi-Square	3906.0958
Degrees of Freedom	54
p-Value	0 (< 0.05, likely correlated)

In order to make the table readable the applications are abbreviated

	Which of the following smart applications are you interested in embedding on your cultivation? (You can choose more than one answer)										
	Systematic measurement of soil moisture.	**Systematic measurement of the chemical properties of the soil.**	**Systematic measurement of conditions capable of diseases and pests spread.**	**Use of drones for spaying.**	**Automated harvest with GPS.**	**Control of the cultivation through smart devices.**	**Collection and analysis of the cultivation statistical data.**	**Fully automated greenhouse environment.**	**Use of sensors in livestock.**	**Other**	**Total**
Do you believe that smart farming applications would benefit your cultivation practices?											
Yes	**106** 93.8% 101	**115** 98.3% 106	**130** 94.9% 102	**41** 97.6% 105	**43** 97.7% 106	**74** 93.7% 101	**98** 97.0% 105	**25** 100.0% 108	**33** 97.1% 105	**6** 85.7% 93	**188** 26.9 %

No	**7** 6.2% 84	**2** 1.7% 23	**7** 5.1% 69	**1** 2.4% 32	**1** 2.3% 31	**5** 6.3% 86	**3** 3.0% 40	**0** 0.0% N/A	**1** 2.9% 40	**1** 14.3% 194	**15** 2.1%
Total	**113** **16.2%**	**117** **16.7%**	**137** **19.6%**	**42** **6.0%**	**44** **6.3%**	**79** **11.3%**	**101** **14.4%**	**25** **3.6%**	**34** **4.9%**	**7** **1.0%**	**203**

Pearson Chi-Square	1268.6824
Degrees of Freedom	9
p-Value	0 (< 0.05, likely correlated)