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Skills Alliance for Sustainable Agriculture

Project Acronym

SAGRI

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1. Foreword

This Report was prepared with the aim to define the state-of-the-art on agricultural technologies sector, according with Task 2 of Workpackage 2 of the SAGRI Project. It contains all the information collected regarding the most recent practical advancements of the sector, as well as a comparative analysis regarding the advantages of using specific new methods and tools, with respect to the conventional ones.

The recent ready-to-apply advancements in the agricultural technologies sector was here gathered and studied. Particular focus has been put on environmental technologies that are of direct interest for the participant end-users, but also for European farmers in general. This study also includes novel practices and methods for applying advancements in environmental technologies to an agricultural and environmentally challenged society and facilitate the farmers' everyday activities. Additionally, a comparative analysis has been made to point out the benefits of the new tools and methods with respect to the traditional ones.

Moreover, the agricultural research partners (P1, P5, P8) of the SAGRI Project have gathered information regarding the advancement of the application of the directive EU directive 2009/128/EC - establishing a framework for Community action to achieve the sustainable use of pesticides - in their countries. Additionally, they have filtered and categorized the information in the directive, in order to facilitate the transfer of the most critical points of it to the agricultural workers.

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2. Introduction

"Sustainable agriculture" means an integrated system of plant and animal production practices having a site-specific application that will over the long term:

- Satisfy human food and fiber needs.
- Enhance environmental quality and the natural resource base upon which the agricultural economy depends.
- Make the most efficient use of non-renewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls.
- Sustain the economic viability of farm operations.
- Enhance the quality of life for farmers and society as a whole.

The basic goals of sustainable agriculture are environmental health, economic profitability, and social and economic equity (sometimes referred to as the "three legs" of the sustainability tool). Every person involved in the food system — growers, food processors, distributors, retailers, consumers, and waste managers — can play a role in ensuring a sustainable agricultural system.

There are many practices commonly used by people working in sustainable agriculture and sustainable food systems. Growers may use methods to promote soil health, minimize water use, and lower pollution levels on the farm. Consumers and retailers concerned with sustainability can look for "values-based" crops that are grown using methods promoting farmworker wellbeing, that are environmentally friendly, or that strengthen the local economy. Researchers in sustainable agriculture often meet cross-disciplinary lines with their work: combining biology, economics, engineering, chemistry, community development, and many others. However, sustainable agriculture is more than a collection of practices. It is also a process of negotiation: a push and pull between the sometimes competing interests of an individual farmer or of people in a community as they work to solve complex problems about how we grow our food and fiber.

A systems approach implies interdisciplinary efforts in research and education, this requires not only the input of researchers from various disciplines, but also farmers, farmworkers, consumers,

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policymakers and others. For farmers, the transition to sustainable agriculture normally requires a series of small, realistic steps. Family economics and personal goals influence how fast or how far participants can go in the transition. It is important to realize that each small decision can make a difference and contribute to advancing the entire system further on the "sustainable agriculture continuum." The key to moving forward is the will to take the next step.

The main goal of the SAGRI project is to allow agricultural workers or farmers to acquire skills, knowledge and ability to understand and analyse agro-environmental systems as natural ecosystems modified by human activity – in the framework of the modern concept of rural landscape - with an emphasis on environmental technologies that can be applied to achieve crop sustainable production by means of improved systems management.

Thus, this document tries to find science-based solutions to today’s biggest sustainability challenges for farmers. Through interdisciplinary research, partnerships with expert farmers, other agricultural professionals and innovative communication, is considered a correct way to conserve and regenerate critical natural resources while maintaining agricultural productivity at the farm, regional, and state level. It is important to point out that reaching toward the goal of sustainable agriculture is the responsibility of all participants in the system, including farmers, labourers, policymakers, researchers, retailers, and consumers. Each group has its own part to play, its own unique contribution to make to strengthen the sustainable agriculture community.

To be sustainable, the system must be profitable. Profits generate support for all the activities outlined in the Integrated Farming Framework. Financial support for environmental and biodiversity activities varies throughout the European Community but in all cases requires the farmer to commit labour and planning to such activities (EISDA, 2012).

Integrated Farming goes beyond simple compliance with current farming regulations, reinforces the positive impact of farming practices on the environment and reduces their negative effects, without losing sight of the profitability for the farm. It is geared towards the optimal and sustainable use of all farm resources such as farm workers, livestock, soil, energy, water, air, machinery, landscape and wildlife. This is achieved through the integration of natural regulatory processes, on-farm alternatives and management skills, to make the maximum replacement of off-farm inputs, maintain species and landscape diversity, minimise losses and pollution, provide a safe and wholesome food supply and sustain income. If external resources are needed, there is a clear focus on using local resources first.

The strategies to reach a sustainable agriculture in a holistic all farm approach are grouped according to areas of concern: Farming and Natural Resources, Plant and Animal Production Practices, and the Political, Economic, Social and Technical (PEST) Context. They represent a range of potential ideas for individuals committed to interpret the vision of sustainable agriculture within their own circumstances. The changes in technology, work organisation and available tools have and are changing the skills requirements of agricultural workers, concerning:

a) Green skills. Skilled agricultural workers increasingly need to have a holistic awareness of sustainability. This may relate to understanding climate changing, the need for carbon emission reduction, renewable energy, biofuels, water resources and ecosystems management, and to be updated with new regulations and legislation linked to the sustainability agenda.

b) Digital or technological skills. Skilled agricultural workers will need to be able to understand and apply new technologies related to: primary production for both food and non-food uses, soil science, crop and livestock genetics, agri-chemicals and general purpose technologies such as remote sensors, satellites and robotics.

Of course, not all agricultural workers or farmers have sufficient knowledge to understand all the new developments in agriculture applied research, since some of them require a minimum education level. Therefore, prior to identifying the skills it is mandatory to define the agricultural worker profile to whom they are destined. In the SAGRI project we decided to analyse the skills needs of an agricultural worker or farmer considering that he or she would have a minimum education level of high school and a basic knowledge and experience in agriculture, at a practical level. Seven major areas were identified in a significant technological developments that can help farmers for a more sustainable agriculture: 1) Precision technology; 2) Remote sensing to assess land capability; 3) Integrated pest management in plant protection; 4) Agricultural reuse of organic

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residuals; 5) Drip irrigation and water-conserving technologies; 6) Renewable energy and its application as green agricultural energy source and 7) Bioenergy and energy crops.

These skills will be the basis for the developing of new innovative curricula integrating the latest advancements of the "agri-tech" sector, and training courses for agricultural workers according to the EQF/ECVET framework.

3. Specific skills

The role of implicit learning in skill acquisition and the distinction between implicit and explicit learning have been widely recognized in recent years. The two different directions of learning (*top-down* versus *bottom-up*), provide a new perspective on skill learning (Sun, 2004). The skill learning, in terms of *top-down* learning, that is learning that goes from explicit to implicit knowledge) have been identified in the framework of the SAGRI project for each of the proposed training modules. They are job-specific skills with a highlight in the awareness for all agricultural sustainability aspects and in the introduction to major technological developments in the specific areas. The introduction of new technologies for supporting agricultural sector management allows the efficiency and quality of production to be improved and, at the same time, reduces the environmental impact. The rapid evolution of information communication technologies and geographical science offers enormous potential for the development of optimized solutions for distributed information for precision agriculture.

3.1 Precision technology

The last 10 years have seen a rapid evolution in technology, especially in the world of agriculture. Precision agriculture (PA), or precision farming, is a term that has become increasingly popular with the rise of technology. It is a modern farming management concept using digital techniques to monitor and optimise agricultural production processes. Rather than applying the same amount of fertilizers over an entire agricultural field, or feeding a large animal population with equal amounts of feed, PA will measure variations in conditions within a field and adapt its fertilizing or harvesting strategy accordingly (EPRS, 2016). Likewise, it will assess the needs and conditions of individual animals in larger herds and optimise feeding on a per-animal basis. This study intends to inform all stakeholders in agriculture sector about the current state-of the-art, possible developments for the future, societal concerns and opportunities, and policy options for European

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policy-makers to consider. At the present, a wide range of enabling technologies for PA are available.

The specific skills that could be reached thanks to practical technological advancements in Precision Agriculture are:

a) Notions on the concept and principles of Precision Agriculture and the potential benefits from its use. The methods of PA rely mainly upon a combination of new sensor technologies, satellite navigation and positioning technology, and the Internet of Things. PA has been making its way into farms across Europe and is increasingly assisting farmers in their work. The aim is to save costs, reduce environmental impact and produce more and better food.

b) Notions on the criteria for PA adoption and implementation. PA methods promise to increase the quantity and quality of agricultural output while using less input (water, energy, fertilizers, pesticides, *etc.*). First implementations of PA practices already exist in arable, vegetable and dairy farming, but PA technologies can also be applied to other sectors. Now, a lot of progress has been made in PA development, and the PA market is fully embraced by the sector and investors, but the full potential of PA has not yet been harnessed.

c) Notions on the better techniques and technologies to evaluate field variability. Making farmers the owners of their data and providing opportunities to control the flow of their data to stakeholders should help build trust with farmers for exchanging data and harvest the fruits of the analysis of big data. Rural development policy and regional policy should guarantee access to wide bandwidth in the internet (4G / 5G) and help to find new forms of employment in case agriculture becomes less labour intensive. Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD). This regulation lays down general rules governing Union support for rural development, financed by the EAFRD and established by Regulation (EU) No 1306/2013.

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d) Skills for implementation and/or use of precision technologies. The PA technologies are used for object identification, geo-referencing, measurement of specific parameters, Global Navigation Satellite Systems (GNSS), connectivity, data storage and analysis, advisory systems, robotics and autonomous navigation. For the development of precision agriculture practices, question of data management, data ownership and access to open data is of key importance. Special attention is needed for establishing an open data approach throughout the food chain, with adequate standards that facilitate data exchange while preventing misuse of natural monopolies or lock-in effects. Beyond the sustainability issue, PA already offers technologies for producing more agricultural output with less input. For instance, sensor-based monitoring systems provide farmers with better information and early warnings on the status of crops, and improved yield forecasts. PA also plays a major role in animal husbandry. PA will contribute more and more to food safety. PA makes farming more transparent by improving tracking, tracing and documenting. Crop and livestock monitoring will give better predictions on the quality of agricultural products. The food chain will be easier to monitor for producers, retailers and customers. It will also play a significant role in terms of plant health. Current technologies allow to monitor to different levels of resolution in precision farming.

PA uses not only satellite navigation and positioning systems but also a wide range of other technologies. These cover: (EPRS, 2017):

- Automated steering systems, which can take over specific driving tasks such as auto-steering, overhead turning, following field edges and overlapping of rows. Automatic steering systems reduce human errors. In addition, they contribute to effective soil and site management. Automated headland turns could, for instance, already save from 2 % up to 10 % fuel consumption (EPRS, 2016).
- Geo-mapping, which are used to produce maps identifying, for instance, types of soils and levels of nutrients for particular fields. With this aim they can be used to correlate production techniques and crop yields with land variability. The correlation enables the farmers to develop the most effective soil/plant treatment strategies, hence enabling higher

farm production. Today, farmers in developed countries use GPS mapping for more precise application of pesticides, herbicides, and fertilizers; better control and dispersion of these chemicals are possible through precision agriculture, thus reducing expenses, producing a higher yield, and creating a more environmentally friendly farm (http://farmnxt.com/). Remote Sensing, Geographic Information Systems (GIS), and Global Positioning Systems (GPS) may provide technologies needed for farmers to maximize the economic and environmental benefits of precision farming. However, most farmers do not have the skills to utilize these technologies effectively (Seelan et al., 2003).

- Sensors and remote sensing, with which data can be collected from a distance to evaluate soil and crop health, measuring parameters such as moisture, nutrients, compaction, and crop diseases. These sensors can be installed on mobile machines. EU farmers already make use of a wide range of sensors for capturing variations in properties of soils and crops, weather conditions and animal behaviour. Thermal, optical, mechanical and chemical measurements by sensors are applied to quantify crop biomass, plant stress, pests and diseases, soil properties, climatic conditions (Gebbers, 2014).
- Agricultural robots of the future will be autonomous and able to reconfigure their own architecture to perform various tasks. They will offer an enormous potential for sustainability:
    - They will ease the energy transition. Robots will be powered by electricity. The required electricity could be produced at the farm site.
    - They can minimise soil compaction due to heavy machinery. Swarm robots will be lighter and able to intervene only where they are needed, staying permanently on the fields. (Swarm robots are a group of simple robots, which can be coordinated in a distributed and decentralised way, in order to jointly execute more complex tasks).
    - Less work effort and resources input will be required, and robots will most likely provide greater output, as they already do in the dairy industry.

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- o Robots will optimise inputs used by farmers (fertilizers, pesticides, insecticides) and reduce the impact on soils and water tables.

3.2 Remote sensing to assess land capability

As land is a limited resource and the competition between land use alternatives is complex, a knowledge of physical constraints identified from a land capability assessment, becomes a major consideration in any planning exercise. Building a solution to these constraints or potential problems into the planning phase of a project is generally cheaper than using a restoring approach afterwards. If soil and landform characteristics are neglected soil erosion, flooding and slope failure can result as development proceeds. Much of this damage results from disturbance and mismanagement during the construction phase but may continue well after construction has finished in areas of critical erosion risk (http://www.legislation.act.gov.au).

The agricultural workers need some information regarding the use of remote sensing for land capability assessment. The specific skills that could be reached thanks to practical technological advancements in Remote Sensing to assess land capability are:

a) To understand the concepts of land capability and land suitability. Land capability or suitability analysis requires the use of different kinds of spatial and non-spatial data (soil, climate, land use, topography, *etc.*). These data can be incorporated into a Geographical Information Systems (GIS) to attain diverse thematic information to be used in land assessment procedures. The use of remote sensing techniques, due to its capacity to cover large areas within a reasonable time and reliable accuracy, has become increasingly important to collect large amounts of field data, facilitating the evaluation of land use possibilities.

b) <u>Notions on land evaluation objectives, principles and land classification.</u> Land capability assessment comprises an extension of erosion risk to consider the consequences of development on a particular area of land. When the effect of a proposed development is

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considered in conjunction with the erosion risk, it becomes the erosion hazard. The converse to this is consideration of the soil or slope development constraints that may occur in an area. These two complementary pieces of information provide an assessment of the capability of an area of land to support a particular land use. Numerous factors contribute to the initiation of erosion during development. These include the destruction of vegetation and disturbance of the ground surface caused by the construction of access roads, disposal of runoff, excavation and land filling. Unsuitable stabilisation techniques also initiate or aggravate erosion and may prolong its effects after the construction phase. Erosion risk assessment includes characterisation of soil properties and identification of temporary and permanent conservation practices that may be required. These may be land grading and shaping, terraces, surface and subsurface drains, diversions, berms, sediment basins, waterways, grade stabilization structures, plant cover on critical sites and mulching. Consequently, land capability assessment will provide three sorts of information:

- erosion risk based on existing conditions
- erosion hazard which factors in how development activities can increase erosion risk
- constraints on development imposed by natural conditions.

c) Notions on land evaluation procedures and required data. Detailed information of soil profile properties is essential for initiating crop suitability evaluation. Hence, soil survey data are indispensable for generating a soil map of the given region, which helps in deriving crop suitability and cropping system analysis. RS data coupled with soil survey information can be integrated in the geographical information system (GIS) to assess crop suitability for various soil and biophysical conditions.

d) To know the definition of remote sensing, its principles and major techniques for land capability assessment. Remote sensing (RS) data are used for estimating biophysical parameters and indices besides cropping systems analysis, and land-use and land-cover estimations during different seasons (Rao et al., 1996 and Panigrahy et al., 2006). However, RS data alone cannot suggest crop suitability for an area unless the data are integrated with the site-specific soil and climate data. RS data can be used to delineate various physiographic units besides deriving ancillary information about site characteristics, slope, direction and aspect of the study area.

3.3 Integrated pest management in plant protection

“Integrated pest management” means careful consideration of all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms and keep the use of plant protection products and other forms of intervention to levels that are economically and ecologically justified and reduce or minimise risks to human health and the environment. ‘Integrated pest management’ emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms, according with the European Parliament and Council Directive 2009/128/EC, which establishes a framework for Community action to achieve the sustainable use of pesticides.

The application in Italy of the EU Directive 2009/128/EC on the sustainable use of pesticides has been transposed into Italy by Legislative Decree No. 14 of August 14, 2012, published on the Italian Official Journal – G.U. n.202 of 30 August 2012. After years of battles over the introduction of the recipe as in the medical field, this Law has introduced the figure of the Consultant, *i.e.*, a figure with a qualification certificate that must be provided to be able to market the agrochemicals, having adequate training on the techniques of Integrated defense and not just to provide buyers with all the information they need to use (and above all to post-use) the agropharmaceuticals. Thanks to this Law – which entered into force in November 2015, overcoming the previous Italian legislation (DPR 1255 of 1968) - the following novelties were introduced: Certification for using all chemical products; periodical control of equipment and machines; ban of aerial treatments (with some possibility of derogation); water protection; reduction in the use of plant protection products in some specific areas; confirmation of the Register of Treatments; Integrated Defense

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compulsory. Some of these new obligations are anyway currently still far to be actually implemented, while relevant controls are still in a definition phase.

The application of the directive 2009/128/EC in Greece was transposed with the law 4036/2012 (A'8) issued on 27-1-2012. The scope of the law was the transposition of this directive to national legislation and in addition to establish national compliance measures to the requirements of the directive 2009/128/EC.

For this reason the provisions of this directive were transposed by the articles 15 to 31, which were separated in a chapter characterized as "Measures for the immediate implementation of the directive 2009/128/EC" followed by the article 32 to 46, which were separated in another chapter characterized as "National compliance measures to the requirements of the directive 2009/128/EC".

The National Action Plan was fully described in the law and certain provisions of the law 4036/2012 provided measures evaluated as critical for the implementation of sustainable use of pesticides in Greece such as an electronic application for the collection of statistical data on pesticide sales by the retailers.

The National Action Plan was issued by the Common Ministerial Decision number 8197/90920/22-7-2013 signed by the Minister of Rural Development and Food, the Minister of Environment, Energy and Climate Change and the Minister of Health.

In the present site of the Ministry of Rural Development and Food, the part of the law 4036/2012 referring to directive 2009/128/EC and the Hellenic National Action Plan on Sustainable Use of Pesticides are available in English.

The application of the European Directive 2009/128 / EC in Portugal took place in two phases. The Decree-Law no. 86/2010 of July 15, 2010, which turned compulsory the inspection of equipment for application of plant protection means. In 2013 the Law 26/2013 of April 11, regulates all aspects of the sale, distribution, marketing, transportation, storage and application of plant protection products.

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The application of these legal documents was made progressively, as foreseen by the European Directive 2009/128 / EC and began in November 2014 (January 1, 2014), with the obligatory agricultural production under the principles of Integrated protection. This passage to the principles of integrated protection, required the review of all plant protection products approved by the General direction of Agriculture and Veterinary (DGAV) of the Ministry of Agriculture, namely the list of active substances accepted in integrated protection.

The Law no. 26/2013 of April 11 implied the training of everyone involved in the sale and / or application process. In this context, all users of any plant protection product must have an applicator card and their number must be recorded in the act of sale by the reseller. The act of sale, now defined by article 9 of Law no. 26/2013 of April 11, as a responsible selling act, requires compliance with several requirements, namely: to alert the buyer to the possible risks that the plant protection products contain; to inform the buyer of the precautions to be taken to avoid risks to the use of plant protection products and to advise on the correct conditions for the use, transport and storage of plant protection products, in particular procedures for the treatment of packaging waste and surplus plant protection products.

This Law strengthens the role of the entity providing services in the field of land application of plant protection products, which must be recognized by the DGAV for work in both agricultural and forestry areas, or in non-agricultural areas. The article 8 of the European Directive 2009/128 / EC was transposed to PT legislation by the Decree-Law no. 86/2010 of 15 July. This document establishes the obligation to inspect all equipment for the application of plant protection products in use up to the date of November 26, 2016, based on the European Standard NPEN 13790: 2003. Inspection of plant protection product equipment should take place in the Community area (Member States), and inspections should be accepted and recognized. The equipment for the application of new and inspected plant protection products is valid for 5 years until the next inspection is carried out, a period that decreases to 3 years after January 1, 2020. The Spraying Periodic Inspection Centers (CIPP) are recognized by the DGAV and its list as well as the list of all authorized inspectors is disclosed by DGAV on its website.

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The specific skills that could be reached thanks to practical technological advancements in integrated pest management are:

a) Notions on general goals and principles of integrated pest management (Directive 2009/128/EC Annex III); the term "integrated pest management (IPM)" was originally developed as *Integrated Pest control* in 1959, focusing on pest scouting to determine threshold for application of pesticide. However, this approach was changed in 1970's to integrate farm and natural resource management, after realizing that the agricultural practices influenced pest development, and that crop intensification often leads to increased pest problems. Therefore the pest management measures have to fit into farming system. Directive 2009/128/EC Annex III has the objective to establish a framework to achieve a sustainable use of pesticides by reducing the risks and impacts of pesticide use on human health and the environment and promoting the use of Integrated Pest Management and of alternative approaches or techniques such as non-chemical alternatives to pesticides. There are some recent advancement under IPM that may play significant role (Patel, 2015).

- Judicious use of pesticides: Pesticide players from private industry, central and state government has to come together to design a road map for right use of pesticides and stopping the spurious one.
- Novel insecticides: Excellent efficacy, high selectivity and low mammalian toxicity make novel insecticides as attractive replacement for organophosphates, pyrethroids and carbamate. Majority of them are considered as 'reduced risk' insecticides. The wide variety of new modes of action is extremely helpful for delaying resistance in key pests.
- Seed treatment: It must be used as basis for successful validation and implementation of IPM in farmers' field with proper process, appropriate treating agents and due precautions.
- Safe for pollinators: Bee pollination would be made as an essential component of IPM. It is essential to devise location specific IPM modules that will not affect pollinators.

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Chemical pesticides may be used as last resort that too using safer newer selective insecticidal molecules sparing the pollinators.

- Better pesticide formulations: Effectiveness of any pesticides under IPM largely depends on its types of formulation. New generation formulations (Water Dispersible Granule-WDG, Suspension Concentrate-SC, Concentrated Emulsion-CE, Microemulsion-ME, Controlled Release (CR), Suspo Emulsion (SE), Tablet Formulation (WT), Multiple Emulsion Formulation and Nanoformulation) are relatively more effective, safe, easy to handle and environment friendly compared to conventional formulations.
- Balanced nutrition and good crop health: Pest preference and their multiplication remains less in nutritionally balanced healthy crops. The role of beneficial elements like Silicon (Si) is to be checked in understanding pest population dynamics and pest-disease resistance.
- Pesticides resistance management as part of IPM: There is now strong recommendation that Resistance Management Programme is to be developed within the framework of an overall IPM approach for a given pest and cropping system. Tactics developed for resistance management include mixtures of pesticides, rotation of pesticides, use pesticides with different mode of action, need based application of pesticides, use effective pesticides with recommended doses etc.
- Agro advisory in IPM: It is now great useful for agro-meteorologists, forecasters, modelers, farmers and other stakeholders to harness the potentialities of weather based pest forecasting, weather pest calendar and e-pest surveillance resulting value addition in form of farmers' advisory with special reference to IPM.
- Diagnostic service: Specific right diagnosis of plant pathogens is considered as important step of IPM. In this regard, opportunities have been opened for rapid diagnosis of plant parasitic nematodes and viruses applying molecular technology.
- Contingency plan for pest outbreak: Pest scenario in particular cropping system is already experienced with any time alteration due to climate uncertainty. So,

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contingency IPM plan could be available in hand to manage any sudden pest outbreak situation.

- Plant growth promoting rhizomicroorganisms (PGPR): Bio-inoculants in the form of living microorganisms (bio-fertilizer and bio-pesticide) when applied to seed, root zone or plant surface promotes holistic plant growth that contributes plant resistance against pests.

b) To know relevant national legislation and regulations for the adoption of integrated pest management. One of the key features of the Directive is that each Member State should develop and adopt its National Action Plan and set up quantitative objectives, targets, measures and timetables to reduce risks and impacts of pesticide use on human health and the environment and to encourage the development and introduction of integrated pest management and of alternative approaches or techniques in order to reduce dependency on the use of pesticides. Are included compulsory testing of application equipment, training and certification of all professional users, distributors and advisors; a ban (subject to derogations) on aerial spraying; special measures to protect the aquatic environment, public spaces and conservation areas; minimizing the risks to human health and the environment through handling, storage and disposal.

c) Notions on integrated pest management strategies and techniques, it is possible to define IPM as a strategy or system that combines all available methods to ensure that crop plants are growing healthy so that they produce high yields according to their genetic potential. This is why the fundamental principle of IPM is to grow healthy crops through application of crop health management practices. This is the best approach to effective pest and disease management in the field and in storage which leads to healthy environment and sustainable agriculture for development.

d) Decision making. The involvement of the farmer in the decision making became evident and took into consideration site specific agro-ecological and socio-economic conditions. The current approach to IPM is therefore more participatory and the farmers have to participate in the technology development or adaptive studies in order to determine site

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specific solutions. Both farmers and experts focus on producing a healthy crop that in turn produces high yield and profitability. Therefore in order to implement a successful IPM, we have to think on how to grow healthy plants on healthy environment and find out what they need in order to grow and give high yield profitably. All crops need fertile soils, enough water, and sufficient sunlight and usually suffer from pests, diseases or weeds at any stage of crop growth. Under the favorable conditions, crop plants will grow and produce abundant fruits and seeds. Therefore, in the absence of insect pests, diseases, weeds, poor soils and water shortage, crops will grow healthy and strong.

e) Notions on the standards for a sustainable use of plant protection products: Plant disease management is based on several important principles. While plant disease control is often not practical or even possible, it may be possible to reduce the progress of the disease and keep it at an acceptable level (University of Nevada):

- Exclusion of plant diseases consists of practices designed to keep pathogens (things that cause disease), vectors (things that spread disease) and infected plants out of disease-free areas. The goal of this method of management is to prevent the disease from entering the area where the plants are growing. For example, never plant diseased or infested plants. Another method is to establish plants in areas where the disease organism does not occur.
- Eradication consists of eliminating, destroying or inactivating a disease organism after it has become established. This includes:
  - Destruction of infected plants
  - Disinfection of storage bins, containers and equipment
  - Soil disinfection by fumigation, pasteurization, solarization or drenching.

Since complete eradication is not always possible or economically feasible, this control method also includes reduction of the disease organism to an acceptable level. Reducing the level of infestation involves cultural practices, such as sanitation, removing diseased

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plants or plant parts, rotating crops, eliminating weeds or other plants that may be alternate hosts for the disease, and discouraging or preventing insect vectors.

- Protection establishes a chemical or physical barrier between the host and the cause of the disease. For example, there are chemical applications available to prevent a disease from becoming established, such as fungicidal dusts and nematicides (nematode controls).
- Resistance. This method of control focuses on planting resistant varieties. Resistance is achieved by altering the genetic system of the host to make it less susceptible to the disease organism. There are two types of resistance used in plant disease management. Vertical resistance provides very high level resistance, or immunity, to specific strains of disease organisms. Horizontal resistance is a lower level of resistance, or tolerance, to many more strains of disease organisms. Both types of resistance are used in the development of agricultural crop plants. There are also many trees, shrubs, and ornamental and vegetable crops with resistant varieties on the market.
- Therapy. This method of plant disease management is achieved by incorporating a chemical control agent into the physiological processes of the plant to reverse the progress of disease development after infection has occurred.
- Avoidance. This method of plant disease management includes cultural practices that help avoid the potential for infection. Practices such as planting date selection, seedbed preparation and water management are cultural practices that help avoid disease. Poorly drained soils, shade and other factors can increase the susceptibility of plants to disease.

By using remote sensing and GPS, it is possible to identify the exact location where the application of fertilizers or pesticides is required. The Variable Rate Treatment (VRT) is a system that regulates the rate of pesticides or fertilizers, releasing only the required amount over the areas or the field that are in need of the chemicals. It greatly reduces the amount of chemicals that are applied in the field. This leads to lower cost for the farmer, since less quantities are required, and also has a reduced effect to the environment (http://www.seos-project.eu). In addition to pesticides and fertilisers, water is becoming a very valuable commodity, as good quality water is becoming

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less and less available around the world. Saving on water with the use of variable-rate treatments is already important and will become even more significant in the years to come.

3.4 Agricultural reuse of organic residuals

Organic residual materials or organic fertilizers are vital to the capacity of soils to reproduce humus and play a key role in the recycling of plant nutrients. In terms of their quantity and use, two opposing trends have been seen in recent years. While the volume of organic fertilizers generated by agriculture and reapplied in agriculture has risen sharply in regional terms, non-agricultural demand for biomass hitherto used to replenish humus levels has also developed strongly over the same period. The growing quantity of organic fertilizers can be attributed (i) to the regional increase in livestock farming and (ii) to the rise in digestates resulting from greater biomass fermentation in biogas plants. In addition, organic residual materials from wastewater treatment as well as from industrial and household waste are used for agronomic purposes (Scientific Advisory Board on Fertilizers Issues at the Federal Ministry of Food and Agriculture, 2015). The following factors pose a particular problem as regards the correct use of fertilizers in agriculture in line with the Fertilizers Act and the Fertilizer Application Ordinance:

- the local and regional concentration of livestock farming and biogas production which often leads to a nutrient surplus at farm, local and regional level,
- the growing pressure that this produces to use the surplus at inter-farm and supra-regional level, which in turn leads to increased phytosanitary risks and risks of infection in respect of farm manure too, and
- the contamination of organic fertilizers and organic residual materials by inorganic and organic pollutants. The growing non-agricultural demand for biomass can be explained primarily by the possibilities to either recycle straw or use it as a means of generating energy. Taking straw out of the agricultural material cycle poses a problem if humus is not sufficiently replenished or the increased use of alternative fertilizers to replenish humus

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results in soils becoming contaminated. Organic fertilizers and organic residual materials are to be assessed in terms of their nutrient contents and nutrient availability, pollutant contents, nutrient and pollutant loads as well as with regard to the phytosanitary risks associated with their use in agriculture. The estimated requirement, actual quantities and an assessment of benefits and risks are to provide a basis on which the areas of agriculture, administration, policy-making and legislation can issue recommendations regarding the use of organic fertilizers and organic residual materials.

Based on the current crop growing statistics (Statistical Yearbook 2014), it was assumed when calculating the nutrient requirement (nitrogen (N), phosphorous (P), potassium (K)) that the quantity of fertilizer required in the medium term will correspond to the nutrient uptake (harvest products and joint products) of the various crops. This nutrient requirement was compared with the actual quantity of nutrients contained in the aforementioned organic fertilizers and joint products from crop farming and generated by the cultivation of both humus-enhancing crops and green manure crops (nitrogen fixation by legumes). When considering all substance groups, approximately 91% of the N requirement, 71% of the P requirement and 76% of the K requirement for crop farming is contained in organic fertilizers and organic residual materials, although the actual degree of effectiveness is not taken into account. Within the current global trend aimed to exploit renewable energies and reuse the by-products, agriculture may play a significant role, mainly when the energy valorization of agricultural by-products, co-products and waste is concerned. Agricultural biomass is a diffuse source of energy, having one of the highest potential to cover renewable energy needs for the future, but the previous restoration of organic matter in the soil should be anyway properly considered (Blaschke et al., 2013; Statuto & Picuno, 2017). It is also important to consider the best solution of the possible reuse of by-product in high value chains, in agricultural sector, according to the waste management hierarchy that indicate as the best solution the prevention of non-waste. When the waste is produced, the suitable way is to reuse the by product in other sector, after that there is the possibility to recycling and recovery before the last possibility that is the disposal (http://ec.europa.eu).

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The specific skills that could be reached thanks to practical technological advancements into agricultural reuse of organic residuals are:

a) Notions on available organic residuals and their potential uses. Farm-produced fertilizers, digestates from biogas facilities and harvest residues are by far the three largest sources of nutrients. By contrast, compost, sewage sludge, animal by-products and presumably plant by-products too are less relevant on the whole in terms of their nutrient replacement capacity. It should be noted that the level of nutrients retrieved from sewage sludge currently used in agriculture only covers around 3% of the potential. Even if all of the sewage sludge produced during public wastewater treatment (1.846 million tonnes of dry matter) were to be used as fertilizer, it would only account for some 10% of the P requirement. Some studies reports that harvest residues can cover approximately 71% of the humus requirement, while the present level of cultivation of humus-enhancing crops and catch crops accounts for just under 8% of the requirement. Farm manure and digestates from biogas plants more than cover the remaining requirement. However, since these contain a large quantity of the substances needed to replenish humus (together they account for 65% of the humus requirement for arable crops), it should be borne in mind that some of the farm-produced manure is to be used on grassland. Compost and sewage sludge play a minor role in humus reproduction and at present only account for approximately 4% of the total humus requirement.
b) To know the legislation regarding the use of organic residuals. Directive 2008/98/EC sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling, recovery. It explains when waste ceases to be waste and becomes a secondary raw material (so called end-of-waste criteria), and how to distinguish between waste and by-products. The Directive lays down some basic waste management principles: it requires that waste be managed without endangering human health and harming the environment, and in particular without risk to water, air, soil, plants or animals, without causing a nuisance through noise or odours, and without adversely affecting the countryside or places of special interest.

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c) Notions on environmental and economic aspects of using organic residuals. Crop residues, manure or compost can be used in agriculture reducing the use of fertilizers, offsetting the environmental impacts of its use (the energy consumption for its production, or gas emissions and leaching), the use of pesticides or irrigation water (European Commission, 2010). This may also bring economic benefits for farmers. However, there can be some biological and chemical risks (from direct exposure or from contamination of food and water), depending on the source of the organic residuals or its previous treatment. Treating material to reduce or eliminate pathogens, for example, will affect costs associated with beneficial uses. To optimize economic benefits, the viability of all end use options must be factored into decision-making processes. Land application of organic residuals may only be feasible if certain economic incentives are instituted. These incentives may evolve as a result of a fuller understanding of the benefits of reusing organic residuals (King et al., 2011).

d) Notions on transport, storage and treatment requirements for different organic residuals. Previous to its use, organic residues may have to be transported to the application site, and in some cases stored or transformed prior to its application. According to Höhn. (Hohn, 2014), the maximum transportation distances for raw materials should vary from 10 to 40 km, depending mostly on the orographic characteristics of the territory. Starting from the quantification of available biomass it could be possible to define different solutions: only one centralized plant, and alternatively two, four or five power plants. The size of each candidate plant was determined according to the extent of its biomass catchment area (supply basin) and the corresponding capacity (electrical productivity) of the plant (Delivand, 2015).

e) Notions on organic residuals management and treatment techniques that could be performed in the agricultural farm. Waste treatment and disposal methods are selected and used based on the form, composition, and quantity of waste materials.

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3.5 Drip irrigation and water-conserving technologies

Improved irrigation technology and advanced farm management practices offer an opportunity for agriculture to use water more efficiently. Farmers may install new equipment, such as drip irrigation systems, or adopt advanced water management practices to conserve water without sacrificing crop yields. Often investment in technological improvements has incurred higher water prices, however, without gaining the full potential benefits through water efficiency. Farmers generally lack adequate means and incentives to know crops water use, actual irrigation applications, crops yield response to different water management practices, and thus current on-farm water-efficiency levels (Levidov et al., 2014).

Irrigation systems have been under pressure to produce more with lower supplies of water. Various innovative practices can gain an economic advantage while also reducing environmental burdens such as water extraction, energy use, pollutants, *etc.*

The specific skills that could be reached thanks to practical technological advancements in drip irrigation and water-conserving technologies are:

a) Manage irrigation following an irrigation scheduling. Farmers can better use technological systems already installed, adopt extra technologies, enhance their skills in soil and water management, tailor cropping patterns to lower water demand and usage, reduce agrochemical inputs, plan the irrigation time in a schedule, *etc.* Water-efficient practices potentially enhance the economic viability and environmental sustainability of irrigated agriculture, without necessarily reducing water usage. Drip irrigation is a technology that can conserve water, improve crop quality, and increase crop production relative to traditional irrigation systems (Alcon et al., 2011). Drip technology improves irrigation efficiency by reducing evaporation from the soil surface, reducing run off and deep percolation, and eliminating the need to drastically over-irrigate some parts of the field to compensate for uneven water application.
b) Definition of different irrigation goals. While farmers decision to adopt water-saving irrigation technology responds to the cost of water, physical properties of the land such as

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topography or soil texture dominate the choice of irrigation technology. Innovative irrigation practices can enhance water efficiency, gaining an economic advantage while also reducing environmental burdens. In some cases the necessary knowledge has been provided by extension services, helping farmers to adapt and implement viable solutions, thus gaining more benefits from irrigation technology. The application of fertilizers and other chemicals can also be optimized through the use of drip irrigation, weed growth can be reduced, and salinity problems can be mediated. Drip irrigation may require less energy than sprinklers, and is very adaptable to difficult soil and terrain conditions.

c) Irrigation system evaluation. A drip irrigation system consists essentially of mainline, sub mains, lateral, drippers, filters and other small fittings and accessories like valves, pressure regulators, pressure gauge, fertilizer application components.
d) Maintenance of irrigation systems. To maintain the irrigation system to ensure his lifespan. The agricultural worker must know how drip irrigation systems, more than other irrigation systems, require a good maintenance, including annual operations to clean filters, pipes and drippers.
e) Irrigation evaluation and monitoring. Properly designed, installed, and managed, drip irrigation may help achieve water conservation by reducing evaporation and deep drainage when compared to other types of irrigation such as flood or overhead sprinklers since water can be more precisely applied to the plant roots. In addition, drip can eliminate many diseases that are spread through water contact with the foliage. Finally, in regions where water supplies are severely limited, there may be no actual water savings, but rather simply an increase in production while using the same amount of water as before. In very arid regions or on sandy soils, the preferred method is to apply the irrigation water as slowly as possible.
f) Notions on the use of low quality irrigation water. The farmer must be aware of the effects of using low quality irrigation water on soils and crops. Because of the way the water is applied into a drip system, traditional surface applications of timed-release fertilizer are sometimes ineffective, so drip systems often mix liquid fertilizer with the irrigation water.

This is called *fertigation*; fertigation and *chemigation* (application of pesticides and other chemicals to periodically clean out the system, such as chlorine or sulfuric acid) use chemical injectors such as diaphragm pumps, piston pumps, or aspirators. The chemicals may be added constantly whenever the system is irrigating or at intervals. Fertilizer savings of up to 95% are being reported from recent university field tests using drip fertigation and slow water delivery as compared to timed-release and irrigation by micro spray heads.

3.6 Renewable energy and its application as green agricultural energy source

Agriculture is the sole provider of human food. Most farm machines are driven by fossil fuels, which contribute to greenhouse gas emissions and, in turn, accelerate climate change. Such environmental damage can be mitigated by the promotion of renewable resources such as solar, wind, biomass, tidal, geo-thermal, small-scale hydro, biofuels and wave-generated power. These renewable resources have a huge potential for the agriculture industry.

The farmers should be encouraged by subsidies to use renewable energy technology. The specific skills that could be reached thanks to practical technological advancements in Renewable energy and its application as green agricultural energy source are:

a) Environmental awareness. The concept of sustainable agriculture lies on a delicate balance of maximizing crop productivity and maintaining economic stability, while minimizing the utilization of finite natural resources and detrimental environmental impacts. Sustainable agriculture also depends on replenishing the soil while minimizing the use of non-renewable resources, such as natural gas, which is used in converting atmospheric nitrogen into synthetic fertilizer, and mineral ores, *e.g.* phosphate or fossil fuel used in diesel generators for water pumping for irrigation. Hence, there is a need for promoting use of renewable energy systems for sustainable agriculture, *e.g.* solar photovoltaic water pumps and electricity, greenhouse technologies, solar dryers for post-harvest processing, and solar hot water heaters. In remote agricultural lands, the underground submersible

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solar photovoltaic water pump is economically viable and also an environmentally-friendly option as compared with a diesel generator set (Chel & Kaushik, 2011).

b) Notions on all possible renewable energy sources. Renewable energy and farming are a winning combination. Wind, solar, and biomass energy can be harvested forever, providing farmers with a long-term source of income. Renewable energy can help to reduce pollution, global warming, and dependence on imported fuels. Renewable energy options for farmers and ranchers can help make renewables a growing source of energy and rural income as (http://www.ucsusa.org):

- Wind Power: Farms have long used wind power to pump water and generate electricity. Recently, wind developers have installed large wind turbines on EU farms and ranches to provide power to electric companies and consumers. Some farmers have also purchased wind turbines; others are starting to form wind power cooperatives. But farmers in many more states could benefit, since some of the best wind resources are found on agricultural lands.
- Biomass Energy: Biomass energy is produced from plants and organic wastes — everything from crops, trees, and crop residues to manure. Crops grown for energy could be produced in large quantities. While corn is currently the most widely used energy crop, native prairie grasses such as switchgrass or fast-growing trees such as poplar and willow are likely to become the most popular in the future. These perennial crops require less maintenance and fewer inputs than do annual row crops such as corn, so they are cheaper and more sustainable to produce. Crops and biomass wastes can be converted to energy on the farm or sold to energy companies that produce fuel for cars and tractors and heat and power for homes and businesses.
- Solar Energy: The amount of energy from the sun that reaches Earth each day is enormous. All the energy stored in Earth's reserves of coal, oil, and natural gas is equal to the energy from only 20 days of sunshine. Solar energy can be used in agriculture in a number of ways, saving money, increasing self-reliance, and reducing pollution. Solar energy can cut a farm's electricity and heating bills. Solar heat collectors can be used to

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dry crops and warm homes, livestock buildings, and greenhouses. Solar water heaters can provide hot water for dairy operations, pen cleaning, and homes. Photovoltaics (solar electric panels) can power farm operations and remote water pumps, lights, and electric fences. Buildings and barns can be renovated to capture natural daylight, instead of using electric lights. Solar power is often less expensive than extending power lines.

c) To know national legislation and regulations promoting the use of renewable energies. The Renewable Energy Directive establishes an overall policy for the production and promotion of energy from renewable sources in the EU. It requires the EU to fulfil at least 20% of its total energy needs with renewables by 2020 – to be achieved through the attainment of individual national targets. All EU countries must also ensure that at least 10% of their transport fuels come from renewable sources by 2020 (Directive 2009/28/EC).

d) Notions on safety measures for using different renewable energy equipment. Farmers have to know about performance of the equipment, the way to improve its lifespan, and the decrease of potential risks to people interacting with them.

3.7 Bioenergy and energy crops

Bioenergy is "energy derived from recently living material such as wood, crops, or animal waste." Bioenergy crops are defined as any plant material used to produce bioenergy. These crops have the capacity to produce large volume of biomass, high energy potential, and can be grown in marginal soils. Bioenergy can contribute to reducing the overall consumption of fossil fuels. It can take the form of solid material (biomass) for combustion or liquid products (Biofuels) that can be used to power vehicles. Both biomass and Biofuels can be derived from dedicated energy crops, agricultural co-products or waste materials. Switchgrass (*Panicum virgatum L.*), elephant grass (*Pennissetum purpureum Schum.*), poplar (*Populus spp.*), willow (*Salixspp.*), mesquite (*Prosopis spp.*), *etc.* have been touted as the crops with the most widespread promise. Planting bioenergy crops in degraded soils is one of the promising agricultural options with C sequestration rates ranging from 0.6 to 3.0 Mg C ha^{-1} yr^{-1}. Bioenergy crops have the potential to sequester

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approximately 318 Tg C yr^{-1} in the United States and 1631 Tg C yr^{-1} worldwide (Dipti & Priyanka, 2013). They contribute to the reduction of greenhouse gas emissions and thus the slowing of climate change and its negative impacts.

The specific skills that could be reached thanks to practical technological advancements in bioenergy and energy crops are:

a) Environmental awareness. As a supplemental alternative energy to coal, bio-energy crops could play an important role as environmentally safe and economically profitable. Bioenergy cannot entirely substitute fossil fuels at present due to the huge cropping areas requirement; nevertheless, it can contribute in reducing the overall consumption of fossil fuels.
b) Notions on the range of bioenergy resources, conversion technologies and markets. Biomass energy is the most abundant and versatile type of renewable energy in the world. Large-scale bioenergy crop plantations will inevitably compete with food crops for land, water, nutrient resources and other inputs; whereas, biodiversity consequences of increased biofuel production will most likely result in habitat loss, increased and enhanced dispersion of invasive species, and pollution. Improvements in composition and structure of biochemical in bioenergy crops will enable the production of more energy per ton of biomass and will improve its caloric value, GHG profile, and GCC mitigation potential (Dipti & Priyanka, 2013).
c) Notions on handling, transport and storage of biomass, bioenergy products and by-products. Bioenergy can be used to produce fuel for the transport sector or through biomass combustion to co-produce heat and/or power. Biofuels appear to be the most viable low carbon transport fuel option in the short to medium term. With rising energy costs and uncertainty of fossil fuel reserves, it's important to oversee cheaper, safer, and more renewable forms of bio-energy.
d) To identify which bioenergy solutions are most appropriate for their own situation, technically and financially. Development of renewable energy can not only contribute to the energy supply, but also to achieve economic and environmental benefits. In recent

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years, many countries have developed policies and objectives for bioenergy and this includes the production of heat, electricity, and fuel. Growing energy crops at a large scale is bound to have significant effects on the countryside and on wildlife that lives in it. Such impacts may range from extremely negative to beneficial.

e) Notions on how to evaluate energy crops as a farm business opportunity. The market for biomass crops is expected to grow significantly - thanks to increasing legislation and government targets to increase the uptake of renewable energy (www.gov.uk). Farmers that are interested in planting the perennial energy crops (SRC or miscanthus) may be eligible for an establishment grant.

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4. Comparative analysis, regarding the advantages of using specific new methods and tools, with respect to the conventional ones.

Traditionally, pen and paper have been used to collect data in the field and for monitoring and evaluation of projects in rural areas. However, this approach is time consuming and susceptible to human error that may affect productivity and accuracy. Information and communication technologies are now being used widely with remarkable positive results to perform these tasks in agricultural development projects.

In a recent global discussion organised by the World Bank to point out the benefits of the new tools and methods with respect to the traditional ones, experts from various fields and organisations around the world shared their experiences and discussed the ways in which they were using ICT – mobile phones, tablets, applications, software, *etc.* – to collect data in the field, and to perform Monitoring and Evaluation (M&E) in development projects, while also working closely with rural communities and taking their feedback. The discussion has been summarised in a policy brief and outlines the benefits of using ICT for data collection. The following important factors should not be overlooked:

• Technology **itself is not sufficient, a well trained team is also required:** case studies show that investing solely in technology will not ensure successful implementation of ICT applications; it is necessary to invest in a team that can effectively perform M&E tasks, as well as to invest in capacity development of the end users who can ensure the sustainability of the project.

• **Complex ICT or complex platforms are not necessarily essential:** technologies already being used by farmers should be taken into consideration. For example, USAid's *Feed the Future* project employs a combination of traditional instruments to collect basic data in the field, which is then recorded in Excel sheets and subsequently shared free of cost with potential buyers in real-time through DropBox.

• **Contextual factors:** local factors such as the lack of adequate resources must be taken into account beforehand (*e.g.* electricity, gender issues, limited network coverage and low bandwidth,

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local languages). Implementation approaches need to identify the specific needs of the intended users by working in collaboration with them. There is not one single solution that fits all projects: context, policies, marketing efforts and incentives are all essential factors to ensure participation from community members.

• **Data integrity and security** must be ensured throughout the project and when using ICT applications. Experts agreed that leveraging location data and other metadata with individual records helps maintain integrity.

More in detail, ***Precision Agriculture*** may improve agricultural yield and reduce potential environmental risks. The main benefits are (http://www.iris-eng.com):

- Monitor the soil and plant physicochemical parameters: by placing sensors (electrical conductivity, nitrates, temperature, evapotranspiration, radiation, leaf and soil moisture, etc.) the optimal conditions for plant growth can be achieved.
- Obtain data in real time: the application of sensing devices in your fields will allow a continuous monitoring of the chosen parameters and will offer real time data ensuring an updated status of the field and plant parameters at all time.
- Automate your field management: by incorporating a Decision Support System (DSS) in Precision Agriculture environment the best conditions for the specific soil and plant species will be automatically optimised based on the data obtained by the sensors. The DSS will suggest the best moment for watering (or whether there is need or not), the need to irrigate to wash the salt content due to an excess in the radicular area, the need to fertilise, etc.
- Save time and costs: by introducing a PA system in the daily operation of an agricultural exploitation time is saved due to the on-line measurement methods. Data from the sensors is automatically transmitted to a central server and this can be consulted using a Smartphone or Laptop. Or even, email or SMS alerts can be programmed to notify the field owner when there is a need to irrigate, fertilise or address any issue in their properties. Moreover, costs in terms of water, pesticides and others are optimised and can easily be reduced.

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- Improve your image: By using PA technology, not only the yield and profits will be increased but also the perception of the general public and Public Administration (through Smart Agriculture and environmental care) towards your activity will be enhanced.

So, Precision Agriculture seems to bring many benefits to farmers and land owners who decide to use technology to manage their fields.

The applications of ***remote sensing to assess land capability*** in agriculture are designed to provide the farmer with timely information about crop progress. Here follow just some of the benefits that can be gained from the use of remote sensing.

- Early identification of crop health and stress
- Ability to use this information to do remediation work on the problem
- Improve crop yield
- Crop yield predictions
- Reduce costs
- Reduce environmental impact
- Crop management to maximise returns through the season
- Crop management to maximise returns during harvest time.

Remote sensing data, used appropriately and at the right times of the season, has the ability to provide benefits to crop health and hence improve production (http://www.regional.org.au).

Integrated Pest Management in plant protection focuses on the long term application of ecologically-friendly biological methods such as natural predators, resistant plant strains, sterile male technique, and so on. IPM aims to slowly reduce the use of pesticides via biological control methods. The main benefits of IPM are (http://greentumble.com):

- Slower development of resistance to pesticides: pests can develop a resistance to pesticides over time. When the applications of the chemicals are used repeatedly, the pests can develop a resistance to the pesticides via natural selection, where the pests that survive the application of the chemicals will pass on their genes to their offspring.

- Maintaining a balanced ecosystem: the use of pesticides may eradicate the pest population. However, there is a risk that non-target organisms are also affected, which can result in species loss. IPM can eradicate pests while maintaining the balance of the ecosystem.
- Better cost vs. value margin: The reduced usage of pesticides is more cost effective in the long term, as IPM controls pests when there are surges, as opposed to the regularly timed application of pesticides.

The ***agricultural reuse of organic residuals*** may provide agronomic and environmental benefits that were either not previously well understood and/or that are critical to addressing emerging environmental issues associated with climate change. Environmental benefits are possible from manure application if manure and manure nutrients are applied and timing and placement follows best management practices. When compared to more conventional fertilizer, manure properly applied to land has the potential to provide environmental benefits including:

- Increased soil carbon and reduced atmospheric carbon levels
- Reduced soil erosion and runoff
- Reduced nitrate leaching
- Reduced energy demands for natural gas-intensive nitrogen (N) fertilizers

Several long-term manure application studies have illustrated its ability to slow or reverse declining soil organic levels of cropland. The ability of manure to maintain or build soil organic matter levels has a direct impact on enhancing the amount of carbon sequestration in cropped soils. Manure organic matter contributes to improved soil structure, resulting in improved water infiltration and greater water-holding capacity leading to decreased crop water stress, soil erosion, and increased nutrient retention (http://articles.extension.org).

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Drip irrigation is a type of micro-irrigation that has the potential to save water and nutrients by allowing water to drip slowly to the roots of plants, either from above the soil surface or buried below the surface. The goal is to place water directly into the root zone and minimize evaporation.

The advantages of ***drip irrigation and water-conserving technologies*** are (http://www.agriinfo.in):

- Maximum use of available water.
- No water being available to weeds.
- Maximum crop yield.
- High efficiency in the use of fertilizers.
- Less weed growth and restricts population of potential hosts.
- Low labour and relatively low operation cost.
- No soil erosion.
- Improved infiltration in soil of low intake.
- Ready adjustment to sophisticated automatic control.
- No runoff of fertilizers into ground water.
- Less evaporation losses of water as compared to surface irrigation.
- Improves seed germination.
- Decreased to tillage operations.

Renewable Energy of all sizes has become a familiar sight around the world for a wide variety of reasons, including economic, environmental, and social benefits. Main advantages coming from ***renewable energy and its application as green agricultural energy source*** are (http://harvestenergysolutions.com):

- Clean water: Turbines and solar panels produce no particulate emissions that contribute to mercury contamination in our lakes and streams. Renewable energy also conserves water resources. For example, producing the same amount of electricity can take about 600 times more water with nuclear power, and about 500 times more water with coal.

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- Clean air: Other sources of electricity produce harmful particulate emissions, which contribute to global climate change and acid rain. Wind and solar energy is pollution free.
- Mining & transportation: Harvesting the wind and sun preserves our resources because there no need for destructive resource mining or fuel transportation to a processing facility.
- Land preservation: Wind farms are spaced over a large geographic area, but their actual “footprint” covers only a small portion of the land resulting in a minimum impact on crop production or livestock grazing. Large buildings cannot be built near the turbine, thus wind farms preserve open space.

Energy crops are unique because they don’t just produce renewable energy – they also provide other environmental and economic benefits (www.cleanenergycouncil.org.au), since they may lead to both new feed and energy from harvesting, in the framework of a circular economy. Other than creating renewable energy, ***bioenergy and energy crops*** also provide:

• Rural & regional benefits

• Distributed baseload power

• Competitive cost proven renewable energy generation.

Energy crops provide therefore great economic and social opportunities for rural and regional communities. Farmers, truck drivers, contractors, suppliers, as well as local restaurants and shops are all provided with an economic boost. This provides a source of permanent fulltime employment unique from the seasonal workforce in many rural and regional areas.

Energy crops also encourage the development of new and innovative farming techniques and can provide economic returns on land and crop residue with no other identifiable market or environmental value. As these communities deal with the impacts of climate change, energy crops provide rural and regional areas with a more self-reliant labour force less vulnerable to the impacts of drought and flood.

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Conclusions

The advancements in the agricultural technologies sector, and in particular new technologies for the above mention skills, will be transferred to agricultural workers in the frame of the SAGRI project.

Particular focus is to be put on environmental technologies that are of direct interest for the participant end-users, but also for European farmers in general. The study is focused on novel practices and methods for applying advancements in environmental technologies to an agricultural and environmentally challenged society and to facilitate the farmers everyday activities.

The information will be applied in order to facilitate the transfer of the most critical points of it to the agricultural workers. The acquisition of these skills is an important step to achieve a more technologically advanced and social, economic and environmentally sustainable agriculture. At the present, it is evident the role of the farmer who knows not only the traditional cultivation to produce different crops but they have to take into account the new techniques and technologies to reach a sustainable agriculture.

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