Smart Farming

Subjects: Agriculture, Dairy & Animal Science | Management

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Smart farming: the technological innovation adoption in agriculture requires an innovative conceptualization and management of the several resources in light of the increasingly being available data. An example of an innovative methodology and criteria capable of organizing data and exploiting such information to optimize the use of technologies and primary resources used in production processes is presented

Keywords: farming ; viticulture ; precision farming ; technology ; technology transfer ; innovation adoption

1. Introduction

The concept of precision agriculture, intended as site-specific crop management, lately has been associated with the concept of smart farming. A "smart" system permits an open, inclusive, systematic, inter and transdisciplinary system vision.

The "smart" concept applied in farming includes the employment of new digital and high-tech technology and the creation of a localized community in which these technologies have a meaning. Innovation, intended as a new idea or method, is the cornerstone of smart farming. New forms of innovation cover all dimensions of the agrarian production cycle, along the entire value chain. Those innovations range from crop, input, and resource management, to organization, marketing, and distribution. New technologies such as sensors, Decision Support Systems (DSS), automation and robotics, collected data, traceability, and blockchain are available to farmers for supporting and enhancing productivity.

However, some difficulties are accounted for in adopting PA and smart farming solutions. Those obstacles can be summarized in two focal points. Firstly, there is a lack of information on the advantages of applying smart farming instead of a traditional way of production[1], as those advantages are not perceived [2]. Secondly, the significant amount of technology and data collection necessary in smart farming can be challenging to manage.

For those reasons, a reference framework was created. The aim of this framework is to suggest a methodology for farmers, experts, and other actors of the agricultural sector. This methodology allows the orientation towards the multiple-choice offered by precision agriculture and smart farming to find the best entrepreneurial and technological choice and solution. It is possible to summarize this methodology in four steps:

- Understanding the changes in action;
- Identifying the added value of smart farming processes;
- Verifying the reliability of new technologies;
- Adjusting production processes.

2. Methodology

As previously stated, the present framework present four main aspect:

1. **The understanding of the change in action in the agricultural system**. Those changes, (environmental, economic, social and technical) affect greatly a farm work and organization. In order to counter those challenge, the introduction of PA and smart farming is necessary. However new smart asset and new technologies in farm, in order to be efficient, require a great amount of data and data collection, in particular with the application of a multidimensional analysis that allows us to analyse and categorize several dimensions. Multidimensional data are data that record information related to several different units, called dimensions, for instance, soil, plants, weather, etc. Such a process can help decision-making and planning activities in farms [2]. Therefore, in the methodology here proposed, agronomical choices and objectives, all cultivation drivers, and the knowledge needed to accomplish the objectives and use the drivers can be classified in "layers".

2. Identifying the added value of smart farming processes. Nowadays, starting or renewing a new business in agriculture needs an entrepreneurial approach and entrepreneurial tools that also consider social and environmental aspects. One of the main tools that can be used, when a farmer should approach its business, is the Business Model Canvas (BMC) [3]. The Business Model Canvas describes the logic with which an organization creates, distributes and captures value. BMC is composed of nine blocks—the central one is the "value proposition"; on the right side, there are four blocks focused on customer relationships, customer segments, channels, and revenue streams, on the left side four blocks focused on activities, resources, partners, and costs. In smart farming, BMC might be a tool to help enterprises to understand how to invest in PA to develop economically while also keeping an eye on social and environmental impact[4]

3. Verifying the reliability of new technologies. The reliability of any machinery and tool used in a farm have a great importance and influence on how well, fast and uneventful a task is completed. In order to verify the reliability of new technologies, the Technology Readiness Levels (TRL)[5] tool can be a valid instrument. The TRL tool assigns a scalar level from 1 to 9 to describe how mature a technology is. The technology maturity levels (adapted from the original NASA one), go from level 1, as the lowest, to level 9 as the highest [6]. Another tool investigated and deemed necessary in the application of this methodology is the Market Readiness Levels (MRL)[7]. This tool allows a technology readiness evaluation of commercialization and diffusion phases. MRL is based on a scale of 1 to 5, with 5 being the most diffused [8]. However, it resulted necessary to establish a third evaluation tool, the Local Ecosystem Readiness Levels (LERL). LERL contains two important terms: on the one hand, the noun "ecosystem" (apart from the biological context), which can be interpreted as a complex network and interconnection between multiple entities. In the agricultural technology context, an ecosystem can be described as an aggregate of independent entities and interrelated factors to allow a system innovation in the whole sector. On the other hand, the adjective "local" strongly correlates to the ecosystem which needs to exist not only in the macro-area but also in the local area Therefore, the LERL is a tool that permits to evaluate the maturity level of the local ecosystem and to establish at which point of the transformation road, from new product to innovation, a new technology is located.

4. Adjusting production processes. The design thinking and the tools of "Lean Production" or "Lean Farming" may be endorsed as decision support tools also in the viticulture sector. The lean approaches, which are fundamentally anthropocentric, realistic, and firmly based on waste management, have been proven to be extremely compatible with companies sustainability policies and activities[9]]. In this methodology are highlighted five main categories regarding the driving factors that determine sustainable organizational efficiency through the implementation of lean methods:

a. Knowledge and training between workers and managers; as the training of key staff with extensive and multi-disciplinary knowledge which provides a broad view of the production processes and consequently a better ability in problem-solving may ensure that workers work independently and competently;

b. Awareness of the operative context; the output outcomes of operational management activities are influenced by the context in which they are applied and must, therefore, be adjusted to the new scenario to achieve the desired results [10]];

c. Organizational structure; the organization needs to motivate workers, concentrating on more organized and responsible behaviour [11], using more appropriate equipment, pattern sequence, and parallel working. Moreover the regularity of the planting layout allows standardization of the settings of the machinery, a more efficient use of resources, and a general optimization by reducing downtime;

d. Technology and decision support; the diffusion of technologies involves minimal changes from an operational point of view (the machines work intelligently supporting the management of the workers), but is relevant from an organizational point of view (changing in settings, maps elaboration, implements configuration); so those technologies must be accompanied by effective organizational processes and procedures in order to exploit their potential to implement more sustainable practices [12];

e. Implementing and cyclical enhancement of the adoption procedure; the practical adoption of innovation through lean methodologies, as highlighted in the previous paragraphs, includes assessments and preparation of all the process elements: structures, plants, tools, services, staff
training, operational protocols. But it also need a continuous improvement of the production process through a cyclical sequence of stages: examine, identify, implement, assess, check of the feedbacks.

3. Conclusions

In adopting the smart farming methodology, data collection is an essential stage. Database collections are a basic tool during the decision-making process and the organization of operation and work in farms. However, driving data is a complex process that requires knowledge and competences in order to acquire and interconnect all the information present or provided in farms. The information collected in a farm can come in different formats and sources. Mainly, in smart farming, information comes from technologies and monitoring. For those reasons, to understand the strategic importance of any inf

ormation, in this methodology, the layer concept is provided. In the layer concept, all the information and all the data are classified and stratified in hierarchical levels, with constraints and available resources at the bottom, and informatics/computing technologies at the top, that gives the agri-entrepreneur an overall picture of their farm and a way to strategically use all the data and the information in the decision-making process. BMC tool application could help to focus on the value proposition of the farm and then to point out the technologies needed to bring added values for the farm outcomes. In agriculture, the TRL tool permits evaluation of the maturity levels both of one technology and of a set of technologies. This tool indicates innovative products' (technology) readiness, but it does not indicate the development of the infrastructure related to the technology. That is why the MRL must integrate it. Indeed, this last tool can provide the degree of the technology readiness for commercialization and diffusion. However, even in this case, not all the variables that contribute to turning an innovative product in a system innovation are taken into account. It is in this perspective that the third evaluation tool (LERL) must be seen. This last indicator aims to evaluate the maturity level of the local ecosystem, i.e., the chain of infrastructures, actors, and formative system in each area or region. Moreover, the LERL may establish at which point of the transformation road, from innovative product to innovation, a new technology is located.

The increasing availability of agricultural technologies able to provide data requires an exact integration process. Tools such as the Business Model Canvas, the assessment of the TRL level and the restructuring of processes according to lean and, most recently, lean plus green methods, offer advantages that allow farms to acquire highly competitive margins.

Priority criteria that determine the success of smart farming can be summarized in the following points:

- The agricultural progress in smart farming could offer huge possibilities to enhance quality and profitability for the future agripreneurs;
- The enthusiasm for astonishing innovative products should be controlled, driving the whole entrepreneur process in a shared system of territorial rural innovation;
- Variability in type of farm, age of actors, and infrastructure (i.e., broadband) should be taken into consideration, scaling the introducing technology in an innovative systems design of new shared, connected services like the territorial digital platform to process data for all sizes of entrepreneurial farms of a productive community;
- It seems necessary to grow the diffused awareness of thinking in terms of added value, assess and allocate, prepare the change in the farming process and adopt, verify and tune-up through a lean-approach;
- More and more appropriate is the High Tech and ITC cluster networks participation to be aware and joined with knowledge at global and local level.

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