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Enhancing Tourism through Viticulture Enterprises in Douro Region: The Inov@Douro Model

Carlos Filipe Campos Rompante da Cunha[1,3], Emanuel Soares Peres Correia[2,3], Raul Manuel Pereira Morais dos Santos[2,3], and Manuel José Cabral dos Santos Reis[2]

[1]Polytechnic Institute of Bragança, 5301-854 Bragança, Portugal
[2]University of Trás-os-Montes e Alto Douro, 5001-801 Vila Real, Portugal
[3]CITAB – Centre for the Research and Technology of Agro–Environment and Biological Sciences, 5001–801 Vila Real, Portugal

Abstract

This paper describes a business and technological model proposal, known as Inov@Douro, intended to support and to promote competitive and sustained precision agriculture practices in the Portuguese Douro Region. Our approach is based on a distributed cooperative network, tailored to meet the specific needs of viticulture enterprises which also explore tourism as a valuable national and international business source. We present the Inov@Douro model from the knowledge generation point-of-view, intended to support the multidisciplinary concept of a cooperation approach among regional partners. This model aims to represent a new working style for this unique region. As a guideline to attain the implementation of such a model, information technology and infrastructures tools are discussed in order to promote precision agriculture practices while giving valuable and dynamic tourist information to the general public.

Keywords: Cooperative networks, Model, Precision viticulture, Tourism

Introduction

Precision Viticulture (PV) in the Portuguese Douro Demarcated Region (DDR) is still at its early development stage despite the economic, social and environmental benefits that may be achieved. The DDR is located in northeast Portugal, and consists mostly of steep hills (slopes reaching 15%) and narrow valleys that flatten out into plateau above 400m. The Douro River digs deeply into the mountains to form its bed, and the dominant element of the landscape are the vineyards, planted in terraces, fashioned from the steep rocky slopes and supported by hundreds of kilometers of dry stone wall. It is the vine, rural and agro tourism that drives and sustain the economic activity in the region, which remains deeply rural and sparsely inhabited to the present days and where there is also a profound lack of technology introduction and an almost non-existent Decision Support Systems (DSS). The region is one of the most ancient winemaking regions in the world, and has been recognized by UNESCO as a World Heritage Site (Espigueiro, 2000). PV seems, from our

Contact Author: Carlos Filipe Campos Rompante da Cunha, e-mail: crc@ipb.pt

point of view, a fundamental success driver for a sustained development of the DDR in winemaking and tourism which is the key to the present proposal.

Although the lack of technology adoption, the current trend in the field of information technology (IT) made possible the monitoring of a comprehensive set of parameters that reflect the behavior of a given physical process. Many of these parameters reflect not only the evolution of a given process or its magnitude, but it also allows inferring about its dynamic. However, the monitoring of these parameters will only result in a real added value to production and economic processes if data gathering is followed by proper processing. The main goal should always be information production and sustained knowledge generation, fostering their distribution by the entities interested in taking advantage of the generated knowledge, applying it in their working practices.

Precision Agriculture (PA), is information intense (Stafford, 2000), it is technological based (Cox, 2002), but some studies have shown that, although there is generally an optimism related to PA, there are some difficulties in verifying the economic gains (Pedersen et. al., 2003) regarding its sustainability. There are also concerns about the lack of computer literacy, integration, requirement of inputs (data) and effective fitting of existing information and farmer working patterns (Alvarez and Nuthall, 2006). The majority of farmers never used DSS or computers planning models. Instead, farmers' focus is the production and the optimization and not the technology itself. We believe this is why PA is not really widespread. Based on this fact, a key issue must be addressed: how to sustain effective PA practices in DDR? If we analyze what other industries/areas have done in the last few years, concerning information systems, we will notice an enormous difference on the introduction, assimilation, results, and perspective that IT have aided to achieved. It is also interesting to notice that many of that successfully applied technologies could offer enormous benefits to PA (the base capability and needs are the same; the application field is the only difference).

This paper describes a business and technological model proposal that aims to contribute for implement real large scale competitive and sustained PA for the DDR that can also be applied to other places, beyond DDR. Our approach is to use a distributed cooperative network model, along with the analysis of operational issues such as acquisition, transmission, data aggregation, and information integration but, based on a knowledge generation perspective. The presented cooperative model covers economical and technological view points. Its focus is to promote PA practices (e.g., plague and diseases detections, DSS, etc.), while creating economical sustainability viability of the model (e.g., tourism support). The paper ends with the discussion of tourism as a key area, capable to bridge the gap between PA needs and economic viability on DDR.

Cooperative network: new farm and farmer concept

Organizations sought new types of businesses models able to fit the new business paradigms. In that search, the relationship concept becomes crucial to the success of organizations (Tapscott, 2009). Results in Davenport (2000), shows that organizations are nowadays much more interconnected. This interconnection movement translates and materializes the networking concept, which can be seen as the capability that organizations enclose to establish cooperative mechanisms with other organizations, through fast and efficient interconnection of business products supported by technological platforms (Osterle et. al., 2001). There are many cooperation examples among pharmacy organizations (e.g., R&D projects) or open-source communities (e.g., software systems development) (Buxmann and Koning, 2000). However, even though several activity sectors have changed their business models, the agriculture sector has not followed the same pattern. Therefore, it is crucial to understand why this happens. Some of the barriers to information systems adoption are reported in Alvarez and Nuthall (2006): failure in fitting with farmer working patterns; requirements of data inputs that are not familiar or available; lack of computer literacy; lack of integration; and unclear cost-benefit relationship. We think that the two major reasons for the non adoption by natural evolution of new business models and IT in PA, as it was done in other industries, are: inadequate information supply based and focused on the farmer; and incorrect and invisible data integration capable to generate applicable knowledge for strategic management. But if these aspects do explain the low IT introduction, they do not explain the lack of cooperation among farmers and several organizations related with agriculture. So what is the major goal of cooperation? What can be their gains?

We follow the vision that the best results are achieved when every organization within a cooperative group, do what is best for him-self and the group. This vision is sustained by the gains that can be achieved by interconnecting several and complementary data, information sources, skills, and knowledge. Whenever in a group everyone can try to eliminate its weaknesses and generate new strengths.

The majority of farmers has never used DSS or computerized planning models, they are focused on production, rather than exploration research, and they do not have time to do data interpretation (Kuhlmann and Brodersen, 2001). What they really want is that someone or something gives her/him an action course, a recipe that will save time and prevents or solves their problems (Burrell at. al., 2004). We sustain that cooperation can bridge the gap between the farmer's needs and profile technological opportunities, if we interconnect the concept of a farm lab and multi information (and services) providers. When we interconnect one specific farm with other farms we will be able to share public data, information, and knowledge, so everyone can cross them with their private data, information, and knowledge. The result will be new better public and private information and knowledge. But as previously mentioned, farmers do not have the necessary skills to carry out and support those interconnections (e.g., IT needs, consulting advising). Typically these skills exist, though they are scattered by technological enterprises, sector associations, biologic advisers, research labs, and many other. The cooperative perspective translates the benefits of interconnecting those different enterprises and the farms network, creating cooperative networks that interchange data, information, and knowledge. Under these cooperative networks we can generate several PA services and, as will be discussed, we can also support many tourism services that can be the sustainability enabler of the cooperative network financial support.

Information sources

In PA practices, classical information sources are usually obtained through data acquisition. There are several instruments capable of measuring many relevant variables for productive systems (e.g., temperature and humidity). Geographic Information Systems (GIS) are also important data sources (e.g., imagery remote sensing). The main goal of the sensors' network is to promote a proactive computing capability that enables the ability of interpreting data, and trigger concrete actions, for example, fight plagues (Wang et. al., 2006) or pests (Koumpouros et. al., 2004). The recent technological advances in sensors and wireless communications have lead to sensors' networks that are being seen as one of the most important tools to a timely detection of problems through continuous monitoring and surveillance of the base parameters that can be capable of trigger perception of undesirable events on farms.

Although sensors are capable of providing data, there is a huge gap between having data and having applicable information. In our case, this perspective is sustained by the previously noted fact that farmers usually do not have the right skills to interpret data, generate information, and truly explore the knowledge that could be attained through data. If a farmer is capable to start a relation with IT specialists and other complementary specialists (e.g., crop consulting advisor), then he can manage a symbiotic relation giving him the possibility to integrate data and generate information. This could also afford for information storage on repositories and several important services for farmer's daily work and farm management. By giving the farmer some decision support we will be contributing with some proactive actions that he will apply on his work. If the results of these actions are stored in the information repository we can achieve a second level of knowledge generation: the analysis and transformation of information based on rules and procedures that will be embedded on a DSS. This materializes the Online Analytical Processing (OLAP) along with the application of data mining.

In a cooperative network the perspective of farm information source is far larger than a sensor and GIS basis; it must include public and private sources of other farms and other complementary private industries, and also governmental entities.

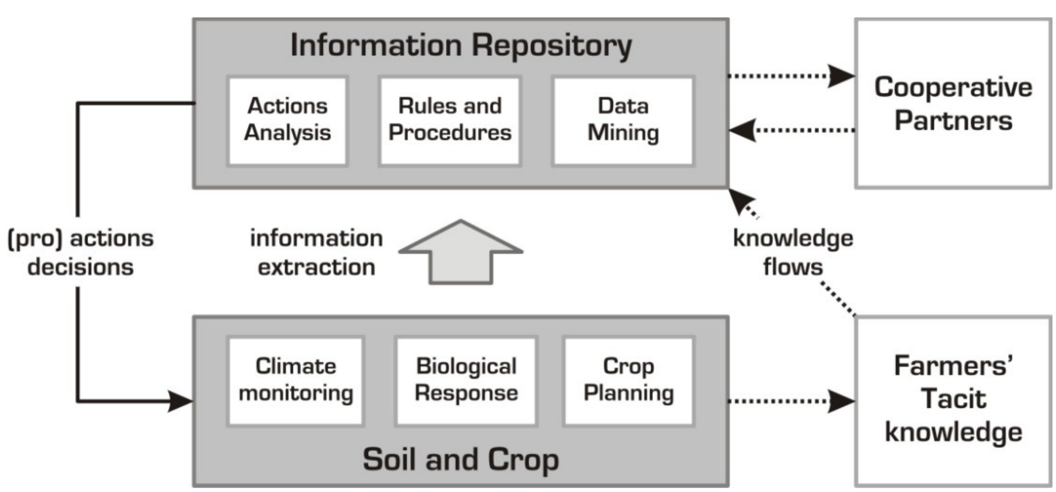
Tailor the information to farmers needs

Farmers have particular needs. They may not have the necessary skills or focus for IT and OLAP analysis, but they sure want to have better support information for their daily work and some help to crops and soil management; for example, by having timely diseases detection systems and adequate advising to apply the correct treatments. If, for example, a particular industry has constantly asked the IT market to develop a new technology to support its needs, the agricultural sector has not followed the same criteria/philosophy. There are researchers and some IT industry groups which are pressing for the materialization of the farm lab concept. The problem can be now formulated: how to tailor information to the needs of farmers if they do not define their information profile? To address this issue, we must first note that every individual has unique characteristics, such as the academic literacy, capability of contents assimilation, and the information needs to its working system process.

For the different individuals composing the system suppliers, buyers, analysts and final users there are divergent perspectives about the criteria and the needs for a successful working environment (Bair, 1995). These divergences will necessarily conduct to systems that are poorly configured to the end users and almost unhelpful. In this context, we assume that it is necessary to analyze function by function needs, or even individual by individual needs, as well as the way and the shape of information representation that is provided. The challenge will be the development of technological platforms for the management of agricultural systems able to monitor and control, while providing friendly management interfaces, configured to the farmer's profile.

Knowledge generation

The cooperative network approach introduces a new philosophy for knowledge generation. Figure 1 shows the most important relationships for knowledge generation and integration. The main bases are the information sources that can be achieved by classic methods, like data acquisition networks and GIS, human being tacit knowledge, and, most important for this approach, the public and private information and knowledge of all partners that contribute to the (cooperative) network (and with whom the share of information and knowledge is made). The distributed knowledge bases that can be achieved by cooperation can also be used to make high level decisions for the management of the premises of connected members, presented in Sigrimis et. al. (1999) as Virtual Agricultural Networks. The next step should be the storage of that information and knowledge on farm repositories. The analysis and transformation information processes, as well as rules, store procedures, and trigger mechanisms, should also be made there. This layer is the decisions supplier to the extent that should advise the farmer on the need to implement actions, either being reactive or proactive (most desirable) actions. Lastly, it is of primordial importance to analyze the return of those actions, either because they have been successful or unsuccessful (by the nature of the actions taken or unexpected or uncontrollable issues). The resulting conclusion should necessarily be stored in the repository and will contribute to improve future decisions for similar initial conditions.



Organizations are increasingly focused on their core competencies and on finding other complementary and needed competencies through cooperation (Kitchen, 2008). Precision agriculture is information intensive and the needed skills to support and sustain an integrated farm concept are much larger than the farm perimeter. To achieve these goals, cooperative connections must be established between partners that have complementary skills or interests in exploiting PA natural resources, in an economical sustained perspective (e.g., tourism and DDR precision viticulture procedures).

Our cooperative network model is presented in Figure 2, where a cooperative model, is used to translate the PA cooperation mechanisms, aiming a sustained implementation. The new business perspective can be described as:

- A "cooperative network", which can be defined as a cooperation infrastructure among different farms that translates the interchange of public data and/or public information. The main goal is to share information and knowledge, and cross that information with other information types and sources. The result will certainly be a more precise information and knowledge in order to face the farmer daily work, as planning and management issues. This interoperability offers the organizational system the management mechanisms that maximize opportunities to exchange and re-use the internal or external information (Miller, 2000).

- Cooperative service provider network can be defined as an information and services repository that provides effective help to farmers' needs. It represents the public information library for PA, through the capability to integrate the PA sector knowledge, as well as complementary knowledge archived by cooperation with other external entities (e.g., meteorological services, GIS providers, universities). One of its main contributions to farmers is the ability to provide, low-cost, public information (e.g., meteorological information, satellite images) and services (e.g., soil, crop, business, and IT advising) that individual farmers cannot achieve because it is economically enviable.

- External partner's entities can be defined as external partnerships that are made. They can work in two different perspectives: the way to acquire data, information and external knowledge that complement the support to farmers' needs; a platform to support services based on PA natural resources (e.g. rural tourism).

- Summarizing, it is desirable to achieve a symbiotic relation among the above described entities. It seems consensual that everyone may achieve better results throughout cooperation.

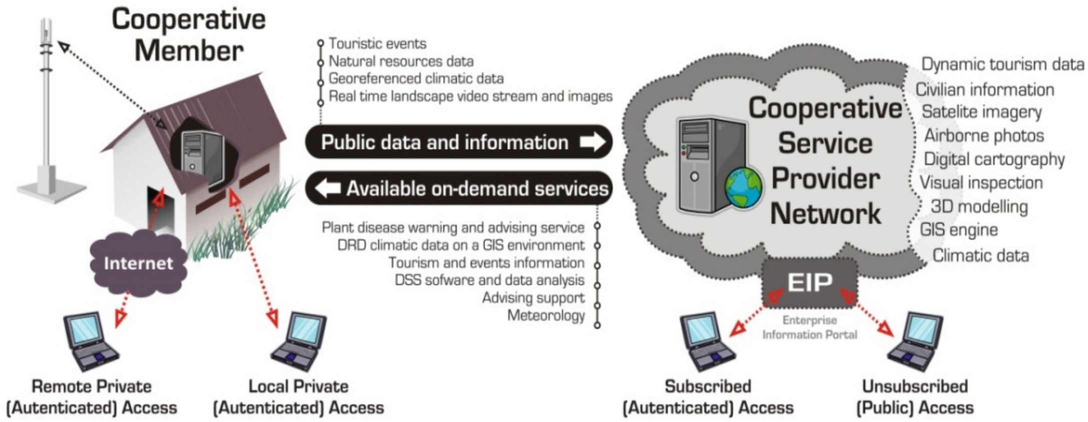


Fig 2. Cooperative model illustrating the major business information/services interchange

The materialization of this concept represents an enormous multi-domain challenge (Schulze et. al., 2007) (e.g., sociological, effective farmers' needs comprehension, IT infrastructure). The architecture of the information system, being a concept enabler, is a vital issue to support the cooperative network.

Technological cooperative network model proposal

The cooperative network business model necessarily builds upon Information Systems (IS). Its perspective must be IT multidisciplinary to bridge the gap among collecting and transmitting raw data, integrating those data to generate helpful information, and finally to extract knowledge in a time analysis perspective. PA is information intense, but only an integrated IS, capable of fusing engineering and agronomic knowledge, can effectively increase value from data collection to strategic management (Kitchen, 2008).
The presented model covers intelligent data acquisition, transmission, integration, and information access issues, as well as a cooperative enterprise information portal (EIP) concept. The core perspective is to support effective farmers' daily needs, by letting the farmer decide what type of data and information he needs, paralleled with data, information and knowledge cooperation, among several farms, as well as with complementary organizations that have core skills which can be applied to agronomic needs.

Wireless sensor networks for vineyard variability studies

The PA information is achieved through several levels of technology and networking. One of those levels is the hardware itself where microelectronics and sensors are of main importance. The use or development of sensors for infield measurements or integrated in agricultural machinery has motivated further research in this area. Devices, equipment and responsive mechanism actuators also needs some research. More specifically, wireless sensors are special enablers of several sensor applications, such as monitoring remote areas and locations, where otherwise would be very difficult to collect data (Wang et. al., 2006). Sensor networks are responsible for raw data acquisition.

DDR has unique characteristics related with topographic aspects, erosion control, vertical planting, water availability, and temperature span across the day and year. This uniqueness demands the existence of distributed monitoring, with processing capabilities to help farmers understanding vineyards variability so that they can manage them effectively, improving the quantity and quality of their wines. To face this challenge, wireless sensor network are commonly used to measure key parameters in variability studies.

Gateway as a field server

Studies involving vineyard variability require a huge amount of sensor data which makes the task of getting meaningful information from disparate sensors nodes deployed as WSN not trivial one. Besides network availability and scalability, traffic overhead, node hardware and energy issues, the heterogeneity of each sensor node or data acquisition device, makes extraction, aggregation and making available sensor data at the processing elements much harder. To address these issues, each management zone, or cluster, has a sink node operating as a cluster head (CH) that is responsible for storing all rules and procedures of programmed and real-time sensor acquisition (i.e., defines the sensor and actuators network behavior), as well as providing multi-protocol network access (e.g., Bluetooth, Wi-Fi) to query past and real-time field acquired data (Morais et. al., 2008). This CH is the link between the "acquisition area" and the farm operation centre. This last is translated by a data base server and application server responsible for the integration of the network sensor acquired data, GIS information as well as other data and information that the farmer is interested to integrate. It also does the management of the cluster head rules and procedures. Everything is finally mixed with top rules and procedures that try to act proactively anticipating possible problems, react to undesirable scenarios, and extract knowledge on a time basis perspective. The aim is to provide daily planning information to help the farmer to achieve his objectives.

The main functions of the CH are: sensor network coordination. To achieve this, the CH is composed by a database with rules and procedures. It describes how the sensor network is intended to work (e.g. define when to capture data such as temperature, image acquisition) as well how the network must behave (reactive or pro-active) when a set of factors are presented (e.g. send an order to an irrigation management system if a humidity parameter is low). As second objective, the CH must be able to report relevant information to the office management level, enabling the farmer to manage the daily work as well as to plan future activities. The office management level has the responsibility of defining and uploading the set of rules and procedures (i.e. the intelligence system) to the CH. The last function is to support a query system, for the farmer on PV practices, but also as a public data access gateway, Figure 3. As an example, even when the farmer is working on the vineyard, he can check CH stored data and he can also send data to the CH using a mobile device. To achieve this, the CH needs to support multi wireless communication protocols such as Bluetooth (for short range) and WI-FI for larger range. This can also be used as an access point for tourist's access to information and services supported by the farm, or simply for accessing public services platforms.

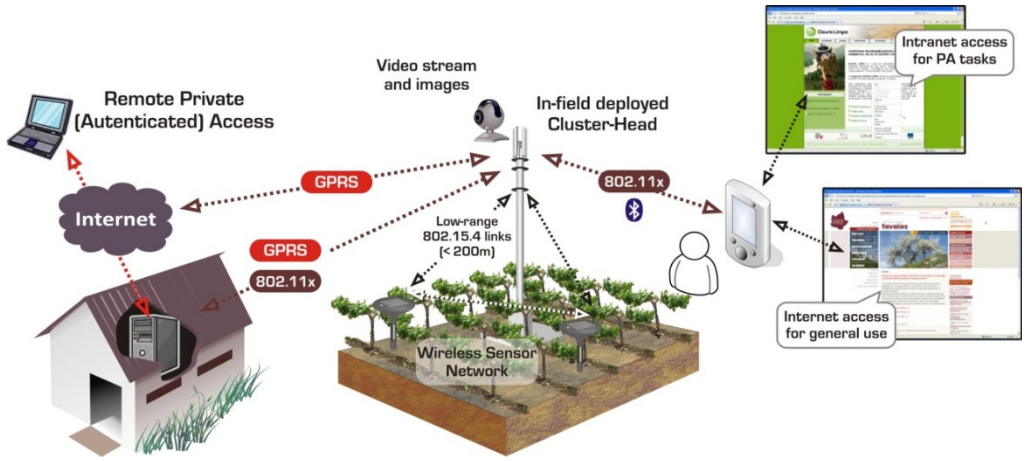


Fig 3. Accessing public and private data through in-field cluster-head, as a sink node for wireless sensor network data and as a public service provider

The office management level

The office management is the farm lab command center, represented by a computer based system, having a data warehouse where all the data acquired by the sensor network is stored, as well as different data introduced by the farmer whether to express tacit knowledge or by acquisition from other information sources. It also should have several services that will help farmers' with daily activities and management work. To achieve the status of "farm lab" some requisites need to be satisfied. In Murakami et. al. (2007) is described the major requirements for PA. From our perspective, in a cooperative scenario, the following features must be included:

- The system must support secure cooperative interconnections with other systems.
- The knowledge generation needs to support business intelligence, information management, OLAP and content management mechanisms. All this is needed to transform data and obtain real-time information and sustained knowledge.
- Cooperative functions, such as sharing public data to other cooperative network partners.
- Pro-active mechanisms/services, providing alert and response to an emerging scenario. This response can be farm based or act in a wider extension being able of triggering response mechanisms to the full extension of the cooperative network.
- Capability to have upload services. The possibility of uploading new services (developed by partners such as R&D organization), operating side by side with farm data and, possibly, correlate them with other data sources, will be fundamental to expand and improve the office management capabilities.

The combination of data acquisition, cluster head and farm repository will be an operational help to daily farmer activities and the information management will help on the management of soil and crop planning; finally, the generated knowledge will lead to better operational and management solutions in the future (i.e. in similar scenario). But although the aforementioned model covers the farm perimeter; cooperative model extends the farmer dimension by the need to enlarge the information, knowledge and skills to others sources and at the same time have a share perspective of public data, information and knowledge to the farms that cooperate with us as to other organizations included on the cooperative network (e.g. R&D organizations, tourism sector, e-government). The result will be a cooperative network supported by an IT infrastructure capable to respond to farmer perimeter needs, support cooperation to several organizations, and integrate the public sector knowledge as well provides services to the sector and complementary sectors. The presented technological model also can effectively respond to the tourism sector by being an enabler of services based on the PA information system. The technological infrastructure designed to support the cooperative network business model concept can be seen in Figure 4.

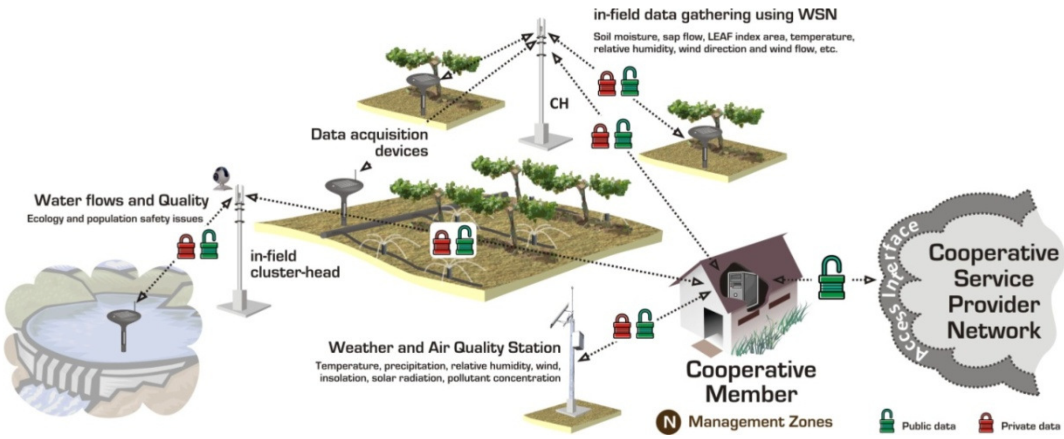


Fig 4. Technologic infrastructure model with illustration of public and private data

Enterprise information portal

The EIP can be defined as a unified architecture, capable of combining powerful tools that can provide knowledge to the business decision support systems. This support can be distributed to different organization levels (i.e. operational, tactic and strategic level) and its main goal is to provide knowledge to the PA sector characterized by having great amount of data, poor information resources and an inexistent stored knowledge repository.

The EIP for the PA should translate the cooperative network existent knowledge and be the centralized interface to network elements as well to the masses (e.g. tourists). One important issue is that EIP can be the internal and external interface of the PA sector, and with that to provide internal services focused on the farmer's needs and simultaneously having services to focus on external needs, like tourism industries that in DDR have mutual interests. Also EIP can be an interconnecting gateway between the PA sector and the governmental entities, focused on farmers (e.g. agro financial programs, agriculture ministry).

Services platform over the cooperative network infrastructure

In the DDR, there is a natural interconnection between tourism and viticulture. It is the vine, mainly the well known Oporto wine and rural and agro-tourism that drive and sustain the economic activity in the region. The proposed business and technological architecture can simultaneously cover the needs of PA and tourism, achieving, with this symbiotic relation, the support for the economical sustainability of PA requirements. The same range of data and also the same technological infrastructure that can help farmers to drive successfully crop and soil management, can also support tourism services. One first feature is image acquisition. Supported by the CH it can be a valuable tool in order to predict diseases like mildew (Helly et. al., 2004) (i.e. image analysis into diagnostic expert system) on vineyards as well as to support video streaming to tourism services. One second issue is the fact that EIP can support PA information to farmers as well as having information support to tourism services (e.g. wines tasting schedules, wines brands information).

As illustrated in Figure 5, the same technologic infrastructure can acquire process and supply information to PA services as well as to tourist services. As it was previously focused, companies that exploit the viticulture and wine, also provide several tourist services. With our approach, we promote a common platform to achieve the desired breakthrough to PV effectiveness in DDR and, at the same time, we also provide an infrastructure, capable of supplying end-user services and/or information to partners that have interest on the exploitation of PV information (e.g. universities viticulture R&D or wine sailors), as also the supply of tourism-related information for partners like tourism agents. As an example, results on the use of the presented infrastructure can be seen in Figure 5. The SIGPV prototype is presented. Created for winemakers, using contextualization mechanisms, like visual tags (e.g. QR Code), wine information and services are delivered to consumers. It also acts as a bridge to tourism dynamic services and e-commerce. This information and services are stored in the cooperative network. Also showed is the use of the same technology in PV practices, namely in the collecting and consulting of in-field information, helping to promote DSS infield-centered instead of actually existent office-centered systems.

By using a common infrastructure as a cooperation support, a sustainable knowledge generation and the supplying of new business opportunities to the DDR agents can effectively be attained.

a) Illustration of an access to tourist information on a vine using a mobile device

b) Illustration of the SIGPV application and the use of QR Code placed on wine bottles to render dynamic tourism services and events

c) Illustration of uploaded photos and data about vineyard mapped points

d) Illustration of the use of mobile devices and QR Code in a site-specific management tool supporting PV practices

Fig 5. Examples of developed applications, for PV and tourism, over the proposed cooperative network using the same technological infrastructure

Discussion and final remarks

This paper describes a cooperation network model that can revolutionize the concept of PA support, management philosophy and sustainability. In the first part of the paper we introduce the concept of cooperative network. A clear definition of the concept and its applicability to the PA sector was provided. This first part also described the business and knowledge generation perceptive of the concept and the major gains that can be achieved.

In the second part of the paper we described the proposed cooperation network technological support model. This model covers the most relevant aspects from data acquisition and sharing to hi-level integration information and knowledge.

Tourism was focused several times as the "bridging the gap mechanism" between PA effective implementation and its economical sustainability. The DDR tourism has natural harmoniousness associated to viticulture farms but, unfortunately, in the moment there aren't any relevant symbiotic relationships or cooperation channels. By promoting cooperation between farms and tourism sector, we enable PA has a natural source to tourism services like previously exemplified. In a world where cooperation seems the unique way to overcome the new challenges of survival where major sectors like banking are merging and performing acquisitions, PA needs to give a decisive step towards a development that despite being late, needs to be given urgently, otherwise the concept of PA in the DDR, will never really be materialized.

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