BIO Web of Conferences **9**, 01023 (2017) DOI: 10.1051/bioconf/20170901023
40th World Congress of Vine and Wine

Interest of seeing Precision Viticulture through two distributed competences: Determination of resources and schemes allowing some practical recommendations

Leslie B. Moreiro

RITM, Université Paris-Sud, Faculté Jean Monnet, 54 Boulevard Desgranges, 92330 Sceaux, France

Abstract. The aim of this article is to better understand resources needed and constraints to avoid in implementation of Precision Viticulture technologies. In this view, we adapt distributed cognition theory to multilevel model of competence in management sciences. We use a qualitative methodology based on semi-structured interviews in 7 cases study. The main results allow us to distinguish the two aspects of Precision Viticulture, artifacts, providers of resources, and their utilization scheme. Furthermore, Precision Viticulture is decomposed here in two tasks. The first task is characterization of heterogeneity. The second is modulation of technical itineraries. These two tasks are complementary. In addition, we present ours results by highlighting resources used by firm using these technologies and constraints that they face. Finally, with these results, we can do some practical recommendations to designers and users of these technologies.

Introduction

Precision Agriculture is the technological revolution in measuring and processing spatial information [1–3] in order to put the right input at the right place and at the right time [4]. Precision Agriculture is based on concept of heterogeneity (of soil or plant), for characterizing it and for modulating technical itineraries regarding it [5]. In this article, we will focus on a part of Precision Agriculture, Precision Viticulture, because of its specificities. By blending several theories in social sciences like distributed cognition theory and multidimensional model of competence, we try to define Precision Viticulture as competences composed by a set of resources coordinated by a scheme. By this theoretical blend we hope to show that precision viticulture isn't only technology and we try to make some practical recommendations as to designers than to users. To this end, we first do a state of the art, before to explain methods and materials used. Finally, we explain the results founded that allow us to do some recommendations.

1. A particular kind of technology: Precision Agriculture

1.1. A brief history of Precision Agriculture

The concept has been more developed since discovery of NDVI (Normalized Difference Vegetation Index) formula in 1973, the most used index for studying vegetation characteristics [6]. Then, a joint venture for developing and commercializing Variable Rate Technology applicator (VRT) was made in United States between CENEX, Farmer Union Central Exchange, and Computer Company Control Data Corporation. The first VRT was used in 1995 [1]. The first yield maps were used in 1993 in United States of America and in 1997 in Europe [2]. But, Precision Agriculture is an evolving concept. It has been called "Specific Farming" or "Spatially Variable Field Operations" [4] or "Farming by Soil Types" [1]. First, from end of 1980's until middle of 1990's, it has been called "Grid Sampling" because of a fixed sampling mapping of plots. From middle to end of 1990's, we had headed toward "Soft Sampling" by the fact that sampling cans evolutes on the time. Since the 2000's, we talk about "Management Zone" because of the interest to isolate several homogeneous zones in order to provide them best input regarding their needs [7]. But we can ask now what the new paradigm is? By the way, Jullien and Huet (2005) [2] differentiate two types of use. There is a proprietary system where farmers are owners of technology and data recorded with it. Instead, there is service delivery where data collection and mapping are made by advisors.

1.2. Precision Agriculture is composed by several steps with different artifacts

Precision Agriculture is breaking down by scientists in several steps. These steps are presented as data collection, data processing with data interpretation and finally application of inputs [5,8,9]. Data collection can be made by several kinds of sensor. We don't come back to differences in terms of technological standards. This question has been discussed by some scientists like Dobermann et al. (2004) [10] who explain differences between mechanic sensor, acoustic sensor, pneumatic sensor, electrochemical sensor, optic and radiometric sensor. In other ways, scientists make differences between several kinds of data collection. There is proxy-detection like on-the-go sensors, or remote sensing by several kind of support like drone, aircraft or satellite [2]. There is sensor for measuring soil characteristics or vegetation recovering or meteorological data. Each of these sensors has advantages and inconvenient regarding farmer's interests. The data collected is localized by several kinds of Global Positioning System (GPS). Finally, sensors can give several indicators of soil (pH, composition and acidity of soil...), indicators of plant characteristics (LAI, Leaf Area Index, NDVI...) [6] or others (meteorological...).

The data collected is first cleaned before to be mapped on Geographic Information System (GIS) software. It is interpolated in order to frame management class. Number of class is determinate regarding several criterions like economic feasibility, dimension of agricultural equipment or hardship of work. Classes are eventually validated by testing [11]. The number of management class is linked to spatial resolution of pictures, or more precisely the coverage area of pixel. More high is resolution, more heterogeneity is considered and less coverage area is important [6]. But management class isn't management zone. Class refers to all area with same characteristics and zone is the spatial and continuous area on a plot [11]. This differentiation is interesting for the understanding of spatial repartition of class in geographic zone and its evolutions in the time [12]. This understanding is possible with regularly frequencies of collection data [6]. Data processing is realized with superposition of several information layers on a map [13]. It's possible to do another map with recommendations of technical itineraries regarding heterogeneity [5].

Finally, application of inputs can be made in several kinds of action like seeding, fertilization, irrigation and disease management [5]. Choice of value to measuring depends of the type of action farmer wants to modulate. It's possible to do modulation in real time during data acquisition or from the data of the last year. Thus, it's possible to collect new data during modulation of technical itineraries and reclosing new cycle of Precision Agriculture [12].

But we can wonder if these steps described in an academic environment can be the same that in firms which use Precision Agriculture Technologies. Our principal question is to understand despite of their differences if firms of a same industry can have a same way of use these technologies and can develop the same competences. By the way, we think that it can be useful to understand complementary resources that can be used to facilitate use of these technologies as constraints users can face.

1.3. Limits of Precision Agriculture

Precision Agriculture technologies can have some constraints and limits. They still have a long and uneven development. It's in part due to the fact that they were on the market in a too immature shape [14]. Scientists have listed ten years ago limits in Precision Agriculture. It can be problem of compatibility between several data standards and compatibility of dimensions with other agricultural machines and tractors [15,16]. Furthermore, there is a lack of training and outreach regarding these technologies [15,17]. Analysis requires rare skills and knowledge and need training [18]. For Robert (2000) [15], this have as consequences that famers use service instead of using their own purchased artifacts. That makes them dependents of service providers. By the way, Jullien and Huet (2005) [2] highlight important costs of purchase. And designers have difficulties to provide adapted decision support tools including economics values and factors of temporal heterogeneity [17]. In fact, economic feasibility is important in modulation of technical itineraries and be too precise in modulation can increase cost and error risks [2].

For Arno et al. (2009) [18], lack of adapted decision support tool is particularly relevant in Precision Viticulture. For them, the choice of value to measuring and the way to use artifact is very important for helping farmers. That's why we partly focus on that.

1.4. Particularity of Precision Viticulture

We choose to focus in one specific industry, viticulture, for having a coherent sampling of firms despite of heterogeneity of firm and technologies used. Viticulture has specifics issues. Sensors and decision-support models used in viticulture are not the same that for other crop because of some particularities like specificity of roots system or particular needs of the vine [3]. Contrary to arable crop, vine life cycle is at least 30 years, it's a perennial crop. This perennial aspect of vine enables comparison years after years [3,18]. Furthermore, a particularity of Precision Viticulture is to take into account variability of grape yield and quality [19]. This variability can have many causes like climate and sanitary situation, soil properties, diversity of Woodstock, age and type of vine, topography, etc.

Moreover, viticulture is linked with important site specific knowledge of winemakers. This is due to the fact that viticulture needs more manual activities than other culture. In other part, in some countries like France, knowledge is linked to importance given to the concept of *terroir*. Due to this concept, the diversity of methods used by winemakers has an impact of vine heterogeneity [3]. That's why there are several indicators of climate, vegetation and soil characteristics that can be used in a complementary way. All these things suppose a different way than in other industry for data processing and analyzing. In order to better understand these specific resources needed in the use of these technologies, we analyze Precision Viticulture as technologies AND competences.

2. From competence to technology

2.1. A multidimensional view of competence

Researchers have highlighted 3 competence perspectives regarding countries. First, the job-oriented definition in the UK considers competence as work station attribute. The US worker-oriented definition defines competence as attribute of individual who is the only one responsible of it. In this view competence doesn't include contextual, organizational aspect. Finally, we follow the multidimensional definition used in European countries, like France [20,21]. In this view competence is a combination of several resources, internal and external at the individual, group or firm who develop it. Competence is expressed in action, depending in part of it environment [22]. It as a goal, the "what is to be made", that mean the task described by de Montmollin (1986) [23]. Competence is dynamic and has a life cycle [22,24]. We consider that this approach can be enhanced by distributed cognition theory, in order to better take into account importance of action and external resources presents in the environment.

2.2. Interest of distributed cognition theory

Theory of distributed cognition can be linked to this view and thus adapted to the concept of competence. Distributed cognition is defined as information flux which is distributed in individuals mind and some media in human environment as artifacts and other human minds. This distribution is made in the time and it's coordinated by a structure which defines several steps of action [25, 26]. In order to better understand it, Hutchins (1995) [25] proposes to focus on activity realized in task frame. So we can adapt this theory by saying that competence can be distributed in the time, between people (that's mean socially distributed) and between human and technology, more precisely under artifact form. This view is in harmony with multidimensional model of competence where competence is composed by several resources and not only human resources. We can adapt distributed cognition theory to competence in order to say that competence is distributed. Orlikowski (2002) [27] has already showed that competence is socially distributed. Latour (1992) [28] has supposed that distribution of action between human and artifact can lead to a distributed competence. Then we try to link competence to technology.

2.3. A multidimensional view of competence

Finally, by mixing these two theoretical pans, we can define competence as composed by set of resources and a structure or a scheme. Resources can be internal to humans or included in their environment like artifacts. Structure, although defined as scheme by several scientists, is needed to mobilizing resources in competence [29].

Technology is discussed through several generic terms, as tool, instrument, and machine. We think that the concept of instrument is particularly relevant for our analysis. Rabardel (1995) [30] define instrument as composed by two entities: artifact and scheme. For him, artifact is material or immaterial structure of instrument. This structure may impose restrictions and bring new opportunities by allowing or not some of these actions in the implementation of activities [25,31]. Scheme is an abstract and stable model of action [29], more particularly; utilization scheme is a model of action concerning use of this artifact [30]. The utilization scheme can be common for a group [32]. The utilization scheme can be the way to coordinate the resource distributed in competence, when this competence is linked to the use of instrument. This definition of technology is very interesting because it allow us to overcome typology of technology like Information and Communication Technology, automated process technology, decision technology. By this way, we can define technology in same terms than competence: scheme and resources (provided by artifact).

3. Materials and methods

We based on qualitative methodology with semi-structured interviews. We have anonymized some data about our informants. On one side, we have interviewed 7 experts of Precision Agriculture (designers, researchers and network facilitators) in order to better understand the technologies studied and interactions between users and designers. On the other side; we interviewed 9 people in 7 firms using Precision Viticulture technologies. These 7 firms constitute our 7 case studies situated in several regions of France. The sample is composed by 6 independents wineries and one cooperative.

The first firm, named firm I is a wine-producing holding of 360 ha and employing 123 people. It uses a vigor sensor. The firm J is a wine-producing holding composed by 1150 ha and 1300 employees. It uses the same vigor sensor than firm I. Firm F is a familial vineyard of 41 ha and with 25 employees. It use drone with camera. Firm P is a familial vineyard in a growing phase, with 135 ha and 15 employees. It use meteorological border with 2 hygrometric probes for characterizing water stress. Firm O is a vineyard with 31 ha and 6 employees, using a service providing of vegetation cover mapping for characterizing vegetation heterogeneity.

Firm Y is a cooperative. It include 18 vineyards for 1870 ha and 181 farmers. It has 3 own vineyards in 140 ha and 91 employees. It use service providing of NDVI and vigor mapping for characterizing vegetation heterogeneity of all cooperative area. Maps have been used one year in their 3 own vineyards with an automated spreader with DPAE for modulation of fertilization. Finally, a vintage machine is used in these 3 vineyards in order to do modulated vintage regarding maps of service providing, but also with sensors of the vintage machine. The last, firm A is a familial vineyard composed by 3 partners and one employee on 9 ha. It uses a DPAE (flow rate proportional to the electronic advance) to modulate doses of input.

4. First results

First we briefly describe artifacts used. Even if there are device composed by several artifacts, we describe it as one unified artifact in order to simplify analysis. Then we explain task where they are used and we finish by describe steps of competence scheme.

In firm I sensor is linked with a GPS, an on-board computer and mounted on a tractor equipped with pre-pruner. In addition, a USB stick, simple software programmed under Python and the free software Qgis are used for data processing. This is used in a task of characterization of heterogeneity. This task is clearly oriented by attainment of environmental and quality target. We distinguish several steps of the competence scheme, were use of technologies is made in group. First, sensor is mounted before pre-pruning on a tractor equipped with pre-pruner. In winter during pre-pruning period, each day tractor-drivers, chosen for their experience, use this sensor for data collection. At the end of the day, after data collection, data are stored in USB stick and transferred to members of management team who will transfer data by mail to the individuals who do the processing step. Data processing is made during the same period than data collection. It consists to filter incorrect data, realize repartition graph of the values and mapping the value. The first year of use, it's made by Deputy Management of the wine-growing holding. Years after, it is made by accountant of the firm who is accustomed to use many data management software, even if she hasn't agronomic degree. At the end of the season, sessions of data analysis are made in group between management team, tractor-drivers, experimentation manager and field labors. This analysis is made by collective step back with confrontation of sensor data with knowledge of field labors, experimentation results, soil analysis, grape analysis, visualization by comeback by foot in some plots, etc. It allows doing zoning for creating modulations of technical itineraries. People were trained, sensitized for using these new technologies. This use is strongly linked to global production goals of the firm. By other way, strong links with sensor designer, who is part of a professional organization, allow him training and help them and adapt sensor to their needs. Much technologic watch is made in this firm and people are accustomed to try new artifacts each year.

In firm J, artifacts used are the same than in firm I. The several steps of the scheme are also the same, even if there are some differences in the way to perform it. First, sensor was tested in R&D department of the firm, with few users and just one individual for data collecting. With transfer to operational services, the use is made in group, but not really coordinated. For example, during the first year of transfer, people who do sensor mounting, data collection and transfer aren't identified. Individuals that take part of this process aren't trained and sensitized. People who help them and do the data processing are trainees who aren't the same year after year. Furthermore, the mounting is not the same as in firm I. Transfer of the data is more complicated and implies more displacement for management team. To finish, data analysis isn't also democratic as in firm J and sensor use isn't linked to production goals of the firm. In this firm, sensor use has been unsuccessful. Few reliable data were collected and few maps were realized. But recent and new organizational choices improve results, as choice and training of new users.

Firm O use service providing of mapping by satellite. These maps are used in the task of characterization of heterogeneity. This task is linked to the need of determining date and modulation of vintage. Data collection, data processing and one part of data analysis are made by service providers. But the farmer, who is user, makes himself analysis of the map by matching with other sources of information and checking the data with observations of the plants. Then, he can take decision about zoning plots and vintage date. But, due to his professional experience in multinational sanitary product firm, he has some difficulties to impose his decisions. It's because employees don't consider he has experience in viticulture. Moreover, they are unwilling to practices change.

Firm F uses drone with camera, GPS, SD card and joystick. Camera provides pictures viewable on a computer. Drone is used by managers in the task of characterization of heterogeneity. This characterization is linked with general goals depending of situation. It can be used for characterization of sanitary situation, vintage modulation, etc. For that's concern utilization scheme, data collection can be made by leading drone alone or accompanied by other people. The first visualization of picture is occasion to "processing" data. It's not processing by making a model, but by cleaning and joining pictures. A second visualization, made alone or with colleagues is occasion to better understand picture and compare it with other information. At the end, it's possible to take decision on zoning plots including advice of other people like oenologist. We can highlight that people of this firm make many technological and agronomic watch, they try to regularly test new product and technologies, especially for improve their sustainable approach.

Firm P uses meteorological border with 2 hygrometric probes, composed in part of GPS, sensors SD cards and coupled with use of Internet and computer for having access to data. This device is used by the farmer and is father in characterization of temporal heterogeneity of water stress. Data acquisition is automatically made. Data are automatically processed and are validated by border provider. A first data analysis is made by the farmer or his father. After this analysis, a is taken in order to choose what kind of action is needed to modulate (irrigation, sanitary protection). In this firm, interest of new knowledge by internal research, openness toward innovation, discussion with international farmers and partnership by testing technologies in development are particularly showed as important for firm growing.

Firm A use a DPAE, an on-board computer with GIS mounted on a tractor. It's composed by bus CAN (Controlled Area Network), a sensor on the vessel, speed sensor and linked with electromagnetic valves. This device is used during task of technical itineraries modulation. This task is strongly linked to the willing to avoid exceed doses authorized by biodynamic label. Utilization scheme is decomposed in three main steps. First step is registration of data (setting) in on-board computer. These data, like vine variety or inter-row width, define heterogeneity of plots and choice of technical itineraries. The second step, application of input is in part made automatically by processing of the registered data and in another part in real time with information collected by speed sensor. Application can also be made manually by the drivers of the tractors regarding information visualized on the on-board computer or the tractor environment. The last step is refinement of setting regarding the new collected data. In order to improve his practice, the farmer takes part to collective exchange of practice within group of users constituted by an organizational organization.

Finally, firm Y uses three sets of device. One of this is a service providing of mapping. The first year, data acquisition was made by drone. The second year it was made by aircraft and years after by satellite. Maps and recommendations are transmitted to users by Internet. This service is used in characterization of heterogeneity to understand crops and their needs of input. This understanding is linked to a general goal of the firm, importance for saving input and to have sustainable behavior in input application. Data collection and a part of data processing are made by service providers. A second data processing with Qgis and an analysis of these data are made in the cooperative. Returns of these data are made in recommendations form to each farmer in order to explain them interest of this service. The other device used is a fertilizer spreader, in part composed by DPAE, sensor, SD card, GPS, IDE (Internet Data Exchange) and an on-board computer where maps realized before were stored. This fertilizer spreader is used in modulation of technical itineraries (modulation of fertilizer) for economics and sustainability goals. Utilization scheme is the same that in firm A, with little adaptations, for example spreader user can see the map in on-go computer, that isn't the case in firm A. The other device used by firm Y is a vintage machine. It includes sensor, on-board computer, IDE, SD card and GPS. It's used for modulation of technical itineraries, more precisely vintage modulation, and it's linked to willing to improve quality of wine. Utilization scheme takes the same form that for using fertilizer spreader. For example, the first step is the setting, with inclusion of map realized during characterization of heterogeneity. Grape selection is made regarding this map and with data recorded in real-time by sensor measuring anthocyanin rate. Feedbacks of data recorded in real time and shaped under map allow setting improvement. This can be the opportunity to make another loop of Precision Viticulture by begining a new task of characterization of heterogeneity.

5. Discussion

Regarding these results, we can develop a grid of analyze. Precision Viticulture includes here two main tasks where distributed competences take place. It also includes several kinds of technologies related by utilization scheme and artifacts providers of resources.

Before use or purchase, some reflections are made by users in order to define tasks where technologies are needed. Task is considered here as the goal of action [23] or the aim of use of technologies. This is what de Sanctis and Poole (1994) [33] called spirit of technology. But this spirit has to be interpreted in managerial and production terms, that's Hatchuel and Weil (1992) [34] have called managerial philosophy. Interpretation scheme is a part of the scheme focused on technology aim, interpreting technology spirit [33]. It allow to link spirit to managerial philosophy. It is highlighted when people that we have interviewed explain us that it is important for them to keep in mind their own production objectives during all the steps of the scheme. This is particularly pointed out during data analysis and decision of zoning. These two steps are also called data interpretation and recommendation zoning by several agronomic scientists. It's important to link spirit to managerial philosophy because there are many values that we can measure or evaluate (soil composition and moisture, NDVI, anthocyanin, vigor…). And there are many kinds of technical itineraries that can be modulated (spread of fertilizer, sanitary product, vintage, modulation of grass in inter-row…). The willing to reach production targets impacts the choice of value to measuring or choice of technical itineraries. The only one firm that doesn't have made this link is firm J and it is the one that has many difficulties to record reliable data.

We can say that Precision Viticulture is decomposed in two main tasks: characterization of heterogeneity and modulation of technical itineraries regarding this heterogeneity. These tasks have been intuitively mentioned by de Carvalho Pinto et al. (2007) [5]. We see here that the task made in first is characterization of heterogeneity, were the diagnosis competence take place. The second task, modulation of technical itineraries is place where we encountered scheme and resources of competence of technical itineraries management. Performing diagnosis competence can help to manage technical itineraries. However we have seen the possibility that management of technical itineraries can give opportunity to begin another diagnosis.

But, as we have seen in the first part of this article, in viticulture the concept of *terroir* induces the fact that characterization and modulation are task already made by winemakers with more traditional methods. Characterization is made by visualizing plots during manual activities of winemakers, or by coring the soil or doing grape analysis [2]. Modulations are generally made during manual activities regarding information obtained by characterization. Thus, what is really new in Precision Viticulture concept? As Tisseyre (2012) [3] says, the new technologies used create some revolution of information for more precise information and better automation. Then, we can say that Precision Viticulture is as a way to act than a set of technologies in two kind of competence. There is a traditional Viticulture Precision and a modern one, some "Viticulture Precision +" with added technologies. We have seen that is possible that a firm use Precision Viticulture technologies only for one of the two referred tasks.

We will recap the resources provided by artifacts and the utilization scheme for each competence. A part of competence scheme can be made by a service provider, like data collection and processing in firm O and Y.

Task of characterization of heterogeneity is where is patterned the scheme of the competence we call diagnosis competence. The scheme associated to this competence is variable regarding kind of technology, situation, and firm.

But we can find some common steps between several firms:

- step 1: mounting (in firms I and J)
- step 2: data collection
- step 3: data transfer (important step for data reliability in firms I and J)
- step 4: data processing
- step 5: data analysis, it can be made separately (firms O, F, P and Y) or associated with step 6 (firms I and J)
- step 6: decision of zoning. All studied firm in this step do complementary manual soil and crop sampling or visual observation in order to be sure of Precision Viticulture data. And as Zwaenepoel and le Bars (1993) [4] say, farmers and employees expertise on their plots is essential to take decision that can at first sight to be contradictory to Precision Viticulture data.

In this task, artifacts provide several kinds of resources that we call here "means". We can see in the Table 1 that even if artifacts used are different, they provide the same kind of resources.

The second task, named task of modulation of technical itineraries, is where is patterned the scheme of the second competence. We choose to call it competence of management of technical itineraries. The scheme associated can be broken down as follows:

- step 1: setting by data registration
- step 2: application of modulation (application of input, vintage) by data processing
- step 3: refinement of setting

In this task, artifacts provide similar kind of resources explained in Table 2.

We can see the common resources provided by these technologies, with some particularities for each

Table 1. Resources provided by Precision Viticulture Technologies in task of characterization of heterogeneity.

Means of data process-sing and analyzing	Means of data transfer	Means of data store	Means of data visualization	Means of locomotion or fixing device	Means of data localization	Means of data collection	Resources
Desk computer, software	USB stick, IDE, Internet	USB stick, computer	On-board soft-ware	Tractor	GPS	Sensor	**Firm I**
Desk computer, software	USB stick, IDE, Internet	USB stick, computer	Computer, software	Tractor	GPS	Sensor	**Firm J**
Desk computer, software	Internet	Computer, binder	Computer, software, binder	Satellite	GPS	Sensor	**Firm O**
Desk computer, software	Remo-e control, SD card	SD card, computer	Desk computer, software	Drone and joystick	GPS	Came-a	**Firm F**
Desk computer, software	Internet by WIFI	SD card, computer	Desk computer, software	Housing of border and probes shaft	GPS	Sensor on border and probes	**Firm P**
Desk computer, software	Internet, IDE	SD card, computer	Desk computer, software	Drone, Aircraft, Satellite	GPS	Sensor	**Firm Y**

Table 2. Resources provided by Precision Viticulture Technologies in task of modulation of technical itineraries.

Resources	Firm A	Firm Y for input modulation	Firm Y for vintage modulation
Means of data collection	Speed sensor, storage meter, on-board computing (for pre-registered data)	Speed sensor, storage meter, on-board computing (for pre-registered data)	Sensor, on-board computing (for pre-registered data)
Means of data localization	GPS	GPS	GPS
Means of locomotion or fixing device	Tractor	Tractor	Vintage machine
Means of data visualization	On-board computer	On-board computer, desk computer, software	On-board computer, desk computer, software
Means of data store	On-board computer, SD card	On-board computer, SD card	On-board computer, SD card
Means of data transfer	IED, SD card	IED, SD card	IED, SD card
Means of data processing and analyzing	GIS on on-board computer	GIS on on-board computer	GIS on on-board computer
Means of acting on heterogeneity	Electromagnetic valves	Electromagnetic valves	Harvesting head, sorting table, vessels

task. In task of characterization of heterogeneity, means of data processing and analyzing are more developed than in task of modulation, where they are only used to allow acting in real-time. In modulation task, new means appear: means of acting on heterogeneity. In these two tasks, data analysis or refinement of setting is the place for step back on work. That is a way to improve competence and develop knowledge [29]. Farmers say us that uses of these technologies allow them to go back to fundamental agronomical concepts. Particularly in task of characterization, they are associated with investigating work in order to better understand causes of heterogeneity. By the way, we can see that even users of service do a part of processing and analysis. This work challenge affirmation made by Jullien and Huet (2005) [2] distinguishing proprietary of technologies like actors and pro-actives from "passive" consumer of service.

However, as we consider competence is distributed, there are other resources to take in consideration than only Precision Viticulture resources, like material and financial resources, human resources other organizational resources and extra-organizational resources.

In the interviews we have leaded, several resources appear to facilitate use of technologies and resources they provides. For example, financial resources were mentioned in interview for all cases. They can facilitate adoption of these technologies considered as expensive. Material resources are important because of compatibility needs as for equipment dimension than for data standard in automation. Human resources are particularly relevant. It's a priority for all our informants. They consider that a lack of people who have the good skills and knowledge can dissuade to use these technologies or encourage requesting service provider more than acquire technologies. There is other kind of organizational resources like openness and interest for innovation, which encourage and facilitate to see opportunity bringing by technology. And the learning made by using other innovation and technology can be resources adapted to use of the new one. The management type can allow users to improve their use of technology. Interest for sustainable practices for example, can give clear goals to technology, clarify it spirit. By this way, we can see that the only one firm which has difficulties in using technology is firm J. This is the one which

Table 3. Main resources provided by firm and its environment in task of characterization of heterogeneity.

Human resources	Extra-organizational resources	Other organizational resources	Material and financial resources	Resources or constraints
Deputy Manager, tractor-drivers, field labors, sector leaders, foremen, experimentation manager, accountant	Help and support from designer, exchange with other users	Openness to new technology (by testing and adapting every year new equipment), participative management, resources provided by training and awareness , interest for sustainable practices	Additional material (like pre-pruner), disposition of the equipment, financial resources	**Firm I**
Team managers, tractor-drivers, sector leaders, R&D engineer, engineer trainee (changing every year), Garage manager	Help and support from designer, exchange with other users	Lack of thinking about goals reached by technology use, R&D department, since 2015 resources provided by training and awareness	Additional material, own garage, financial resources	**Firm J**
General Manager	Regular use of advisors, help and support from professional organization, part of the scheme realized by service provider	Lack of resources in terms of openness to innovations, lack of interest of employees and relational difficulties	Additional material, new fermentation tank	**Firm O**
General Manager, Technical manager, head of cultivation, trainee, soil scientist	Training for drone piloting and data processing software	Familial management, interest for sustainable practices, interest for innovations	Additional material, financial resources	**Firm F**
Farmer and his father	Exchange with other users and designers, researchers, maintain of borders	Interest for sustainable practices, interest for innovations, Openness to new technology (watch), experience in R&D project with designers	Other material (like drip irrigation system, simple agricultural equipment), financial resources	**Firm P**
Innovation Manager and his assistant head of cultivation, oenologist	Help, support and part of the scheme realized by service provider, exchange with other users, interest from any famers	Interest for sustainable practices, interest for innovations, experience in R&D project with designers, representation of almost of designation	Additional material, financial resources	**Firm Y**

doesn't have a clear and strong technology spirit. Even if for firm F and P, technology spirit and goal of use are changing depending situation of use (measure sanitary state, anticipate vintage…). A participative management style can help to make collective discussion, even with people who aren't users but who can provide their knowledge in order to better understand data. This is highlighted in firm I by the help of field labor on collective step back in data analysis. Training and awareness made for users and their colleagues are important resources. Training is the opportunity to develop new knowledge and skills and awareness develop motivation of people and eliminate fears linked to technology. It is particularly relevant in firm I where manager too are trained and aware of this technology. Participative management expands awareness to other people like field labor who aren't direct users but participate to data analysis. We can see difference between this firm and firm J. Firm J is the only one firm where training and awareness aren't made. In this firm, lack of skills, knowledge and motivation has consequences on data acquisition. These lacks can concern as users as their managers (sectors leaders and foremen). In general, training can be made by people external to the firm like advisor or designers. In this case, we consider that the resource is extra-organizational. It can be provided with other help and support supplied by designer. Designers can help users when they face problem with technology. And a discussion with users allow designer to improve technology. Service provider realize part of the scheme of action and other users bring some knowledge and exchange "best practices" in some formal or informal users communities.

We choose to name "constraints" the lacks of resources that can be damaging for a good perform of Precision Viticulture competence. These constraints appear in case J, Y and O. We have seen the problem caused by lack of strong technology spirit and the lack of training, awareness, participative management. In firm O, the constraints are lack of openness to innovation of employees and relational difficulties General Manager has with them. That has for consequences a zoning less precise than General Manager wanted. Constraints can be extra-organizational, like regulatory and institutional constraints. Ours informants have highlighted the relative importance of these aspects in the two Precision Viticulture competences. For example, in case Y, difficulties in obtaining European funding delay the development and testing of new spreader more adapted to firm goals. On the contrary, for firm A, regulatory constraints can be understood as resources. In fact, statutory limits for Demeter label (biodynamic agriculture) is an aim of use of DPAE, it constitute a motivation for farmer of firm A.

Table 4. Main resources provided by firm and its environment in task of modulation of technical itineraries.

Resources or constraints	Firm A	Firm Y for input and vintage modulation
Material and financial resources	Management and traceability tool, complementary agricultural equipment and repair equipment, financial resources	Complementary agricultural equipment, financial resources
Other organizational resources	Openness to new technology (technology watch), interest for sustainable practices	Interest for sustainable practices, interest for increase wine quality, interest for innovations, experience in R&D project with designers
Extra-organizational resources	Share of users experience, training	Data obtained in task of characterization of modulation, help and support from designers, share of users experience, difficulties to obtain European financial help
Human resources	Farmer	Innovation Manager, tractor-driver

As we have seen, the two studied competences are distributed between several people (social distribution) and entities, as human and technologies. It distribution is made in the time during several step of a scheme coordinating these resources. The analysis of these resources and constraints liked with a model of action, the scheme, allow us to do some practical recommendation to designers and users of Precision Viticulture technologies.

6. Practical recommendations

This work can help users by giving them some practical recommendations in order to improve performance and interest of Precision Viticulture technologies. We begin by recommendation to designers. We showed here interest highlighted by Prost et al. (2012) [35] for designers to take in account users since first step of conception. Spirit of technology has to be clearly identified and fit with production goals, resources and constraints of the farmers. It can be possible for example through participatory research [36], like in case Y. These kinds of design and conception can inform about needs of some particular resources like specific human resources, or data standard compatibility, needs of other equipments and specificities of designations and regions. That helps designers to adapt their technology to several market segments. Many of the technologies studied in our case are designed by several firms, each of them providing a specific expertise. By the way, partnership with other designers can be helpful in order to create peripheral equipments needed that can have been set in relief by partnership with users. These peripherals equipments can be adapted in term of dimension and data standard to Viticulture Precision technologies. In addition, maintain good relationship with users after purchase is helpful for designers. By helping and providing training to users, they can better understand their needs and problems. That can lead to improve technology and develop other complementary tools. Due to the fact that Precision Viticulture is still unknown and there is few training in this domain, this support provided by designer can be a commercial argument to choose this tool instead of another. Furthermore, as one of our informant said, it's important that at least one of firm designer comes from Viticulture industry, in order to better understand its constraints and specificities. Agriculture is a specific sector and more particularly, viticulture hasn't the same characteristics than other kind of crop. If it's not the case, designers had to do a partnership with professional organization of the sector in order to gain credibility. This partnership can include training and support to users made by a professional organization.

We have also some recommendation to users. Our researches show importance for users to define what aims they want to reach with Precision Viticulture technologies and in what kind of task. The use of these technologies can be linked with sustainable practices, interest for increasing quality or developing tractability. This is the occasion to evaluate feasibility of implementation by an audit of resources they need and those they have. Resources can be determinate in term of financial or material resources, human resources, other organizational resources as production routines or openness to innovation, and finally external resources provided by their environment. These external resources can be the link with other users, the designers or the academic community. Human resources (HR) practices and management are other important aspects. We have seen that identifying the good people, training and making awareness to employees is crucial for success of technology implementation and well perform the competence. Awareness allows employees to better identify aim of technology use. With socially distributed aspect of competence, we have seen that these HR practices shouldn't be focused only to direct users, but to others people with whom they interact during all the steps. A participative management helps users to implicate to improvement of the competence. This participative management gives to the floor to participate in collective feedback and to reach a consensus in order to build a common utilization scheme and have the same interpretation of aim of use (technology spirit). That's why others people than direct users are important, like trainer and advisors (who can be internal or external to the user firm), or the gatekeeper. Gatekeeper is individual who is at interface between users and designers. He can be a referee, that's mean the supervisor of technology implementation. The problems in firm J shows that the referee has to be stable in the time in order to create long relationship with users and better understand them. Managers who supervise users' work are other kind of important people. In firm J, unmotivated managers demotivate tractor-driver in data acquisition, that's lead to bad results. Although with motivated managers, good results have been encountered. To have these good examples of success is a way to lean on lead users. These lead users can motivate others users, and transmitting knowledge [37]. They also can be external to the firm, like users community. Eventually, openness to innovation, watching, habits of testing new tools and agronomics experimentation can facilitate new technology uses. It can be interesting for users doing participative research with designers for testing new technology and see if it can be useful for them before a purchase. Once technology purchased, the firms which have the most of people implicated in technology use (firm I, Y and firm J when they try to solve their problem of sensor use) have a particular way to implement technology use. They choose to gradually increase area where used technologies are. We think this way allow to rapidly identify problem of use before too duplicate them and increase bad way of use and demotivation.

7. Conclusion

Our work allows us to highlight that Precision Viticulture can be considered like technologies and through two kind of distributed competences: diagnosis competence and competence of management of technical itineraries. They are composed by resources and scheme. We think that this work can help to better understand what can provide Precision Viticulture technologies and how it can be used. Thus, we hope having produced the illustrate case studies needed for helping adoption of Precision Viticulture [17]. By this way, we have seen that limits emphasized by scientist 10 years ago are in part still relevant. On the other part, we have identified some good practices and some problems that enable us to do some practical recommendations as for designers than for users. By this way, we hope taking the translator role attributed to social scientist [38] in order to facilitate relationship and understanding between specialists and non-specialists, designers and users of Precision Viticulture technologies.

References

[1] P. C. Robert. Precision agriculture: an information revolution in agriculture. Agricultural Outlook Forum (1999)
[2] A. Jullien, P. Huet. Agriculture de précision. *Agricultures et territoires*, Lavoisier, Paris (2005)
[3] B. Tisseyre. Peut-on appliquer le concept d'agriculture de précision à la viticulture. Mémoire d'habilitation à diriger des Recherches (2012)
[4] P. Zwaenepoel, J.-M. Le Bars. L'agriculture de précision. Ingénieries-EAT **12** (1997)
[5] F. D. A. de Carvalho Pinto, D. M. de Queiroz, E. Chartuni, E. Ruz. Agricultura de precisión: nuevas herramientas para mejorar la gestión tecnológica en la empresa agropecuaria. Revista Palmas **28**(4), 29–34 (2007)
[6] D. J. Mulla. Twenty five years of remote sensing in precision agriculture: Key advances and remaining knowledge gaps. Biosystems Engineering **114**(4), 358–371 (2013)
[7] D. Boisgontier. Les nouvelles technologies de l'information aux Etats-Unis Etats des lieux et perspectives vus de la France. Colloque AgriMédia, France (2004)
[8] R. Ortega, L. Flores. Agricultura de Precisión: Introducción al manejo sitio-específico. *Ministerio de Agricultura, Instituto de investigaciones agropecuarias. CRI Quilamapu*. Chile, 13-46 (1999)
[9] T. Catanzarite Torres, A. B. González Fernández, F. J. Benavente Cobo, J. R. Rodríguez Pérez. SIG para el seguimiento vitícola y diferenciación de lotes de vendimia en la DO Bierzo (León-España). (2009)
[10] A. Dobermann, S. Blackmore, S. E. Cook, V. I. Adamchuk. Precision farming: challenges and future directions. 4th International Crop Science Congress. **26**. Brisbane, Australia (2004)
[11] J. A. Taylor, McBratney, A. B., B. M. Whelan. Establishing management classes for broadacre agricultural production. Agronomy Journal **99**(5), 1366–1376 (2007)
[12] E. Jallas, M. Crétenet, M. Aide à la décision en agriculture et gestion des ressources naturelles: Note introductive. Savanes africaines: des espaces en mutation, des acteurs face à de nouveaux défis. *Colloque Cirad-Prasac*, Garoua, Cameroun (2003)
[13] B. Ariaux. Les SIG utilisés en agriculture de précision. *Colloque Agriculture de Précision, Educagri*, Dijon France 55–65 (2000)
[14] J. Lowenberg-DeBoer. Precision farming or convenience agriculture. *11th Australian Agronomy Conference*. February (2003)
[15] P. C. Robert. L'agriculture de précision: les verrous liés à la technologie et à la gestion agronomique. *Colloque Agriculture de Précision, Educagri*, Dijon (2000)
[16] C. Martin, C. Pages. Conditions et moyens d'une gestion informatisée des données pour la mise en oeuvre de l'agriculture raisonnée: exploration stratégique par la méthode d'audit patrimonial. Ingénieries-EAT, 30 (2002)
[17] A. McBratney, B. Whelan, T. Ancev, J. Bouma. Future directions of precision agriculture. Precision agriculture, **6**(1), 7–23 (2005)
[18] J. Arnó Satorra, J. A. Martinez Casasnovas, M. Ribes Dasi, J. R. Rosell Polo. Review. Precision viticulture. Research topics, challenges and opportunities in site-specific vineyard management. Spanish Journal of Agricultural Research **7**(4), 779–790 (2009)
[19] A. Matese, P. Toscano, S. F. di Gennaro, L. Genesio, F. P. Vaccari, J. Primicerio et al. Intercomparison of uav, aircraft and satellite remote sensing platforms for precision viticulture. Remote Sensing **7**(3), 2971–2990 (2015)
[20] T. N. Garavan, D. McGuire. Competencies and workplace learning: some reflections on the rhetoric and the reality. Journal of Workplace learning **13**(4), 144–164 (2001)
[21] F. D. Le Deist, J. Winterton. What is competence?. Human resource development international **8**(1), 27–46 (2005)
[22] E. Rouby, C. Thomas. L'articulation compétences individuelles/compétences stratégiques: vers une solution de gestion intégrée des compétences. Revue Interventions économiques **40** (2009)
[23] M. De Montmollin. L'intelligence de la tâche: *Eléments d'ergonomie cognitive*. P. Lang. (1986)
[24] T. Durand. L'alchimie de la compétence. Revue française de gestion **160**(1), 261–292 (2006)

[25] E. Hutchins. *Cognition in the Wild*. MIT press (1995)
[26] E. Hutchin. Distributed cognition, *Internacional Enciclopedia of the Social and Behavioral Sciences* (2000)
[27] W. J. Orlikowski. Knowing in practice: Enacting a collective capability in distributed organizing. Organization science **13**(3), 249–273 (2002)
[28] B. Latour. On interobjectivity. Mind, culture, and activity **3**(4), 228–245 (1996)
[29] P. Pastré, G. Vergnaud. La didactique professionnelle. Revue française de pédagogie **154**(1) (2006)
[30] P. C. Rabardel. Les hommes et les technologies; approche cognitive des instruments contemporains (1995)
[31] J. Hollan, E. Hutchins, D. Kirsh. Distributed cognition: toward a new foundation for human-computer interaction research. ACM Transactions on Computer-Human Interaction (TOCHI) **7**(2), 174–196 (2000)
[32] P. Beguin, P. Rabardel. Concevoir pour les activites instrumentees. Revue d'Intelligence Artificielle **4**(1), 35–54 (2000)
[33] G. de Sanctis, M. S. Poole. Capturing the complexity in advanced technology use: Adaptive structuration theory. Organization science **5**(2), 121–147 (1994)
[34] A. Hatchuel, B. Weil. *L'expert et le système: gestion des savoirs et métamorphose des acteurs dans l'entreprise industrielle; suivi de Quatre histoires de systèmes-experts*. Economica (1992)
[35] L. Prost, M. Cerf, M. H. Jeuffroy. Lack of consideration for end-users during the design of agronomic models. A review. Agronomy for sustainable development **32**(2), 581–594 (2012)
[36] J. N. Pretty. *Regenerating agriculture: policies and practice for sustainability and self-reliance*. Joseph Henry Press (1995)
[37] L. B. Jeppesen, K. Laursen. The role of lead users in knowledge sharing. Research Policy **38**(10), 1582–1589 (2009)
[38] M. Callon. Éléments pour une sociologie de la traduction: la domestication des coquilles Saint-Jacques et des marins-pêcheurs dans la baie de Saint-Brieuc. L'Année sociologique (1940/1948-) **36**, 169–208 (1986)