ROBS4CROPS

D 1.1

Farmers perception on the proposed and running agricultural robotic systems

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Abstract:	This document presents the perception of robotic systems for weeding application by farmers. It contains a description on how these perceptions were collect, the farmer's perception and an analysis of those data. This deliverable D1.1 will mainly be used to orientate the work of the "Design" Work Packages (WP2, WP3 and WP4) by directing them to the primary needs of the end-users

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CoDS	Co-Design Session
LSP	Large Scale Pilot
R4C	Robs4Crops
Raas	Robot as a Service
WP	Work Package

1 Introduction

Robs4Crops aims to create a high-end agricultural robotic system. In the project, this system will be used for spraying and mechanical weeding, but the aim is that the system will ultimately support other applications in the field as well. An unmanned ground vehicle (UGV), robot or tractor, will carry the smart implements (sprayers and weeders), which will use the standard 3-point linkage and communicate with ISOBUS and TIM. The Farming Controller (planning software) supervises the system with Digital Twin technology and the data, which are going to be collected by UGVs and implements, will be saved in a Farm Management Information System (FMIS). This robotic system will allow farmers to plan agricultural tasks remotely. Selecting a specific implement, farmers will be able to proceed with the appropriate vehicle for their operation at their field. They will supervise the executed activity through the simulation environment of the farming controller in real-time. All the data will be visible and therefore, farmers will be able to intervene and customize the system's operation if the situation necessitates.

The aforementioned methodology will be adapted and implemented in the context of four Large-Scale Pilots (LSPs), farmers' field where the robotics systems are tested.

The purpose of this document is to provide the perception by farmers on current robotic systems for weeding (mechanical or spraying) and disease control (spraying). This document is organized as follows. Two methods to collect data on farmer perception are given in section 2. In section 3, the farmer perception is developed and ends with a few requirements. Finally, an analysis of those perception is presented as a conclusion.

2 Methods

Thanks to a better knowledge of each partner and to a more consistent work available, we have evolved our methods to collect farmers' perception between the beginning and the end of the R4C project's first year. Therefore, we will talk about ***first inputs*** for the answers to the method employed at the beginning of the project (in month 2), and ***second inputs*** for the data harvest at the end on the first year (in month 11). In this section, we give an overview of the methods detailed in Annexes.

2.1. First inputs - Mail, Month 2

At first, we wanted to get a global overview from all the consortium partners. Therefore, we contacted them by mail while asking to answer the following:

"

What is the perception of a robotic system by a farmer concerning:

- Weeding work,
- Economic system,
- Ethical considerations?

How was the information collected?

"

Those inputs allow WP1 Leaders to get an overview of what was expected for robotic systems and to start T1.2, defining some requirements.

2.2. Second inputs - Co-Design Session, Month 11

After almost a year of the project, we wanted to get data directly from the farmers. To do this, we organised four Co-Design Sessions (CoDS), one in each LSP, led by a facilitator and a monitor with about ten participants. A CoDS could be defined as follow:

" Co-design is an approach to design, attempting to actively involve all stakeholders in the design process to help ensure the result meets their needs. It enables a wide range of people to make a creative contribution in the formulation and solution of a problem. "[1]

We have prepared a methodology with the goal of defining requirement directly with the final users. It results the following session logic:

The session seeks to explore for each LSP how a specific robotic technology can be developed further so that it optimally serves the needs of farmers as well as that of the wider society. The set-up of the session is based on the following logic in terms of the developmental process:

- The robotic system is intended to serve a specific function and has certain characteristics to help achieve that.
- These characteristics, however, also have further impacts that can either be positive or negative (e.g. a weed remover may also damage crops). These impacts can be on farming but also on the wider environment (e.g. less pollution or lower CO2 emissions).
- Partially because of these impacts, there are barriers and opportunities towards further development (e.g. damaging of crops creates technological barriers; lower emissions create opportunities for political or societal support).
- All these combined, set a number of requirements for further development, either technical requirements for the robotic system itself or requirements to foster the developmental process (e.g. support from specific stakeholders).

Based on this, the session programme includes the following exercises to be carried out with the participants:

- Assess function(s) of the system
- Assess potential positive and negative impacts
- Assess barriers and opportunities for further development
- Identify requirements for further development (on the technology as well as the process)

These requirements define the final output of the session. Each meeting will thus help to identify the key aspects that the LSP will need to address in the following year.

To prepare those CoDSs, we have performed several tasks:

- we guided the LSP leaders to do their practical organisation,
- we met with the facilitators and monitors of the CoDS to do a training session and
- we prepared documents to help facilitators during the CoDS, then monitors sent us back important inputs for the R4C project.

[1] **Co-Create Basics.** RESOURCES. *CO-CREATION SKILLS & TRAINING.* [Online] 11/12/2021. http://www.cocreate.training/resources/

Figure 1 : Final rendering of a R4C Co-Design session (NL – 27/10/2021)

You will find all those documents and templates in the Annex 2: Script of the Co-Design Session and the complete methodology in the Annex 1: Methodology of the Co-design Sessions.

3 Perception of robotic systems by farmers

In this section, you will learn about the perception of robotic system by farmers in early 2021 (first inputs) and late 2021 (second inputs).

3.1. First inputs

In this section, you will find the perception of farmers on robotic systems concerning five aspects:

- Mechanical weeding,
- Spraying weeding,
- Robotic system,
- Vision of the economic system and
- Ethics.

These data were collected differently for each LSP. For French winegrowers, in 2017, Terrena (TER) had 3 workshops with groups of 3 to 4 winegrowers of Loire Valley to detect their perception of robotic system and in 2020, Terrena received feedback from 4 farmers who tested a robotic mechanical weeding service in their field.

For Greek grapes farmers, data comes directly from Pegasus (PEG) farmers.

For Spanish apple farmers, data comes directly from Serrater (SER) farmers .

For Spanish winegrowers, EUT has accessed data from INNOVI (an Innovative Business Associations of the Spanish Ministry of Industry), a group with 33 members who own or supervise vineyards.

For Dutch farmers, data comes from three partners :

ABE has been carrying out Dutch market research for the last two years. AGI has also been collected over the years the perception of farmers on their robot (Robotti). In 2020, SAT talked with 15 to 20 farmers individually while the robot was working. Those farmers are now early adopters of the robotic system.

3.1.1. Mechanical Weeding

3.1.1.1. For French Winegrowers:

The goal of weeding is to lower competition between vines and weeds under the row and to have a clean plot for grapes harvesting. With a mechanical weeding, it is desired to obtain a result as good as chemical weeding; a plus would be to produce more grapes.
Since mechanical weeding was used for centuries before chemicals compounds, farmers are sure of its efficiency. But they do not have the knowledge on how to do it well. They require knowledge about what to do, when do it and how to do it.
However, some organic winegrowers have re-acquired knowledge about mechanical weeding, and they know that the first pass is decisive for the whole season. For them, a threat is the damage to vines. As mechanical weeding involves physical movements, there is a risk to kill a vine; this risk must be minimised. Also, the first goal of mechanical weeding is to get a clean plot, preparing the grape harvest.

3.1.1.2. For Dutch farmers:

The knowledge of the Dutch farmers, concerning mechanical weeding, is already at an advanced stage. Some of them have already switched from traditional farming to organic farming since crop protection biocides are less available and/or are even banned. Because of this, organic farms or not, the hoeing technique has received considerable attention for years. In recent years there has been a lot of investment in camera-controlled hoeing, in which a lot of experience has been gained. Now farmers feel that it's time to fully automate these tasks.

3.1.2. Chemical weeding

3.1.2.1. For French farmers:

Spraying is considered a very effective and cost-effective solution, but not sustainable, as its use for weed control will soon be banned.

3.1.2.2. For Spanish farmers:

Spraying is not about to be banned in Spain, although the level of spraying of some products has to be at a minimum to avoid the potential development of unwanted organisms. Robots could therefore improve working conditions: for instance, staff will not be exposed to chemical products when spraying. Treatments will also be applied in a more sustainable way due to a wider window of opportunity to apply the products.

However, this new technology must be accompanied by what is valued in chemical weed control: low cost, functional, safe and reliable. And the fact that robots may reduce work rate compared to previous practices must be compensated for, (e.g. by the possibility of working at night).

3.1.2.3. For Dutch farmers:

Chemical weeding is the favourite method for conventional growers. This is easy, faster and cheaper than mechanical weeding. It takes less time, less fuel, and does not disturb the soil, so no favourable conditions are created for new weeds to emerge. Farmers have knowledge about the conventional way of spraying the whole field with a 33-meter width sprayer. Yet, the functionality of data and an algorithm for variable rate application is hard to understand for a farmer. Farmers therefore need to know what a spot-sprayer is and what costs are involved.

Over the years the field sprayer has had an increasingly poor image while this is often not justified, e.g. growers not only spray crop protection products but also fertilizers. There is an awareness that there is a public demand to change the way we use chemicals on the farm.

3.1.3. Robotic system

3.1.3.1. Global European point of view from FSH research:

Due to high labour costs and labour shortages, more and more farmers are switching to less labour-intensive crops, and some are turning to technology to make their farms more efficient. Farmers are generally interested in agricultural robotics because it can offer both environmental benefits, and a good potential solution to the labour crisis. When it comes to the willingness of adopting these novel tools, young farmers are showing a more positive attitude than the elder ones. The reason that young farmers, who do not have a large experience in the field, are more open to innovative technologies is mainly that these technologies can provide them with the support necessary.[2]

3.1.3.2. For French Winegrowers:

Unanimously, winegrowers think robots have their place in French vine croppping. They are most eagerly waiting for a robot to work on pruning and weeding but they are wary of pruning since it's a subjective task. They are afraid of losing their thinking or skill if a robotic system does the pruning.
They expect more precision than a tractor so they count on improvements of quality and homogeneity of their field. The reliability of a robotic system is to be proved, especially the navigation part.
A three-point attachment is expected for the attachment of implements.
Data collection about disease, bug, missing vine trees, yield or the global state of the vineyards parcel is expected. Data about what's done, what's in progress and what's still to be done is also expected.
Photos or videos of plots while the robot do the work are asked.
Winegrowers know that some tools (like Kress Fingers) needs a speed up to 8km/h. They fear the use of a ripper (see Figure 2) with a robot since it's a very effective tool but it's difficult to manage and could easily damage the vine.

[2] *From Smart Farming towards Agriculture 5.0: A Review on Crop Data Management, February 3, 2020* ; *Automation is changing modern farming, August 20, 2018* ; *Automating Agriculture: Innovations in Farm Robots, May 21, 2020*

Winegrowers who have already tested a robotic system are fine to prepare their fields for the robot. They wish to have a specification or a framework to follow and get that work done by themselves on their fields. Some of those winegrowers think that the land survey which is needed for guiding the robot could be done with technologies already used for other task needed on field. Also a clear roadmap of all (robotic or not) interventions in each field must be drawn up so that one task doesn't interfere with another task.

Figure 2 : A ripper in vineyard. From front on the left. From rear and in use on the right.

*3.1.3.3. For Spanish **apple** farmers:*

Most apple growers are reluctant to introduce technology, sometimes even young farmers. They do what they are used to do, since it works. The adoption of new technologies is only considered when the business is at economic risk. Adoption barriers include the lack of control or knowledge about the process (how robots work), the high cost of the system, and the robotics system need other security investments to protect robots. On top of that, Spanish apple farmers think that the robotic system will not solve 100% of tasks and the human intervention will still be required for decades to come.

*3.1.3.4. For Spanish **winegrowers:***

Due to its artisanal legacy, viticulture is still sometimes practiced with rudimentary tools, even in a few cases including animals. Despite that, the lack of generational replacement is changing working practices allowing opening of some of the owners to new technology such as robotics.

For Spanish vinegrowers, the most time-demanding labour is pruning. For example, the training programme on pruning techniques at INNOVI lasts more than five years. Applying these techniques in practice result in a large time investment in each plot that is pruned. But if these techniques are not applied, the lifespan of the vineyard is reduced from a potential of more than a hundred years to 2-3 decades.

Spanish winegrowers expect a robotic system for pruning in the first place, but also for harvesting work in the second place. Nowadays most of the vineyards are harvested automatically by suction but as the grape skin breaks, the juice oxidizes for hours during its transportation to the wine cellar causing chemical and microbiological deviations. Robotizing harvest would increase the added value of the grapes harvested increasing the revenue of the whole vineyards.

Winegrower await the arrival of robotics in the vineyards. But they also know that there is a lot of knowledge about the processes that need to be robotized in the future. They think that including specialized personnel in the decision-making process will ensure their trust.

3.1.3.5. *For Greek grapes farmers :*

Greek farmers await from robots to do the same work as a human and to react to issues that a human could see in the field. They wait to see the real effectiveness of a robot job. They asked themselves if an accurate job can increase productivity, reduce chemicals, prevent damages.

3.1.3.6. *For Dutch farmers :*

In the Netherlands, it is considered that robotic systems should do a job without human supervision, in a reliable way. The system should replace labour, and make work easier. Farmers want the job to be done in an efficient way. If they need to place fences around their field and warning signals to let the robot do the job, they will do so to make the robot work. However, farmers do not trust a robotic system: they want proof that it works. They want to see them used in applications that are close to their own farm.

Farmers want the robotic system to fit into their current systems as much as possible. For the few demonstration that have been made, farmer's feedback is positive for the most part. They are very interested in the technology.

Time is of the essence, whether it is sowing, hoeing or pruning. Because of this, it is important that robots must be able to drive 24/7 at the time it is possible. It is not the case that the robot must have performed as much work as tractor in the same amount of time. Tractors and machines have become bigger and bigger precisely because human labour has become so expensive; if this issue can be eliminated, machines can become smaller and lighter, which also has advantages for the soil and possibly fuel consumption. However, high quality work is expected, due to smart sensors and techniques. Farmers expect that a robot will detect it when something goes wrong in its environment (as an example, a blocked seed disk) and to warn them in that case.

3.1.4. Business model

3.1.4.1. *Perception of **worker in industrial environment** from LMS:*

Fully automated solutions are not economically viable for the industry due to high costs of acquiring the equipment, perform maintenance activities, as well as writing a high-level program to achieve the cognitive capabilities of human operators. There is a graph in which a curve shows the relation of cost based on the use of workers and the cost based on the use of automation tools. When there are too many humans or too many automation tools, the costs are very high. There is a break-even point that shows that a good balance of human operators and robotic solutions is the best approach from a financial point of view. This makes Human-Robot Collaborative applications the most viable, from a financial point of view, trying to combine benefits from both resources.

3.1.4.2. *For French Winegrowers:*

The economic sustainability of the system is to be estimated.
Two types of farmers stand out: one wants to purchase a service to save time. The other wants to buy in groups or in its own right to work the land as he sees fit.

3.1.4.3. *For Spanish farmers:*

Wine companies in Spain can be separated in 2 groups:

- Wine groups: where co-ops and big wine groups are included. This companies will have the necessary cash flow to invest in robotization in a short time especially if it means saving money in the long term on personnel.
- Small and medium-sized wineries: These wineries won't have access to costly robotic machinery but they are very innovative and will use either machinery

attached to the tractor or they'll rent the machinery as a service but not as an investment.

Concerning apple firms, largeholders can acquire the robotic system, while medium to small scale farmers may share its acquisition via a cooperative.

3.1.4.4. For Dutch farmers:

Land is expensive, so farmers want to use all space in the best possible way to generate more production. If production costs can be reduced, it becomes financially attractive to purchase a robot: Dutch farmers expected a better execution of various tasks or the robotic system must be cost effective by means of cost price calculation for expensive crops.

Before investing, Dutch farmers want to see if there are any local partners, they can get help with. It's an important point that they have people they can get support from. This is a 'make or break' decision point, as if farmers don't have someone to support them, they are unlikely to purchase. One of the decisive factors as to whether or not farmers can invest in robotics is there current debt. If the farmer's debt is too high, they are not able to invest. For a big initial investment to occur, the farmer would prefer to be able to use the robot for a year or so before purchasing to make sure it is a match. Still many farmers are interested in purchasing a robotic system because of problems with labor.

Also, farmers are very interested in a robot as a Service (RaaS) and it's an option already easier to sell.

3.1.5. Ethics

3.1.5.1. For French Winegrowers:

When a robot is left alone on field or on farm winegrowers fear theft, and how it will be dealt with.
In the event of an accident, winegrowers are waiting for a definition of who is responsible for what.
Working with a robotic system is felt as less exacting.

3.1.5.2. For Spannish farmers:

The use of robotics in the vineyard is associated with the loss of job opportunities of temporary workers. On the other hand, the use of robotics in orchard will improve working conditions, for instance staff will not be exposed to chemical products when spraying. Also, treatments will also be applied in a more sustainable manner.

3.1.5.3. For Dutch farmers:

Farmers want to get a precise legislation on robot. They want answers about these questions :

- if something happens to the robot on the field, or there are curious people who go and look at the robot on the field, and something goes wrong, who is liable? Also, in case of damage to valuable crops.
- What happens in the case of a theft ?

On one hand, Dutch farmers want to less rely on migrant labour: in the Netherlands, the use of migrant labour is visible in the fields. This may give a bad reputation to agriculture, because migrant labour is often associated with problems. For example, inadequate housing may lead to unhealthy living conditions, health problems, and nuisance for neighbours. Dutch farmers want to change this. But on the other hand, they also have questions about their staff if they no longer have work for them: what will happen.

A few among them had question about their data and who access it.

3.2. After a year of the project

In this section, you will find the impacts, barriers and opportunities and requirements directly constructed with farmers regarding the arrival of robotics in their fields. These impacts, barriers and opportunities and requirements were defined during a CoDS were participants assessed function(s) of the system, then evaluated the potential positive and negative impacts and assessed the barriers and opportunities for further development, and finally, they identified their requirements (on the technology and as well as the development process).

We categorize these requirements as follows: technical requirements (which will be of interest to WP2, WP3 and WP4) in part 3.2.6 and developmental process requirements (which will concern the entire project) in part 3.2.7.

Also, in this section, you will find impact on the farming level and on the wider environment noted during this CoDS as well as the barriers and opportunities on:

- The technical dimension
- The economic dimension
- The societal and political dimension

These sections (from 3.2.1 to 3.2.5) show the reading of farmers on robotic systems as they mentioned what really matter for a robotic system to occur in their fields.

Note that we named each idea with a combination of the following abbreviation.

Abbreviation	Definition
LSP1	Concerned French Large-Scale Pilot
LSP2	Concerned Greek Large-Scale Pilot
LSP3	Concerned Spanish Large-Scale Pilot
LSP4	Concerned Dutch Large-Scale Pilot
IF #	Concerned **I**mpact on the **F**arming level, idea number #
IF_P #	Concerned **P**ositive **I**mpact on the **F**arming level, idea number #
IF_N #	Concerned **N**egative **I**mpact on the **F**arming level, idea number #
IWE #	Concerned **I**mpact on the **W**ider **E**nvironment, idea number #
IWE_P #	Concerned **P**ositive **I**mpact on the **W**ider **E**nvironment, idea number #
IWE_N #	Concerned **N**egative **I**mpact on the **W**ider **E**nvironment, idea number #
TB	Concerned **T**echnical **B**arrier number #
TO	Concerned **T**echnical **O**pportunity number #

Table 1: List of the abbreviation of Second inputs' tables

3.2.1. Impacts on the farming level

In this part, farmers tell about impacts robots could have on their farm based on their knowledge and imagination.

3.2.1.1. For French Winegrowers:

	Positives impacts	Negatives impacts / Risks
LSP1_IF 1 Labour (saving time)	LSP1_IF_P 1.1: Mechanical weeding requires 1 worker per 12 ha (or 7 ha for organic vineyard) per 6 months! A robot can greatly reduce that. Also, robots can eliminate the recruitment time for workers each year. Then robot can save a lot of time. LSP1_IF_P 1.2: Robots can work around the clock making it easier for farmers to obtain the optimum window of opportunity	LSP1_IF_N 1.1: Low output of work per hour
LSP1_IF 2 Labour safety	LSP1_IF_P 2.1: When the technology will be ready, farmers expect fewer accidents with AI than with a human. LSP1_IF_P 2.2: When spraying pesticides, field workers are not close to chemicals.	LSP1_IF_N 2.1: There is currently no trust in the ability of robots to always detect a human close to them (safety in the neighbourhood of plots) LSP1_IF_N 2.2: The robot must stay inside its virtual fence and never cross it.
LSP1_IF 3 Energy use	LSP1_IF_P 3.1: Small robot consume less energy than tractor that is felt to be consuming always more fuel without a reason for the last decades without a change of tools behind it. LSP1_IF_P 3.2: Robots could be a good opportunity to go electric	LSP1_IF_N 3.1: Electricity means a new logistic to manage batteries
LSP1_IF 4 Crop handling	LSP1_IF_P 4.1: Robots allow more regular passage	LSP1_IF_N 4.1: Currently robots don't adapt their tool parameters to its environment LSP1_IF_N 4.2: Robot does not respond when the weeding implement is blocked with soil, weeds, or crop residue.

LSP1_IF 5 Income or expenditure	LSP1_IF_P 5.1: By saving labour, robots could become cheaper in the total cost versus a tractor	LSP1_IF_N 5.1: Robotics is an expensive technology LSP1_IF_N 5.2: Robots can perhaps not always replace tractors, so farmer still need to buy a tractor LSP1_IF_N 5.2: Battery means additional charge to current thermal solutions.
LSP1_IF 6 Public acceptance of farming and farmers	LSP1_IF_P 6.1: People could like that plots are weeded with robot LSP1_IF_P 6.2: Winegrowers think they can manage how to handle the machine	LSP1_IF_N 6.1: People could dislike that plots are weeded with robot and boycott wines
LSP1_IF 7 Soil Compaction	LSP1_IF_P 7.1: Smaller robots should maintain soil health compared to a tractor	
LSP1_IF 8 Reliability and repair		LSP1_IF_N 8.1: With advanced electronics and computer programs, farmers haven't the capacity to do repairs.
LSP1_IF 9 Layout of vine plots	LSP1_IF_P 9.1: Winegrowers are aware that they will have to adapt their fields to robot. This is not a problem because they do not have a solution to the labour shortage and if, in addition, the machine provides them with real added value, it's all benefits.	LSP1_IF_N 9.1: Robots are not allowed to cross roads alone. A few plots have their headland turns on public road.

3.2.1.2. *For Grapes greek growers:*

	Positives	Negatives / Risks
LSP2_IF 1 Labour (saving time)	LSP2_IF_P 1.1: If the robot saves time, especially during the harvest period (for example by carring out grapes picking handling), robots could allow growers to realise dramatic productivity gains by bringing produce to market that is currently wasted by being uneconomic or impossible to harvest. LSP2_IF_P 1.2: May allow growers to adopt new methods of farming, such as organic viticulture, by reducing the number of employees required to generate a given level of viticulture outputs	LSP2_IF_N 1.1: Robots should be fully autonomous machine and not remote controlled one.
LSP2_IF 2 Labour safety	LSP2_IF_P 2.1: The jobs in agriculture are tiresome, boring and dangerous, still they require intelligence and quick -although highly repetitive- decisions hence robots can rightly substitute human operators.	LSP2_IF_N 2.1: More powerful—and perhaps dangerous—pesticides might be used once human beings were no longer involved in their application. LSP2_IF_N 2.2: There is no guarantee for safe use of robots
LSP2_IF 3 Energy use	LSP2_IF_P 3.1: Electricity isn't an option to be neglected, especially if used with solar panels. LSP2_IF_P 3.2: A hybrid energy system may reduce emission	LSP2_IF_N 3.1: Robots by means of automation and without proper environmental objectives and management systems could have adverse impacts especially on energy use, by using them more often than current farming technique using tractors.

LSP2_IF 4 Crop handling	LSP2_IF_P 4.1: Robots send data to farmers, who use it to optimize crop growth in real time. Then right decisions are taken for spraying applications. LSP2_IF_P 4.2: Field operations in viticulture are quite complex, and various issues should be addressed to allow an effective transition towards the robotics era.	LSP2_IF_N 4.1: Reliance on robots might lead to increased vulnerability of agricultural systems to climate change if farmers do not receive and process the feedback and never go in fields again LSP2_IF_N 4.2: It is possible that by using robots that reduce cost of application in addition to human who are no longer involved in the application, more powerful – and possibly dangerous – pesticides can be used.
LSP2_IF 5 Crop yields	LSP2_IF_P 5.1: Crop yields are expect to increase if weeds are better killed thanks to robots precision: weeds reduce crop yield by competing with crops for light, water, and nutrients, they can release chemicals that inhibit the growth of the crop, and they can also interfere with the quality of crop post harvesting if weeds are mixed.	LSP2_IF_N 5.1: Crop yields could also decrease in case of spraying failure.

LSP2_IF 6 Income or expenditure	LSP2_IF_P 6.1: Robots can reduce the cost of cultivation by controlling the high cost of labour. LSP2_IF_P 6.2: Allow to use more efficiently agricultural inputs	LSP2_IF_N 6.1: Higher investment costs associated with the need to employ robots to compete with other producers could become another barrier to entry into agriculture and/or food production. LSP2_IF_N 6.2: out-competed in particular markets as a consequence of the successful adoption of robotics technology by agricultural producers in wealthier countries LSP2_IF_N 6.3: Larger agricultural producers are able to undercut the prices of small producers by virtue of being able to better realise the cost savings and/or productivity benefits made available by robots, this may lead to smaller enterprises going under and ultimately to further consolidation of, and concentration of ownership in, agriculture. LSP2_IF_N 6.4 : It is possible that application of pesticides might actually increase as the costs are of applying they are lowered or that more powerful – and perhaps dangerous – pesticides might be used once human beings were no longer involved in their application.

LSP2_IF 7 Public acceptance of farming and farmers	LSP2_IF_P 7.1: The balance of risks and benefits will be a matter of how robots are used rather than that they are used. It is human beings who are responsible for the results of technological deployment.	LSP2_IF_N 7.1: Increased use of robots may also impact on the political relationship between farmers and agricultural services providers. By virtue of needing access to high-tech equipment, farmers must already enter into contractual arrangements with agricultural services providers, which severely restrict their freedom to determine how they use these services LSP2_IF_N 7.2: Controlling the data produced by robots is likely to be particularly difficult since robots will likely be further integrated into corporate IT ecosystems than the machines they replace. LSP2_IF_N 7.3: unclear to what extent the public accepts LSP2_IF_N 7.4: little knowledge from farmers for benefits and knowhow will reduce acceptance
LSP2_IF 8 Soil Health	LSP2_IF_P 8.1: reducing levels of fertiliser and pesticide use LSP2_IF_P 8.2: Besides weed management, where herbicide sprayers are used, spraying robots can be used for pests (diseases and insects) and also for liquid fertilizers (foliar). And with the adequate dose for each part of the plot thanks to robotic precision.	LSP2_IF_N 8.1: more chemicals can be used due to less cost LSP2_IF_N 8.2: loss of contact with nature, loss of feeling for the work done with plants
LSP2_IF 9 Soil Compaction	LSP2_IF_P 9.1: Replacing heavy machinery with lighter teleoperated or autonomous machines may reduce problems associated with compaction of topsoil in agriculture	LSP2_IF_N 9.1: If human workers are replaced by heavier robots this might compound existing problems arising from soil compaction

LSP2_IF 10 Chemical precision	LSP2_IF_P 10.1: The application of cameras along with digital farming tools eg metereological station, GPS etc. will increase the chemical precision. LSP2_IF_P 10.2: The robot navigates the field and interprets the assigned task. Always targeted applications are more effective.	LSP2_IF_N 10.1: In case of high weed pressure in a farms' field, robots may not adjust the applied dose and crop risk is high
Other LSP2_IF: Other topics	*Foundation of robotic:* LSP2_IF_P 11.1: Starting work on robotics today in a few crops will makes us better prepare for tomorrow robotic issues.	*Shortage of personnel:* LSP2_IF_N 12.1: After long term robot usage, less experienced personnel will be available.

3.2.1.3. *For Spanish apple growers:*

	Positives impacts	Negatives impacts / Risks
LSP3_IF 1 Labour (saving time)	LSP3_IF_P 1.1: Robots reduced farmers' time on the field	LSP3_IF_N 1.1: Transport time could increase if farmer don't stay on the field and go somewhere.
LSP3_IF 2 Energy use	LSP3_IF_P 2.1: Save fuel	LSP3_IF_N 2.1: Runs out of energy and stop during the job
LSP3_IF 3 Crop handling	LSP3_IF_P 3.1: A lot of data	LSP3_IF_N 3.1: Less opportunity to use farmer's personal experience in making decisions based on his/her own observations
LSP3_IF 4 Crop yields	LSP3_IF_P 4.1: More quality by spraying with a better precision	LSP3_IF_N 4.1: More defects and hits
LSP3_IF 5 Income or expenditure	LSP3_IF_P 5.1: Save labour cost	LSP3_IF_N 5.1: Current high initial cost LSP3_IF_N 5.2: Repair costs increased
LSP3_IF 6 Public acceptance of farming and farmers		LSP3_IF_N 6.1: New knowledge to learn about robotics
LSP3_IF 7 Soil Health	LSP3_IF_P 7.1: Less chemical product application	LSP3_IF_N 7.1: Illness might become more frequent in field du to not enough use of chemical

LSP3_IF 8 Soil Compaction	LSP3_IF_P 8.1: Less soil compaction in one passage	LSP3_IF_N 8.1: Labour repeat so more soil compaction ?
LSP3_IF 9 Chemical precision	LSP3_IF_P 9.1: Chemical product saved	

3.2.1.4. For Dutch farmers:

	Positives impacts	Negatives impacts / Risks
LSP4_IF 1 Labour (saving time)	LSP4_IF_P 1.1: Saving labour when the robot is running smoothly.	LSP4_IF_N 1.1: Current use of robotic is often slower and with a lot of issues compare to using tractor LSP4_IF_N 1.2: Cost time when you only can use him for weeding LSP4_IF_N 1.3: When robot is not running smoothly, it cost much more time and money.
LSP4_IF 2 Labour safety	LSP4_IF_P 2.1: When everything is working smoothly, there will never be an accident in the field any more	LSP4_IF_N 2.1: First stage, you have to check the robot and implement if they're working fine LSP4_IF_N 2.2: The law says, 'you have to watch the machine'
LSP4_IF 3 Energy use	LSP4_IF_P 3.1: Less usage of energy	
LSP4_IF 4 Crop handling	LSP4_IF_P 4.1: When there is a controlled system for weeding, there will be more possibilities	LSP4_IF_N 4.1: The technic is not good enough to leave the robot alone on the field
LSP4_IF 5 Crop yields	LSP4_IF_P 5.1: Less soil compaction, so the yield can increase LSP4_IF_P 5.2: Can have more control in the field than only sitting on a tractor	LSP4_IF_N 5.1: When killing weeds because of a not good working robot, no crops anymore.

LSP4_IF 6 Income or expenditure	LSP4_IF_P 6.1: When all jobs can be done by robot, 'can' save a lot labour time so money.	LSP4_IF_N 6.1: The robots are mostly made for one job, their current price are far to expensive for just one job LSP4_IF_N 6.3: The robots take to much time at the moment.
LSP4_IF 7 Soil Health	LSP4_IF_P 7.1: Robots are lighter than tractors so they will be good for the soil compaction and structure in the soil	LSP4_IF_N 7.1: When it's leaking and you don't know, because can't see, robots could badly impact soil health.
LSP4_IF 8 Soil Compaction	LSP4_IF_P 8.1: No robots above 3.000 Kg, so they will not have impaction under the subsoil.	LSP4_IF_N 8.1: Smaller wheels are bringing nearly the same soil compaction as a tractor.
LSP4_IF 9 Business operations	LSP4_IF_P 9.1: If robotics work pretty well, the complete business operations will change	LSP4_IF_N 9.1: A farmer can't change slowly and start with one robot. If a farm can start again, it will probably start with a complete robot acceptance farm

3.2.2. Impacts on the wider environment

In this unit, farmers tell about impacts robots could have on the citizens or on policy based on their knowledge and imagination.

3.2.2.1. For French Winegrowers:

	Positives impacts	Negatives impacts / Risks
LSP1_IWE 1 CO_2 or other emissions	LSP1_IWE_P 1.1: With a smaller weight (even with a thermal engine), carbon footprint could decrease.	LSP1_IWE_N 1.1:Winegrowers are not convinced that electric motor will reduce their carbon footprint if the manufacture of the motor and its recycling are included.
LSP1_IWE 2 Ethics		LSP1_IWE_N 2.1: Electric motors are an issue concerning the mining of scarce resources and recycling of electric motors
LSP1_IWE 3 Insurance		LSP1_IWE_N 3.1: No current well defined answer to what should be covered and at what price by insurance for the use of a robot. LSP1_IWE_N 3.2: In case of theft, what will happened is not defined.
LSP1_IWE 4 Finance		LSP1_IWE_N 4.1: No current well defined answer to the financial question on how to buy a robot with banks.

3.2.2.2. For Grapes greek growers:

	Positives	Negatives / Risks
LSP2_IWE 1 CO_2 or other emissions	LSP2_IWE_P 1.1: Robots could be electric so they could reduce emission especially by using solar panel. LSP2_IWE_P 1.2: Robots are expected to simplify the processes involved in renewable energy generation, especially in solar energy sources	LSP2_IWE_N 1.1: Calculation of the exhaust emissions for a robot need to be done

LSP2_IWE 2 Food safety	LSP2_IWE_P 2.1: Increasing accuracy on spraying will maximised the food safety index of grapes LSP2_IWE_P 2.2: Reduce contamination risk (lubricants, cleaning, microbiological, workers, etc)	LSP2_IWE_N 2.1: Failure on spraying has negative impact on food safety since it could decreased yield or completely destroyed the crop.
LSP2_IWE 3 Food price	LSP2_IWE_P 3.1: As less personnel & operational cost is working margins for better offers are higher LSP2_IWE_P 3.2: By a higher product uniformity thanks to robot's precision, food can reach better price.	LSP2_IWE_N 3.1: Increased food price. As a result of the standardisation of food items necessary to facilitate the early applications of robots consumers may come to have an even stronger expectation that all fruits will be "perfect" resulting in more food wastage as fewer items are judged suitable for sale. LSP2_IWE_N 3.2: High cost of robot will increase final price

LSP2_IWE 4 Biodiversity	LSP2_IWE_P 4.1: Increasing accuracy on spraying will protect the population of bees and other useful insects promoting the safeguard of local biodiversity. reduce the amount of chemical used by thereby helping support wider biodiversity LSP2_IWE_P 4.2: There could be equally big environmental gains. Mega-scaled agriculture often leads to the ripping out of hedgerows, to pesticides contaminating rivers and streams, and soil erosion that can exacerbate flooding. The alarming decline in the number of bees in Europe, in the USA and beyond is linked to the use of insecticides; the equally sobering fall in bird populations has been traced to the same source. According to its prime movers, robot farming offers alternatives to all these things, and hope of an eventual ecological renaissance.	LSP2_IWE_N 4.1: Increased usage of chemicals
LSP2_IWE 5 Ethics		LSP2_IWE_N 5.1: Use of robots in viticulture is likely to impact on the social fabric of rural communities, especially concerning jobs. LSP2_IWE_N 5.2: The vulnerability of robots to hacking is hardly unique to this technology and represents a familiar challenge to be addressed by cyber security researchers and engineers.

3.2.2.3. *For Spanish apple growers:*

	Positives impacts	Negatives impacts / Risks
LSP3_IWE 1 CO_2 or other emissions	LSP3_IWE_P 1.1: Less emissions (CO_2)	
LSP3_IWE 2 Food safety	LSP3_IWE_P 2.1: Less chemical	
LSP3_IWE 3 Food price	LSP3_IWE_P 3.1: Reduced food price	LSP3_IWE_N 3.1: People may be reluctant to buy food grown with a robot's work.
LSP3_IWE 4 Legislation		LSP3_IWE_N 4.1: No robot laws
LSP3_IWE 5 Recruitment sites		LSP3_IWE_N 5.1: Less work "accessible to all" on farm

3.2.2.4. *For Dutch farmers:*

	Positives impacts	Negatives impacts / Risks
LSP4_IWE 1 CO_2 or other emissions	LSP4_IWE_P 1.1: Lighter machine will use less energy	LSP4_IWE_N 1.1: No capacity enough to do the job
LSP4_IWE 2 Food safety	LSP4_IWE_P 2.1: If we can control more with robot, the crop can be growth healthier	LSP4_IWE_N 2.1: Hard to get paid better.
LSP4_IWE 3 Food price		LSP4_IWE_N 3.1: It's a hard market, and the price is no constant. So a risky investment does not apply.
LSP4_IWE 4 Public acceptance	LSP4_IWE_P 4.1: Citizens would probably be very happy with robots in the field	
LSP4_IWE 5 Focus in practise	LSP4_IWE_P 5.1: We have to focus more on farmers level, the farmers need to accept the robotic systems.	
LSP4_IWE 6 Laws		LSP4_IWE_N 6.1: Nobody knows exactly what is possible and legal and manufacterer make conflicting arguments.

3.2.3. Barriers and opportunities on the technical dimension

In this part, farmers warn about barriers to be raised and advise on opportunities to be seized regarding technical points.

3.2.3.1. For French Winegrowers:

Which Impact	Technical Opportunities	Technical Barrier
LSP1_IF_N 1.1: Low output of work per hour	LSP1_IF1.1 TO1: Robot could be more precise in their work	LSP1_IF1 TB1: Robot must work 24/24 to achieve at least the same output as a tractor per day
LSP1_IF_P 2.1: When the technology will be ready, farmers expect fewer accidents with AI than with a Human.	LSP1_IF2.1 TO1: Robots are more responsive than humans	LSP1_IF2 TB1: Robots must detect and analyse a variety of signals to avoid accident
LSP1_IF_N 3.1: Electricity means a new logistic to manage batteries		LSP1_IF3 TB1: Batteries must be easy to change LSP1_IF3 TB2: Batteries must be fast to change
LSP1_IF_P 4.1: Robots allow more regular passage	LSP1_IF4 TO1: With a regular passage, weed are weaker. Then the tools need to be pulled to a shallower depth. The robots therefore require less force to weed. LSP1_IF4 TO2: Robots could detect disease LSP1_IF4 TO3: Robots could measure disease or issues in the field	LSP1_IF4 TB1: Services on which robot rely must be available 24/24
LSP1_IF_N 4.1: Currently robots don't adapt their tool parameters to its environment		LSP1_IF4 TB2: Robots must detect their environment prior to the work
LSP1_IF_N 4.2: Robot does not manage blockage.		LSP1_IF4 TB3: Robots must detect their environment after the work
LSP1_IF_P 7.1: Smaller robots should maintain soil health compared to a tractor		LSP1_IF7 TB1: Make the robot the lightest possible
LSP1_IF_N 8.1: With electronics and programs, farmers haven't the capacity to do repairs.	LSP1_IF8 TO1: Develop remote assistance	LSP1_IF8 TB1: Make electronics and programs reliable
LSP1_IF_N 9.1: Robots are not allowed to cross roads alone. A few plots have their headland turns on public road.	LSP1_IF9 TO1: Farmers are aware that they will need to adapt their plots a bit to robots like with harvesting machine and are fine with it	LSP1_IF9 TB1: Design robot and robot path so that it needs little space to move from one row to another.

LSP1_IWE_P 1.1: With a smaller weight, even with a thermal engine, carbon footprint could be decrease.		LSP1_IWE1 TB1: Make the robot with the smaller carbon footprint
LSP1_IWE_N 2.1: Electric motor are an issue concerning the mining of scarce resources and recycling of electric batteries		LSP1_IWE2 TB1: Look at the origin of the components regarding ethics LSP1_IWE2 TB2: Think the robot from production to its recycling concerning pollution

3.2.3.2. For Grapes greek growers:

Which Impact	Technical Opportunities	Technical Barrier
LSP2_IF_P 4.2: Field operations in viticulture are quite complex, and various issues should be addressed to allow an effective transition towards the robotics era.	LSP2_IF4 TO 1: Due to the rapid development of computer vision and artificial intelligence, robotic sprayers feature novel intelligence systems that enable selective spraying, compared to conventional uniform spraying across the crop.	LSP2_IF4 TB 1: The ability to spray selectively requires an accurate detection system, and therefore advanced sensors need to be mounted on the robot LSP2_IF4 TB 2: The navigation system in semi-structured agricultural environments, and the intelligence to control both the robotic platform and the implement are issues without answers. LSP2_IF4 TB 3: Terrain assessment LSP2_IF4 TB 4: Route planning LSP2_IF4 TB 5: Human detection for safety issues LSP2_IF4 TB 6: Adjustment of robots to the emergence of new weeds and pests

		LSP2_IF4 TB 7: There is also some danger that, even if such robots can be developed, reliance on robots might lead to increased vulnerability of agricultural systems to climate change. Fires and floods make it difficult for robots to operate effectively. LSP2_IF4 TB 8: Even if robots are more productive than human workers, they may be significantly less robust, and production methodologies based around robotics may be less able to adapt to new realities established by climate change within the timescale required

3.2.3.3. *For Spanish apple growers:*

Which Impact	Technical Opportunities	Technical Barrier
LSP3_IF 6: New knowledge to learn about robotics	LSP3_IF6 TO 1: Easy to understand / Simple interface with the robot to understand and fully control it.	
LSP3_IF 2: Runs out of energy and stop during the job		LSP3_IF2 TB 1: More logistics to manage
LSP3_IF_N 4.1: More defects and hits LSP3_IF_N 7.1: Possibility of illness		LSP3_IF7 TB1: Make sure that plants are well treated

3.2.3.4. *For Dutch farmers:*

Which Impact	Technical Opportunities	Technical Barrier
LSP3_IF 9: If robotics work pretty well, the complete business operations will change = The robots need to replace the complete tractor	LSP3_IF9 TO 1: The Robot need to do all jobs	LSP3_IF9 TB 1: The robots can't do all the jobs what a tractor can

3.2.4. Barriers and opportunities on the economical dimension

In this part, farmers warn about barriers to be raised and advise on opportunities to be seized regarding the business aspect.

3.2.4.1. For French Winegrowers:

Which Impact	Economic Opportunities	Economic Barriers
LSP1_IF_P 1.1: Mechanical weeding represents 1 worker per 12 ha (or 7 ha for organic vineyard) per 6 months! A robot can greatly reduce that. Also, robots can eliminate the recruitment time for this worker each year. Then robot can save a lot of time.	LSP1_IF1 EO Long term 1: According to vinegrowers, a vineyard employee cost about 30 k€/year. Robots could save this money or give "it" a higher added value as the employee can concentrate on non-mechanised tasks	LSP1_IF1 EB Short term 1: Moving from conventional to organic farming (that is mechanical weeding) always comes with a decreased of yield for the 3 to 5 first years.
LSP1_IF_P 3.1: Small robot consume less energy than tractor that is felled like consuming always more without a reason (same tool behind it)	LSP1_IF3 EO Long term 1: Wine could sell better with a "less CO_2 emission" marketing campaign	LSP1_IF3 EB Short term 1: With less energy used in the same amount of time compared to a tractor, it is easy to think that concerning energy, robots will be more profitable than a tractor but it is necessary to prove it concerning the whole picture because robots do not have the same output as a tractor
LSP1_IF_P 5.1: By saving labour times, robots could become cheaper in the total cost versus a tractor	Read LSP1_IF1 EO Long term 1	
LSP1_IF_N 5.1: Robotics is an expensive technology	LSP1_IF5 EO Short term 1: Robot could align with prices of tractors = stay below 100 K€	
LSP1_IF_N 5.2: Robots could be less polyvalent than tractors, so farmer still need to buy a tractor	LSP1_IF5 EO Short term 2: Without the need to participate in field work, tractors power needed will be reduce. Then they will be less expensive.	LSP1_IF5 EB Short term 1: Tractors, because of their versatility, will always be needed. Robots therefore only replace human time and not the "tractor-employee-implement" combination
LSP1_IF_N 5.2: Battery means additional charge to current thermal solutions	LSP1_IF5 EO Long term 1: The whole car industry research for electric car. Therefore, we could expect batteries cost to be lower in the following years.	LSP1_IF5 EB Short term2: Battery are currently expensive, and the total cost of the robot will be far higher of what is currently acceptable.

LSP1_IF_P 6.1: People could like that plots are weeded with robot	LSP1_IF6 EO Short term 1: Wine could sell at a higher price at first	
LSP1_IF_N 6.1: People could dislike that plots are weeded with robot and boycott wines		LSP1_IF6 EB Short term 1: Wine could not be sold anymore.
LSP1_IF_P 7.1: Smaller robots should maintain soil health compared to a tractor	LSP1_IF7 EO Long term 1: Yield could become higher than with a tractor	
LSP1_IF_N 8.1: With electronics and programs, farmers haven't the capacity to do repairs.		LSP1_IF8 EB Short term 1: Farmer will rely on after-sales services in case of a not mechanical breakdown
LSP1_IF_P 9.1: Winegrowers are aware that they will have to adapt their fields to robot. This is not a problem because they do not have a solution to the labour shortage and if, in addition, the machine provides them with real added value, it's all benefits.	LSP1_IF9 EO Long term 1: Crop damage is unavoidable even with a tractor. "A robot shouldn't damage a plot" isn't a prohibitive criterion as long as the damage is equivalent to or less than the rough estimate of a damage caused by a tractor. There will be damage with a robot, winemakers just ask that it's not excessive. In addition, most winegrowers will stop planting young vines in an old plot or will stake their young vines.	LSP1_IF9 EB Short term 1: Adapt the field could lead to less crop per field then less yield
LSP3_IWE_P 1.1: With a smaller weight, even with a thermal engine, carbon footprint could be decrease.		LSP3_IWE3 EB Short term1: Insurance could be at a way higher cost than a tractor
LSP3_IWE_N 3.1: No current well defined answer to what should be covered and at what price by insurance for the use of a robot.	Read LSP1_IF3 EO Long term 1 LSP3_IWE1 EO Long term 1: Robots could decrease taxes on carbon footprint	

3.2.4.2. For Grapes greek growers:

Which Impact	Economic Opportunities	Economic Barriers
LSP2_IF_N 6.1: Higher investment costs associated with the need to employ robots to compete with other producers could become another barrier to entry into agriculture and/or food production.		LSP2_IF6 EB Short term 1: Economic risks
LSP2_IF_P 6.1: Robots can reduce the cost of cultivation by controlling the high cost of labour.	LSP2_IF6 EO Short term 1: Robots may reduce labour costs, by reducing the number of employees required to generate a given level of viticulture outputs.	
LSP2_IF_P 11.1: Starting work on robotics today in a few crops will makes us better prepare for tomorrow robotic issues.	LSP2_IF11 EO Long term 1: The fact that robots will have been designed with existing crops in mind may work to hinder development of new crops and markets for novel products.	

3.2.4.3. For Spanish apple growers:

Which Impact	Economic Opportunities	Economic Barriers
LSP3_IF_N 5.1: Current high initial cost	LSP3_IF5 EO Short term 1: Reduced labour costs LSP3_IF5 EO Long term 1: Competition with possible salary increases of labour	LSP3_IF5 EB Short term 1: Lack of capital
LSP3_IF_N 3.1: People do not buy food grown by a robot.		LSP3_IF3 EB Long term 1: Investment without return

3.2.4.4. For Dutch farmers:

Which Impact	Economic Opportunities	Economic Barriers
LSP4_IF_N 9.1: A farmer can't change slowly and start with one robot. If a farm can start again, it will probably start with a complete robot acceptance farm = First have to look if the robotics fits into a farmer's business operation.	LSP4_IF9 EO Short term 1: Save labour cost LSP4_IF9 EO Long term 1: Big saving in labour	LSP4_IF9 EB Short term 1: Can't just buy a swarm of robots in one time. Too expensive. LSP4_IF9 EB Long term 1: The labour needs a high level of education

3.2.5. Barriers and opportunities on the societal and political dimension

In this part, farmers warn about barriers to be raised and advise on opportunities to be seized from the perspective of a society.

3.2.5.1. For French Winegrowers:

Which Impact	Societal/Political Opportunities	Societal/Political Barrier
LSP1_IF_P 1.1: Mechanical weeding represents 1 worker per 12 ha (or 7 ha for organic vineyard) per 6 months! A robot can greatly reduce that. Also, robots can eliminate the recruitment time for this worker each year. Then robot can save a lot of time.	LSP1_IF1 SPO 1: Without the need to drive a tractor, and to drive it well, it could become easier to recruit workers.	
LSP1_IF_P 1.2: Robots can work around the clock making it easier for farmers to obtain the optimum window of opportunity		LSP1_IF1 SPB 1: Robots working around the clock means that farmers could be possibly bother during their sleep or bother neighbour of their field if the robot isn't silent.
LSP1_IF_P 2.2: When spraying pesticides, field workers are not close to chemicals.	LSP1_IF2 SPO 1: Farmers could spray during night-time that reduce chance to bother neighbour or impact agriculture image.	
LSP1_IF_N 2.1: There is currently no trust in the ability of robots to always detect a human close to them (safety in the neighbourhood of plots)		LSP1_IF2 SPB 1: Trust in the safety of a robot is to be built
LSP1_IF_P 3.2: Robots could be a good reason to go electric	LSP1_IF3 SPO 1: Go electric could improve the image of a vineyard	
LSP1_IF_P 7.1: Smaller robots should maintain soil health compared to a tractor	LSP1_IF7 SPO 1: Safeguarding biodiversity could improve the image of a vineyard	
LSP1_IF_N 9.1: Robots are not allowed to cross roads alone. A few plots have their headland turns on public road.		LSP1_IF9 SPB 1: There is no legal domain where a automated machine could go on a public road, even, being remotely controlled

LSP1_IWE_N 1.1: Winegrowers are not convinced that electric batteries will reduce their carbon footprint if the manufacture of the batteries and its recycling are included.		LSP1_IWE1 SPB 1: There is a lack of knowledge about electric batteries

3.2.5.2. *For Grapes greek growers:*

Which Impact	Societal/Political Opportunities	Societal/Political Barrier
IF_P 4.2: Field operations in viticulture are quite complex, and various issues should be addressed to allow an effective transition towards the robotics era.	IF4 SPO 1: By using selective spray systems, robots could reduce agriculture's environmental impact as well as consumer exposure to pesticides and preventing the development of resistance to those substances by the targeted organisms.	

IWE_N 5.1: Use of robots in viticulture is likely to impact on the social fabric of rural communities, especially concerning jobs.	IF5 SPO 1: Lifestyle could change with the benefits of robots' applications, which include increased family time, flexibility of work, and reduced labour intensity	IF5 SPB 1: While it should be anticipated that use of robots will create jobs as well as eliminate jobs (for instance by creating opportunities to farm crops that might previously been uneconomic due to the cost of labour) the skill sets required to build and maintain robots are likely to be very different to those typically possessed by residents of rural areas and thus many of the jobs created by progress in robotics are likely to be located elsewhere. IF5 SPB 2: If robots eliminate the need for significant amounts of agricultural labour, in the future there may be fewer economic opportunities for those who live in rural areas IF5 SPB 3: If robots lead to further consolidation in the agricultural sector, this may exacerbate inequalities in the distribution of wealth in rural areas. IF5 SPB 4: It has created a need for farmers to manage increasingly complex IT systems
IWE_N 5.2: The vulnerability of robots to hacking is hardly unique to this technology and represents a familiar challenge to be addressed by cyber security researchers and engineers.	IWE5 SPO 1: This threat to national security may constitute a reason for states to resist monopolisation of agricultural robotics in order to reduce the risk that an attack on one system or class of systems might have too large an effect	IWE5 SPB 1: The threat to national security posed by cyber-attacks targeting agricultural technologies should be seriously considered

3.2.5.3. For Spanish apple growers:

Which Impact	Societal/Political Opportunities	Societal/Political Barrier
LSP3_IF_P 1.1: Reduced time on the field	LSP3_IF1 SPO 1: Less physical work	

3.2.5.4. For Dutch farmers:

Which Impact	Societal/Political Opportunities	Societal/Political Barrier
LSP4_IWE_P 5.1: We have to focus more on farmers level, the farmers need to accept the robotic systems.	LSP4_IWE5 SPO 1: By becoming a transparent sector, transparent food could be faster achieve.	LSP4_IWE5 SPB 1: The sector can be more transparent: it's hard to get around the conventional distribution because they have the whole chain

3.2.6. Technical requirements

In this sub-section, you will find the technical requirement defined with the final users.

3.2.6.1. For French Winegrowers:

For French winegrowers, robotic systems must meet the following requirements:

- Be able to work around the clock to achieve at least the same output as a tractor per day.
- A robot must detect a human and avoid accident with it.
- For full electric robots, batteries must be accessible, easy to uncouple and be handled by hand.
- Robots must detect their environment, prior and after the work, to adjust their tool.
- Robot must stay the lightest possible.
- Electronic and programs must be very robust so that farmers don't have to expand their knowledge to do repairs.
- Headland space needed by the robot should be less than 6 m from the end of field to the end of row.
- Come with a clear plan on what append to discarded robot in terms of recycling, to improve the carbon footprint.

3.2.6.2. For Grapes greek growers:

Greek farmers know they have limited knowledge and scientific background to cover robotics, especially : the terrain assessment, the route planing and the human detection for safety. Therefore, they wish that "(…) the operation of robot should not be sophisticated, but it must be grower's friendly and very simple (…). Robots should be designed to operate with two fingers by growers, since most of the cultivation practices in field can be performed by them" in their words.

3.2.6.3. For Spanish apple growers:

Spanish apple growers want the two following point to be resolved for a complete robotic system :

- Farmers must get the energy level of robot from anywhere and must be notified when level become low.

- Control of robotic system must be easy to understand so that the controlled of a robot could be given to nearly anybody.

3.2.6.4. For Dutch farmers:

The first goal, for Dutch farmers, is to get a robot which can "finish" a field the same as a tractor. To do so, Dutch farmers came with the two following requirements :

- Have a good navigating platform, with robot which can drive backwards to finish the headlands.
- Measure field boundaries and make sure the AB lines are the same

3.2.7. Developmental process requirements

In this sub-section, you will find the requirement for a robot to comes to market (everything that is not technical) defined with the final users.

3.2.7.1. For French Winegrowers:

To improve the current development of robotic systems, winegrowers wish the following task to be complete:

- Calculate the carbon footprint of the robotic system.
- Select as many components as possible from controlled or transparent industry regarding ethics especially for the construction of electric motors.
- Recommend a transition from conventional to organic in 3 to 4 years to avoid an insurmountable financial impact (moving from conventional to mechanical weeding always comes with a decreased of yield for the 3 to 5 first years).
- Monitor during a whole year a plot in the greographic location of farmers to convinced them about the impact a robotic system could have in terms of time and fuel at first.
- In the car industry, batteries are leased. This business model help make batteries additional charges more acceptable for cars. Would that be possible with robots ?
- Survey consumers to find out if robots are perceived as a self-driving tractor or something else that could make them never buy again wine.
- LSP1_IF9 EO Long term 1: Crop damage is unavoidable even with a tractor. "A robot shouldn't damage a plot" isn't a prohibitive criterion as long as the damage is equivalent to or less than the rough estimate of a damage caused by a tractor. There will be damage with a robot, winemakers just ask that it's not excessive. In addition, most winegrowers will stop planting young vines in an old plot or will stake their young vines.
- Start discussion with insurance.
- Study the economic benifits when a robot is only use during the day as farmers could be possibly bothered during their sleep at night or bother the neighbour of their field if the robot isn't silent.
- Make the robot as quiet as possible.
- Prove that the robot is safe and build a strong communication on the safety of a robot.
- Start discussion with regulatory institutions to build a legal domain where a machine could go on a public road being remotely controlled.
- Make communication accessible to farmers as well as citizens about how are manufactured electric batteries and their recycling.

3.2.7.2. For Grapes greek growers:

Greek grapes growers wich that small farms don't miss out the benefits of robots. To do so, they expect subsidies for early adoption of agricultural robotics but also the developpment of robots sufficently flexible to allow their used in a wide range of crops and even to livestocks.

They also fear about the impact that robots will have on rural areas' jobs. They wish to start a reflexion as soon as possible on that subject.

3.2.7.3. For Spanish apple growers:

Spanish wish the following task to be complete for a robotic systems :

- Start a study with consumer about "Will they buy food grown with the help of a robot?".
- Initiate discussions with banks on robotic systems to find solution of the lack of capital of farms.
- Start discussion with politician about robotic systems to build a legal domain with robots.
- Evaluate the work performed by robots together with farmers to make sure that plants are well treated (sufficiently covered by chemical products, as well as not damaged).

3.2.7.4. For Dutch farmers:

The priority of Dutch farmers are the two following :

- Test the robot on many hectares, doing different type of jobs on different fields is necessary before bringing the robots to the public.
- Have contact with political aspects to make sure the laws are going the right way

4 Conclusion

From the first inputs, we could see that farmers are interested in robotic systems, but they want to acknowledge their real efficiency, a fact that can be found in the Dutch requirement (second inputs). For most of farmers, a solution where less spraying exists, and robots could become an interesting tool enabling them to do so and answer the labour shortage issue, but only if the workflow is enough.

From the second inputs, an important issue about "will consumers buy food grown with a robot" must be answered quickly as it is a concerned in three of the four LSP.

Questions relating to laws, banks and insurance must also be raised next year in order to offer prospects for appropriate responses: all LSP have concerned about these.

Annex 1: Methodology of the Co-design Sessions

In this Annex, you will find the detail methodology we use in the CoDS.

T1.1 Session Programme

Boelie Elzen and Charles Duchemin, 08/09/2021

Revised Document

1 Introduction

Within T1.1 of the Robs4Crops project, each LSP has to hold a series of 'Co-Design Sessions' (CoDS) with stakeholders, one session during every year of the project. In this memo we explain the methodology on how to organize and conduct these sessions.

1.1 Session logic

The session seeks to explore for each LSP how a specific robotic technology can be developed further so that it optimally serves the needs of farmers as well as that of the wider society. The set-up of the session is based on the following logic in terms of the developmental process:

- The robotic system is intended to serve a specific function and has certain characteristics to help achieve that.
- These characteristics, however, also have further impacts that can either be positive or negative (e.g. a weed remover may also damage crops). These impacts can be on farming but also on the wider environment (e.g. less pollution or lower CO2 emissions).
- Partially because of these impacts, there are barriers and opportunities towards further development (e.g. damaging of crops creates technological barriers; lower emissions create opportunities for political or societal support).
- All of these combined, set a number of requirements for further development, either technical requirements for the robotic system itself or requirements to foster the developmental process (e.g. support from specific stakeholders).

Based on this, the session programme includes the following exercises to be carried out with the participants:

- Assess function(s) of the system
- Assess potential positive and negative impacts
- Assess barriers and opportunities for further development
- Identify requirements for further development (on the technology as well as the process)

These requirements define the final output of the session. Each meeting will thus help to identify the key aspects that the LSP will need to address in the following year.

1.2 General topics

1.2.1 Session duration

On the basis of the programme below, the session is expected to last about 3 hours, although this may vary a bit across the 4 pilots depending upon how much experience the participants have with the robotic system and how much is known about its functioning.

If partners feel this is too long to be able to engage participants, there are some possibilities to make it shorter but this may reduce the quality of the final output. If you think there is a need to reduce the length, please inform the task leader on this and we will assist you to identify how this might best be done. To engage the participants more to this process, it could be helpful to combine the CoDS with a demonstration.

1.2.2 Participants

Ideally, all types of stakeholders that are needed to make the system work in practice and/or who are affected by its use should be invited to participate in the session to ensure that the way they operate will indeed make the practical application possible. The key stakeholders will be the farmers using the system or who consider using it and the developers of the system. But a wider range of stakeholders may be relevant. *E.g*, if use of the system affects quality of the crops, stakeholders from the crop processing value chain may be involved. If use of the system affects the farm environment, representatives from neighbouring residents may be involved; if use of the system faces regulatory barriers or would require innovation support, representatives from regulatory agencies or government bodies could be invited. Additional stakeholders to consider might include farming advisors, agricultural economists, agricultural banks, etc.

This may result in a long list and how to keep that manageable? A first simplification is that the type of participants can vary a bit over the years. A session will be held each project year in which the project experiences from the previous year form the starting point for the next session. It can then be expected that over the years, more experiences with the robotic system will be gained, allowing to further specify requirements for further development or larger scale application. This will be the case for the robotic system itself, as well as for the type of stakeholders that will be affected by the use of the system or that may be needed to support its use in practice. So, which stakeholder plays a key role may vary over the years.

The way to deal with this is that **you make a 'long list' of possibly relevant stakeholders before the first session**, also making an initial assessment of which stakeholder would be key to invite in which year. For the first year, you should have at least representatives from **farmers, specialists on the robotic technology and on the crop(s)** that the robot should work on. These specialists could either be practical specialists or researchers. If you think that in the first year there is another type of stakeholder that has a key role (e.g. to provide financial support for development), also invite that one. For the other stakeholders you decide in later years whether they would indeed be invited and when. Each year, you adapt this stakeholder list if needed on the basis of what you have learned in the previous year.

A CoD Session works best with a group of about 10 persons. Because there is a fair chance that one or two people will not be able to attend eventually, it is best to invite about **12 participants**. Participant do not have to prepare anything.

Finally, the composition of CoDS groups for this year is:
- a facilitator,
- a rapporteur,

- 2 experts,
- 10 farmers.

1.2.3 Reporting

Each year, you should write a report on the results of your CoD session. This should follow a specific set-up, based on a template that will be provided by the task leader.

To stimulate that partners from each LSP can learn from each other's experience we propose the following procedure in reporting:

- Each LSP produces a draft report following the template.
- Then we have a videoconference to discuss each other's experiences and findings, both on how to best do the session and on the outcomes of each session.
- Partners produce a final version of their report, possibly by including some additional material or elaborating certain aspects a bit, based on the videoconference.

1.3 CoD Session general programme

Above, we mentioned four exercises to carry out at the session (function, impact, barriers/opportunities, requirements). Adding some additional items at the begin and the end, the session has the following agenda. The bracketed numbers indicate the minutes planned for each topic or exercise.

Note: with the times indicated, the total duration of the session is about 3 hours (with a little space for delays). If you think this is problematic for your situation, please contact us.

1. Opening and round of introduction (15)
2. Explaining the session (5)
3. Function(s) of the robotic system (30)
4. Impact assessment (agronomic and societal) (30)

Break (15)

5. Barriers and opportunities for development (30)
6. Requirements for robot design and development process (30)
7. Reflection and feedback (10)
8. Closing (5)

Each of these items will be briefly explained below. Each item below has the following subsections (though some less relevant sections have been skipped):

- Objective
- Explanation
- Guidance to run the exercise
- Form (session form used)

2 Session topics and exercises

2.1 Opening and round of introduction

2.1.1 Objective

- Let each participant briefly introduce him/herself
- Loosening up: Dreams and nightmares (ice break step)

Concerning the last point, to commit participants a bit to the process, let each of them briefly indicate what her/his ideal would be in connection with the robotic system at hand and what he/she fears might be the worst that could happen in connection with the system.

2.1.2 Guidance to run the exercise

Give the participants 1-2 minutes to think about this and write their dreams and nightmares on a sticky note. Subsequently each participant briefly presents his/her view. No discussion, it is just for people to get to know each other a little bit by presenting what is of key importance to them in relation to the topic.

The next year, if you have few same participant, you may come back to these dreams and nightmares by asking participants whether these dreams or nightmares have come closer to reality. They would then become part of the content of the session to assess to what extent the developmental process has developed in to a desired or less desired direction.

2.1.3 Form of the exercise

- Put sticky notes on two posters (dreams & nightmares)
- Plenary round of explanation, no discussion. It is just for participants to get to know each other's views a bit.

2.2 Explaining the session

2.2.1 Objective

Inform participants about what will happen at the meeting to achieve a shared understanding of this and commit participants further to this programme

2.2.2 Guidance to run the exercise

There may be a bit of extra introduction needed, depending upon how far the robotic system has been developed and how well the participants in the session know it. This presentation should introduce the general idea behind the system and the stage of development, indicating what we know and what we do not know. This should be very brief (a few mins), just to indicate and share some general things. Details will need to be brought in by the participants in the later exercises.

You could also send the participants a brief memo of 1-2 pages on this, ask them to read that beforehand and briefly explain it at the session itself.

2.2.3 Form of the exercise

- Explanation of session set-up by facilitator and brief Q&A
- If needed: brief explanation on the robotic system.

2.3 Function(s) of the robotic system

2.3.1 Objective

It is important that at the beginning of the session the participants share their understanding of the robotic system that is the core topic. This can be achieved by a brief discussion on the function of the system, i.e. what it should do in the farming practice. Later in the workshop, the function will form the basis for the (design) requirements for the system.

2.3.2 Explanation

A distinction can be made between the 'core function' and 'additional functions'. *E.g.* a specific robot can have 'mechanical weeding' as its main function but additional functions may be to increase crop health and public health (because of lower pesticide use and lower remaining pesticide residue on the food product), energy saving, labour saving, etc.

The importance of these 'additional functions' is that it helps to see the robotic system, not as isolated from the further farming practice, but to acknowledge that it is part of a wider system. Doing so may help to identify potential additional design requirements that can increase the usefulness to the farmer as well as improve the connection between the farming practice and the wider environment (ecological and social). This may then lead to some additional requirements for the system that will be discussed later.

2.3.3 Guidance to run the exercise

The main question in connection with the 'function' is: **what does the robotic system have to do?** Ask this question not only in relation to the agricultural functioning but also in relation to the wider environment of the farm, e.g. citizens in the broad sense or consumers (e.g. in relation to food quality or food security).

In practice, you could end up with a short list of 1 or 2 main functions a possibly somewhat longer list of additional functions. After putting ideas on post-its there is a brief discussion to prioritise the functions to identify which ones are the most important. These are subsequently discussed a little further.

Depending on the number of functions, you may have app. 3-5 mins for each to discuss. Possible questions to ask in each discussion are:

- For which stakeholder is this function important?
- Why is this function important? How crucial is it that the function would be realised for this stakeholder (or, possibly, also for other stakeholders)?
- How difficult is it to realise this function?
  (Pose this as a broad question, just to stimulate participants to think broadly on this; specifics will come later in the session)

Note for partners: depending on the stage of development of the robot and how well participants know it, this discussion could either remain at a rather general level or go into quite a bit of detail. There is flexibility for partners how they implement this for their case.

2.3.4 Form of the exercise

Prepared poster with two sections: (1) main function (2) additional functions

- 5 mins: brainstorm during which participants put post-its with their ideas
- 3-5 mins: prioritise the functions to identify the most important ones to ensure that at least these will be addressed in the following discussion
- 15 mins: discussion of the most important functions
- 5 mins: reflection: is the prioritisation still correct or should it change a bit on the basis of the previous discussion

2.4 Impact Assessment (agronomic and societal) of the system (positive and negative impacts)

2.4.1 Objective

An assessment of what the potential positive and negative impacts of the system might be, both for the farmer as well as the wider environment. These impacts will provide stepping stones towards design requirements.

2.4.2 Explanation

Impacts can relate to the use of the robotic system in the farming practice as well as the impact of the farming practice on the wider environment (e.g. on pollution, CO2 emissions, on food prices and food safety, etc.).

2.4.3 Guidance to run the exercise

You can have two parts in the discussion, the first part focussing at the farm level and the second at the wider environment.

Concerning the farm level, various types of impact could be relevant, including:

- Labour (save time);
- Labour (safety);
- Energy use;
- Crop handling;
- Crop yields;
- Income or expenditure;
- Public acceptance of farming and farmers;
- Soil health;
- Soil compaction;
- Chemical precision;
- Etc.

Concerning the wider environment, the following impact could be relevant.

- CO2 or other emissions;
- Food safety;
- Food price;
- Biodiversity;
- Ethics;
- Etc.

2.4.4 Form of the exercise

Prepare two posters, one for impact on farming and one for wider societal and environmental impact. Each poster has two sections: positive and negative impacts (or risks).

- 5 mins: Participants fill in post-its for each poster and each section. If one section receives little intention, facilitator stimulates people to come up ideas for this section as well. Stimulate discussion while people put post-its to fuel the thinking.
- 5 mins: prioritise impacts for each of the four sections to identify the top 1-3 to be discussed
- 20 mins discussion, i.e. app. 5 mins for each section. So you may just have time to discuss the top 1 or 2 for each.

2.5 Barriers and opportunities for development

2.5.1 Objective

An assessment of barriers and opportunities to develop the robotic system further in a way that optimises the positive impacts and minimise the negative impacts that were identified in the previous exercise.

2.5.2 Explanation

There can be several types of barriers and opportunities, viz:

- Technical
- Economic (purchase, maintenance, operational)
- Societal / Political (regulation, public support or protest, etc.)

These may partly be derived from the previous exercise on impact (e.g. a positive impact on CO2 emissions can help to secure political or societal support for further development), partly they can be based on additional considerations (e.g. certain technical features of the system or the cost of a certain type of robot).

2.5.3 Guidance to run the exercise

This exercise covers many aspects, so time management is of key importance. There are the three dimensions (Tech, Ec, Soc) and each with barriers and opportunities. Easiest to manage is to take 10 mins for each of the 3 dimensions and within each dimension, discuss barriers and opportunities at the same time.

Especially economic aspects need some additional attention because there may be a large difference between initial cost (for one or a few of a kind prototypes of a new robotic system) and longer term costs (when robotic systems can be mass produced). As a result, short term economic barriers can be very different from long term economic barriers.

To inspire you at the session, the table below gives some examples of various types of barriers.

	Technical	**Economic / market**		**Societal / political**
		Short term	**Long term**	
Barrier	•Weeder may damage crops •...	•Prototypes very expensive •...	•High maintenance cost •...	•Existing regulation creates barrier for innovation •...
Opportunity	•Make use of XX technology that has been recently developed •...	•Small number of consumers willing to pay extra for sustainably produced food •Subsidy for sustainable innovation •...	•Dropping prices by economies of scale •...	•Societal and political pressure for more sustainability •...

2.5.4 Form of the exercise

Prepare three posters, one for each of the three dimensions above. Each poster has two sections: barriers or opportunities. For economic you can use two columns as above.

- Take 10 mins for each dimension
- Participants fill in post-its for both barriers and opportunities
- Facilitator stimulates discussion while they do this
- Bit more in-depth discussion on short-term versus long-term economic cost; may take some extra time.

2.6 Requirements for robot design and development process

2.6.1 Objective

Identify design requirements for the robotic system, including technical requirements for the robot itself as well as requirements to make the developmental process a success.

2.6.2 Explanation

The results from the previous exercises can be translated into a set of design requirements for the system and the process. After identifying the requirements, to focus work for the first year in the Robs4Crops project, a useful next step is to prioritise these, i.e. to indicate which points should be addressed first.

2.6.3 Guidance to run the exercise

In the previous exercise, 3 dimensions were assessed: technical, economic and societal. The technical aspects largely determine the technical requirements, the economic and societal aspects largely determine the 'developmental process' requirements. So, for this exercise, you can make two posters with the following headings:

- Technical requirements: overcoming technical barriers (but possibly also to reduce cost, *i.e.* to address an economic barrier)
- Developmental process requirements: overcoming economic and societal/political barriers

In some cases, a requirement can be very specific. This is often the case for the technical requirements. The process requirements, however, tend to be more general, indicating a potential direction to develop a solution. To give some examples:

- To overcome the high cost barrier for prototypes, different types of solutions may be:
  - Set up a system to lease, rather than to purchase robots;
  - Set up a system to purchase a robot with a group of farmers to share costs;

2.6.4 Form of the exercise

Prepare two posters, one for the robotic system and one for the developmental process, using the poster headers indicated above.

- Tell participants to keep results from previous exercises in mind, point them to these posters if needed.
- Take app 15 mins for each of the two posters
  - Participants fill in post-its for each poster (technical and process)
  - Facilitator stimulates discussion while they do this
  - After the brain storm harvest, conduct an exercise to prioritise the requirements
  - Possible question to ask: "If you could have the perfect robot, what would you change?"

The final output of the session would thus be this set of requirements for the robot and the developmental process. This provides input for the LSP activities for the following year.

2.7 Reflection and feedback

2.7.1 Objective

To get feedback from participants on how the session worked. This can be used to improve the sessions for the following years.

2.7.2 Guidance to run the exercise

To stimulate the feedback you can ask questions like:

- What is your general impression of the session?
- What worked well and what did not work well?
- What should be improved next year?
- What important lesson(s) did you learn on the use of the robotic system in the future?

2.7.3 Form of the exercise

- Open, plenary discussion

2.8 Closing

Annex 2: Script of the Co-Design Session

Here you will find the script we design to help facilitator during their CoDS.

Robs4Crops Co-Design Session ... (topic, country)

Note for partners: Below, various parts still need to be filled in to adapt the script for your own workshop. These places are marked as three marked dots as follows**: ...**

Description

Script for Co-Design Session H2020 Robs4Crops project

Location: ...

Date: ...

Time: ...

Objective

Explore design requirements (both technical and in terms of developmental process) for ... (fill in your own robotic system)

Roles

Facilitator: leads and introduces discussions and presentations, opens and closes the meeting (in beginning and after breaks).

Monitor: Takes notes on the content of the discussion and on what works well/not so well concerning the method (important for report on the workshop).

Tools

Prior to the session, prepare flip-overs with the following headers:

(To make the session a bit more lively, you can also write the headers during the session. But it can save time to have them already hanging)

- For the 'function' exercise (see below): One flip-over with '**main functions**' and one with '**additional functions**'
- For the 'impact' exercise (see below): Two flip-overs, one for **impact on farming** and one for **impact on wider environment and society**. Each poster has two sections: **positive** and **negative** impacts (or risks).
- Barriers / opportunities session: three posters as indicated On the next page
- **Requirements session:** Two flip-overs, one for **technical requirements**, one for **process requirements**

Post-its, markers

PowerPoints to introduce and explain different sections in the workshop, such as:

- Overall introduction: **objective** of the workshop and how results will be used in the project
- Explaining the session: **session logic and agenda**
- **Needed:** powerpoint to briefly **explain the robotic system** (for the 'function' exercise)

NOTE:

Since our training, some partners have sent us some specific questions that need to be answered during your CoDS. We have added them at the end of the session.

Please read them carefully.

Example flip-overs for exercise on barriers and opportunities

Technical / agronomic
Opportunities
Barriers

Economic	
Short term	**Long term**
Opportunities	Opportunities
Barriers	Barriers

Societal / Political
Opportunities
Barriers

Time table

Note: The timing below is indicated as starting at 0:00 hours. Adapt this to your actual starting time

Time *(start; duration)*	***Session***	***Elaboration & content***	***Materials & technique***	***Who***
00:00 15'	**Welcome, introduction and get to know each other**	**Seminar introduction** Explain the objective of the seminar • Also explain **how the results will be used** in the project **Introduction of participants** Every participant briefly introduces her/himself starting with the facilitator • Name • Affiliation / position • Interest in the robotic system **Icebreaker: dreams and nightmares** Each participant briefly indicates her/his ideal in connection with the robotic system and what he/she fears might be the worst that could happen.	PowerPoint **Introduction** Give every participant app. 30 seconds Give every participant app. 30-60 seconds Note: let your participants know that it needs to be very brief; no long stories!	**Facilitator** gives introduction **Facilitator** ensures presentations are brief **Facilitator** ensures presentations are brief **Monitor** notes the dreams and nightmares (they can be used later to come back to)
00:15 5'	**Explaining the session**	Briefly explain the **session logic** (cf. section 1.1 in the methodology document) and the **agenda** of the meeting.	**PowerPoint** with the **logic and agenda**	**Facilitator explains**
00:20 30'	**Function(s) of the robotic system**	General leading question: "What does the robotic system have to do?" 3 Main tasks: • **Identify** 'main function(s)' (= what does the robot have to do?) and some 'additional/supporting functions' (=what does the robot have to do to do it well).	Prepared poster with two sections: (1) main function (2) additional functions Note: if participants don't know the robotic system very well, the facilitator could start with a **brief powerpoint** to explain it in 2-3 mins. **4 activities**	**Facilitator** presents brief powerpoint to explain the robotic system if needed **Facilitator** guides the process, asks questions **Monitor** takes notes from the discussion

		Functions could be relevant for **farmer** but also for **wider environment**. • **Prioritise** functions to identify the most important ones to ensure that at least these will be addressed in the following discussion • Brief **discussion** on the most important functions	• 5 mins: **brainstorm** during which participants put post-its with their ideas continuously As the ideas come in, try to group by theme. • 3-5 mins: **prioritise** the functions by determine the top 3 ideas • 15 mins: **discussion** of the most important functions Questions to ask: o For **whom** is function important? o **Why** is function important; how important is it? o How **difficult** is it to **realise**? • 5 mins **reflection**: is the prioritisation still correct or should it change a bit on the basis of the previous discussion	
00:50 30'	**Impact assessment (agronomic and societal)**	Assess **positive and negative impacts** of the robotic system. Impacts can relate to the use of the robotic system in the **farming practice** as well as the impact of the farming practice on the **wider environment** (e.g. on pollution, CO2 emissions, on food prices and food safety, etc.).	Use two impact flip-overs, each with 'positive' and 'negative' section (cf. under 'tools' above) **3 activities** • 5 mins: Participants fill in post-its for each poster and each section. Stimulate discussion while people do this. • 5 mins: prioritise impacts for each of the four sections to identify the top 1-3 to be discussed • 20 mins discussion, i.e. app. 5 mins for each section. So you may just have time to discuss the top 1 or 2 for each.	**Facilitator** guides the process, asks questions; Ask additional questions if some part of a flip-over receives little input **Monitor** takes notes from the discussion
01:20 - 15'	**Break**			
01:35 30'	**Barriers and opportunities for development**	An assessment of **barriers and opportunities** to develop the robotic system further in a way that **optimises the positive impacts** and **minimise the negative impacts** that were identified in the previous exercise. There can be barriers and opportunities for **three dimensions**, viz:	Three prepared flip-overs, one for each of the three dimensions above. Each with two sections: barriers or opportunities. Economic has two columns for short and long term (see example posters under "tools" above). Take 10 mins for each dimension Activities for each dimension: • Participants fill in post-its for both barriers and opportunities and put them on flip-overs	**Facilitator** guides the process, asks questions; Ask additional questions if some part of a flip-over receives little input (see page 6) Many aspects covered: good **time management** needed

		• **Technical / agronomic** • **Economic** (purchase, maintenance, operational); distinguish short and long term • **Societal / Political** (regulation, public support or protest, etc.)	• Facilitator stimulates discussion while they do this • Bit more in-depth discussion on short-term versus long-term economic cost; may take some extra time.	**Monitor** takes notes from the discussion
02:05 30'	**Requirements for robot design and development process**	Identify design requirements for the robotic system, including technical requirements for the robot itself as well as requirements for the developmental process to make it a success. These requirements will focus work for the first year in the Robs4Crops project. To support this, prioritise the requirements, i.e. indicate which points should be addressed first.	Two prepared flip-overs, one for technical requirements, one for process requirements. Tell participants to keep results from previous exercises in mind, point them to these posters if needed. Take app 12 mins for each of the two posters for the following activities • Participants fill in post-its for each poster (technical and process) • Facilitator stimulates discussion while they do this. • Possible question to ask: "To create the perfect robot for you, what would have to change?" After both posters have been filled, conduct an exercise to prioritise the requirements. What would have to be addressed in the coming year.	**Facilitator** guides the process, asks questions; Ask additional questions if a flip-over receives little input **Monitor** takes notes from the discussion
02:35 - 10'	**Specific question**			
02:45 10'	**Reflection and feedback**	Get feedback from participants on how the session worked. This can be used to improve the sessions for the following years	Plenary discussion To stimulate the feedback you can ask questions like: • What is your general impression of the session? • What worked well and what did not work well? • What should be improved next year? • What important lesson(s) did you learn on the use of the robotic system in the future?	**Facilitator** guides the process, asks questions; Ask additional questions if a flip-over receives little input **Monitor** takes notes from the discussion
02:55 5'	**Closing**	Explain how results will be used and thank you.	Explain: The final output of the session are the set of requirements for the robot and the developmental process. This provides input for the LSP activities for the following year. Thank you	**Facilitator** explains, thanks. **Monitor** saves flip-overs, e.g. by taking photos.

Specific questions:

1. 'Assuming you found a field robot that fit your needs and the loans were in place, when would you purchase it?'
   0-1 years, 1-3 years, 3-5 years, 5+years, never

2. 'What are the barriers that would enable you to buy or use the robot?'
   Price, Complex system, Insurance, the safety around the robot, not adapted to the needs of my farm

3. If you were to buy a field robot, rate the reasons why you would buy the robot. 5 is most import and 1 is least important:
   - Labour (save time)
   - Attractive labour (is it more fun to operate a robot than to drive a tractor?)
   - Lower fuel consumption
   - Energy type:
     - Battery
     - Hydrogen fuel cell
     - methanal fuel cell
     - Bio diesel
     - Diesel
   - Closely matches the same way you use a tractor
   - Precision of task? How well the robot is able to perform the task?
   - Speed per hour (capacity)
   - Cost
   - Weight of robot and implement
   - Soil compaction
   - The robot looks good
   - Data collection and intelligent application to reduce inputs (spot spraying, etc)
   - Does the robot need to find the most optimum path, or should it just drive like a tractor does?
   - Control over robot? Feedback systems?
   - In field supervision? (need to be in the field with the robot)
   - Remote supervision? (being able to look through the robots cameras to see what is happening)

4. Please list which FMIS you use and why?
5. What parameters from the farm/field should the ERP take into account?
6. Do you think it is important to prepare the prescription maps of the application with your involvement or a farm advisory board?

Additional question for part "Impact assessment":

<table>
<tr><td colspan="2">Concerning the farm level, various types of impact could be relevant, including:</td><td>Concerning the wider environment, the following impact could be relevant.</td></tr>
<tr><td>• Labour (save time) ;
• Labour (safety) ;
• Energy use ;
• Crop handling ;
• Crop yields ;</td><td>• Income or expenditure ;
• Public acceptance of farming and farmers ;
• Soil health ;
• Soil compaction ;
• Chemical precision ;</td><td>• CO2 or other emissions;
• Food safety;
• Food price;
• Biodiversity;
• Ethics;</td></tr>
</table>