PestNu

D1.3 System thinking feasibility studies & benchmarking

Agroväst

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List of Abbreviations & Definitions

Abbreviation	Definition
AI	Artificial Intelligence
AOP	Agro-ecological and Organic Practices
CAGR	Compound Annual Growth Rate
D	Deliverable
DSS	Decision Support System
DST	Digital and Space-based Technologies
EO	Earth Observation
ESA	European Space Agency
GPS	Global Positioning System
Ha	Hectare
IAB	Industrial Advisory board
LCA	Life Cycle Analysis
RS	Remote Sensor
T	Task
T	Task
UAA	Utilised Agricultural Area
WP	Work Package

Executive Summary

Exploring the main reasons behind the current lack of adoption of similar innovations as developed in PestNu and identify the key barriers to implementation of Agro-ecological and Organic Practices (AOPs) and Digital and Space based Technologies (DSTs) is essential. In this report the obstacles perceived by project partners and some members of the Industrial Advisory Board (IAB) when launching their solutions to reduce pesticides use and to use fertilizers more efficiently are presented. All consortium members were also asked to submit information about the regulations, protocols, datasets, standards, good practices and guidelines that affect their product, technology or business. It also includes a literature review of the techniques similar to the ones used within the project, including benchmarking against the PestNu technologies and a brief overview of the statistics available on the current use of pesticides and fertilizers. This provides the starting point for the challenge of reducing the use of these substances.

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1 Introduction

This report summarizes the experiences collected under the task T1.2 of PestNu's Work Package (WP)1, to pinpoint the obstacles perceived by project partners and some members of the Industrial Advisory Board (IAB) when launching their solutions to reduce pesticides use and to use fertilizers more efficiently. It also includes a literature review of the techniques similar to the ones used within the project, a brief overview of the statistics available on the current use of pesticides and fertilizers which provides the starting point for the challenge of reducing the use of these substances.

1.1 About PestNu

PestNu targets the field-testing and demonstration of Digital and Space based Technologies (DST) and Digital and Space based Technologies (AOP) under a systemic approach to reduce the pesticides and fertilisers use, and loss of nutrients. The consortium brings novel DST including AI robotic traps for real time pest monitoring; Autonomous mobile robots for pesticide monitoring and 3D spot spraying; Earth Observation (EO) missions with robust AgroRadar AI algorithms to map soil/plant nutrients and pest plant inputs using Copernicus data/services; and in-situ and real-time nutrient analysers. All the DST will be interconnected to a user-centric cloud-based Farm Management System, which features a Digital and Space based Technologies (DSS) integrated with a blockchain based system for DST data evidence, integrity, and AI models verification and with a cybersecurity platform to prevent cyber-attacks and IoT vulnerabilities. The AOP include on-site production of biofertilizers from agricultural wastewaters through a robust automated drainage recycling system via an innovative enzymatic hydrolysis procedure; a novel foliar biopesticide formulated by circular bioeconomy operations, targeting fungal diseases with biostimulant effect; and advanced nutritional programs for organic farming. The showcase systemic DST & AOP solutions will be demonstrated and tested in aquaponic and hydroponic greenhouse and open-field vegetable cultivation in Greece and Spain. A Pesticide Reduction Program will evaluate the Maximum Residue and the Acceptable Daily Intake levels to ensure vegetable's food safety and Digital and Space based Technologies (LCA) activities will be performed. All these systemic approaches will be performed under a strong collaboration among all the Farm to Fork stakeholders and European Commission services.

1.2 Purpose of this Document

The purpose of deliverable (D)1.3 is to give an analysis of DST & AOP innovations and identification of the main reasons behind the current lack of adoption of these types of innovations and key barriers to relevant technologies implementation.

Partners have reviewed relevant existing guidelines, good practices, regulations, and standards regarding the reduction of losses of nutrients, pesticides and fertiliser use and also proposed system thinking approaches for PestNu innovations.

An analysis of statistical data for pesticide and fertiliser usage, organic farming, and usage of DST & AOP innovations in agriculture have been carried out and data have been gathered both from project partner countries, European Union (EU) and five countries outside EU as a comparison.

Technical project partners and some members of the Industrial Advisory Board (IAB) who have developed technologies or products similar to the technical partners received a questionnaire in order to survey the barriers and challenges in placing new technologies or products on the market.

1.3 Document structure

Following this introduction, section 2 provides an overview of statistical background and highlights the importance of reduced use of pesticides and mineral fertilisers. Section 3 present techniques similar to the ones developed by PestNu partners, Section 4 provides information on how the project partners are affected by regulations, protocols, datasets, standards, good practices and guidelines. Section 5 presents information about the answers provided by the technical partners in PestNu and members of IAB regarding barriers for putting their products on the market. Section 6 provides conclusions and recommendations. Section 7 and 8 are Annexes with full answers from section 4 and the questionnaire from Section 5.

2 Statistics for pesticides, fertilisers and organic production

In this section data and statistics for pesticides, fertilisers and organic production are presented. PestNu partner countries are compared with each other and EU in total. In the last part EU is compared with five countries in different parts of the world; Brazil, China, India, Russia and United States of America (USA).

2.1 Data and statistics about the use of pesticides in the EU

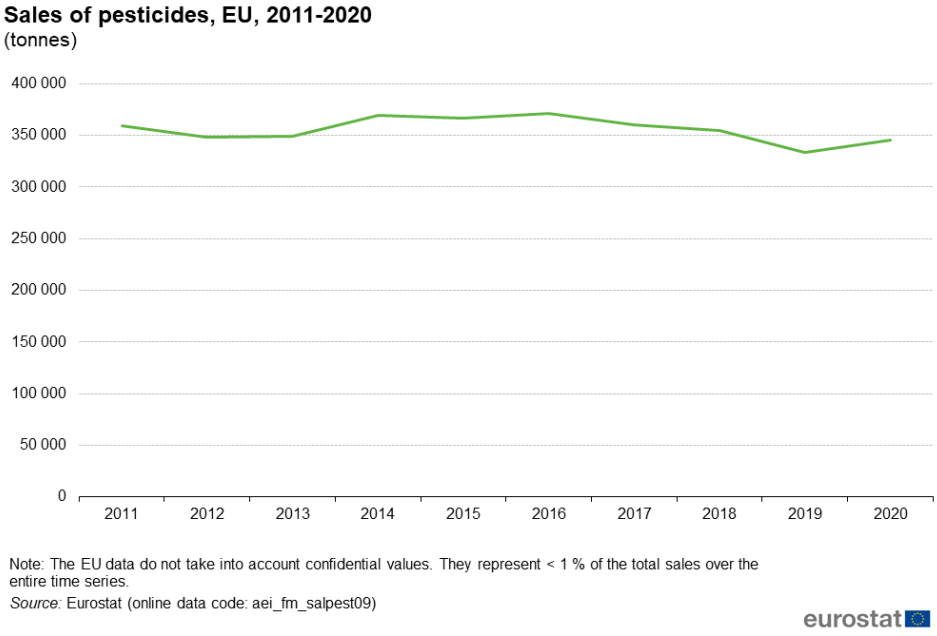


Figure 1 Sales of pesticides, EU, 2011-2020 (tonnes)[1]

Between 2011 and 2020, sales of pesticides in the EU remained relatively stable, the total volume sold annually fluctuated ± 6 % around the 350,000 tonnes level and was 346,000 tonnes in 2020 (Figure 1).

Pesticides' sales are reported for six major groups of substances. Fungicides, bactericides, herbicides, haulm destructors and moss killers were the pesticide groups that recorded the highest sales volumes each year over the reference period.

It is important to note that many of the more hazardous substances have had their authorisation withdrawn, and have been removed from the market, following their evaluation under Regulation 1107/2009 concerning the placing of plant protection products on the market.

[1] Eurostat, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_consumption_of_pesticides#Key_messages

Four EU countries (Germany, Spain, France and Italy) recorded the highest volumes sold in most major groups. These countries are also the main agricultural producers in the EU, with collectively 51% of the total EU utilised agricultural area (UAA) and 49% of the total EU arable land.

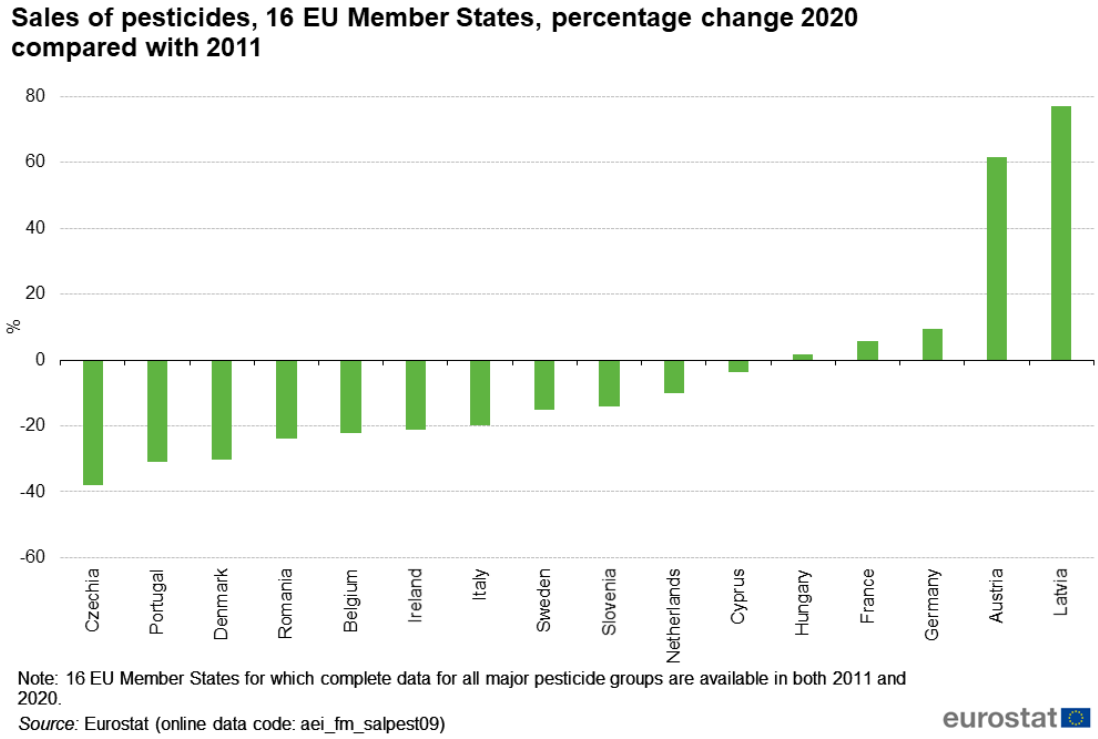


Figure 2. Changes in sales of pesticides in 16 EU member states 2011-2020 (tonnes)[2]

Between 2011 and 2020, there were contrasting developments in the volume of pesticide sales between Member States (Figure 2). There were declining sales in a majority of the 16 Member States, with the sharpest rate of decline recorded in Czechia (- 38 %). Portugal, Denmark, Romania, Belgium and Ireland also reported sales that were at least 20 % lower in 2020 than 2011. On the other hand, Austria and Latvia reported significantly higher sales of pesticides in 2020 than in 2011. It should be noted that the volumes of pesticides sold in Latvia in absolute terms are very low and in Austria, large volumes of inert gases used in the storage of agricultural products inflate the total volume of pesticides sold.

[2] Eurostat, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_consumption_of_pesticides#Key_messages

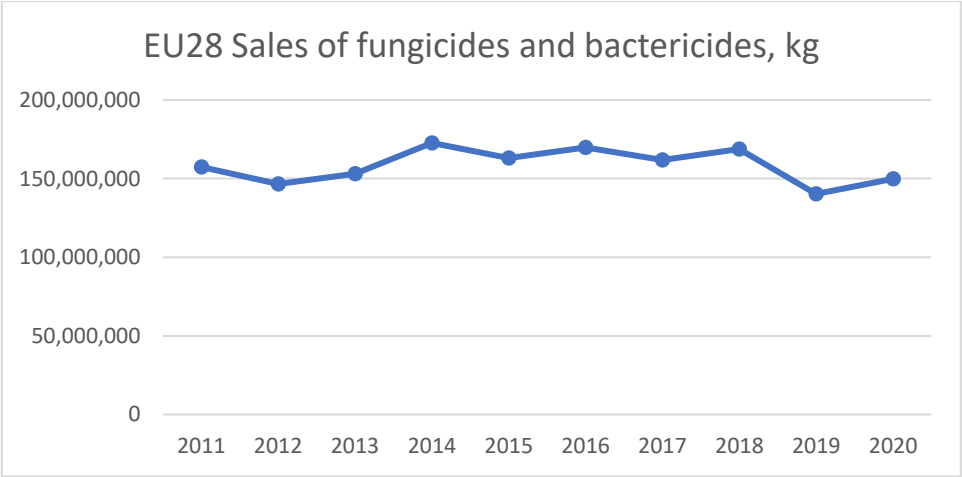


Figure 3 Sales of fungicides and bactericides in EU28 2011-2020 (kg)[3]

About 45% of the sold pesticides in EU are fungicides and bactericides. Between 2011 and 2020, sales of fungicides and bactericides in the EU remained relatively stable around 160,000 tonnes (Figure 3). In 2020, inorganic fungicides accounted for slightly more than one half (56.8%) of the fungicides and bactericides sold in the EU. These inorganic fungicides refer to copper compounds, inorganic sulphur and other inorganic fungicides, many of which are permitted in organic farming.

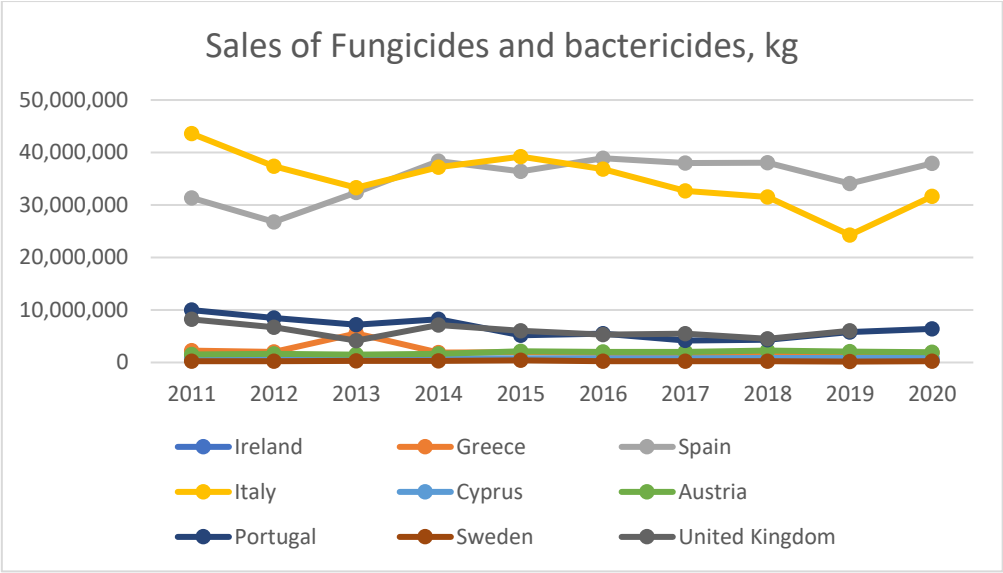


Figure 4 Sales of fungicides and bactericides in partner countries 2011-2020 (kg)[4]

Italy and Spain are the two PestNu partner countries with the highest sales of fungicides and bactericides. In Spain the sales increased between 2011 and 2020 when almost 40,000 tonnes were sold (Figure 4). In Italy, on the other hand, a decrease between 2011 and 2020 has been taken place.

[3] Eurostat, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=aei_fm_salpest09&lang=en
[4] Eurostat, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=aei_fm_salpest09&lang=en

In 2020 a bit more than 30,000 tonnes were sold in Italy. The remaining PestNu partner countries sales of a few hundred tonnes up to 7,000 tonnes were recorded in 2020.

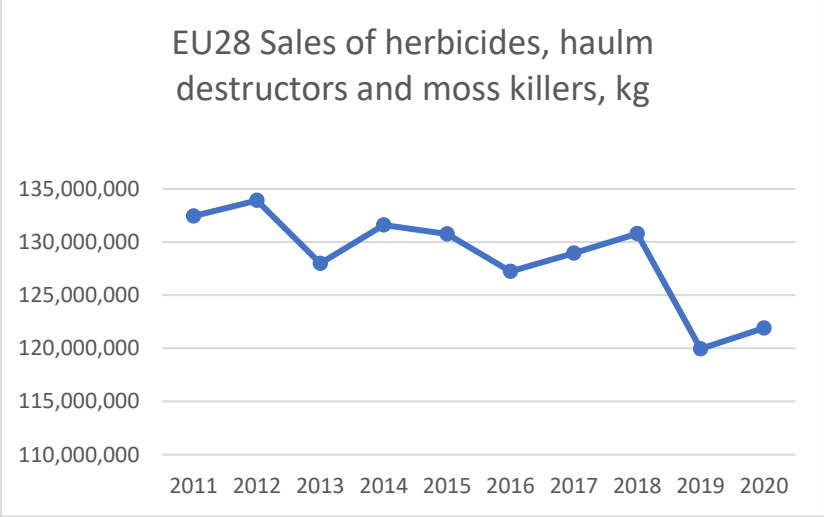


Figure 5 Sales of herbicides, haulm destructors and moss killers in EU28 2011-2020 (kg)[3]

About 35% of the sold pesticides are herbicides, haulm destructors and moss killers and more than 40 % (41.3 %) of sales within this category in 2020 came from the organophosphorus herbicides which includes glyphosate. Between 2011 and 2020, sales of herbicides, haulm destructors and moss killers in the EU has been decreasing from about 133,000 tonnes to around 122,000 tonnes with some fluctuations (Figure 5).

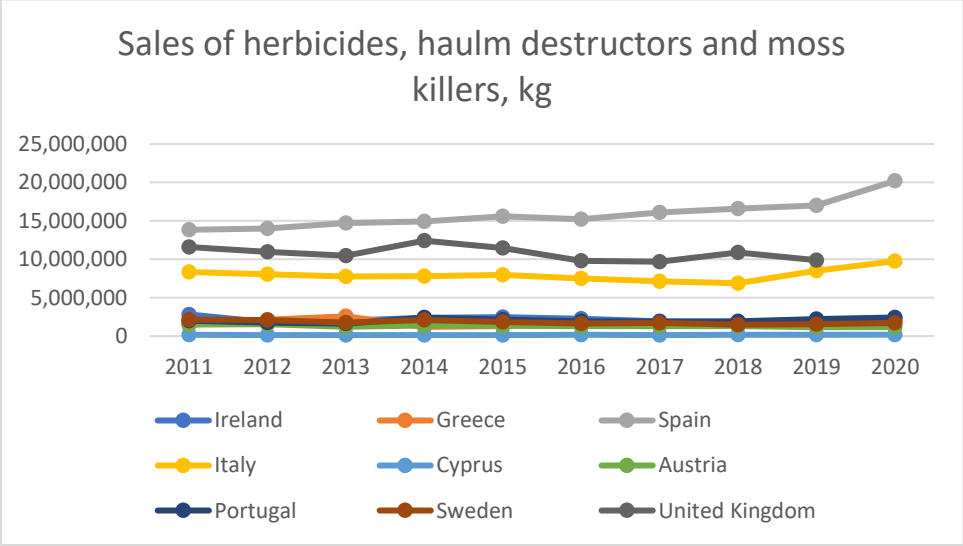


Figure 6 Sales of herbicides, haulm destructors and moss killers in partner countries 2011-2020 (kg)[5]

Italy, United Kingdom and Spain are the PestNu partner countries with highest sales of herbicides, haulm destructors and moss killers (Figure 6). Spain with an increase between 2011 and 2020 when about 20,000 tonnes were sold. Both in UK and Italy, the sales were fairly stable between 2011 and 2020 when about 10,000 tonnes were sold. However, for UK no data is reported for 2020. The remaining PestNu partner countries had sales of a few hundred tonnes to about 2,000 tonnes in 2020.

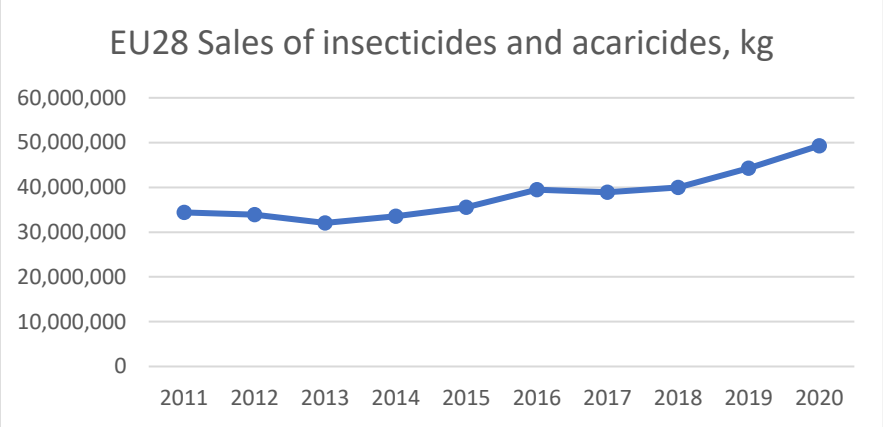


Figure 7 Sales of insecticides and acaricides in EU28 2011-2020 (kg)[4]

The substance group insecticides and acaricides covered about 15% of the pesticide sales in 2020 with an increasing trend the last years (Figure 7). Over 90% of sales in the substance group insecticides and acaricides in 2020 were from the category of products other insecticides. This category includes many substances, including about 30 different insect attractants with the chemical class of straight chain lepidopteran pheromones. The next largest category within the group was insecticides based on pyrethroids

[5] Eurostat, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=aei_fm_salpest09&lang=en

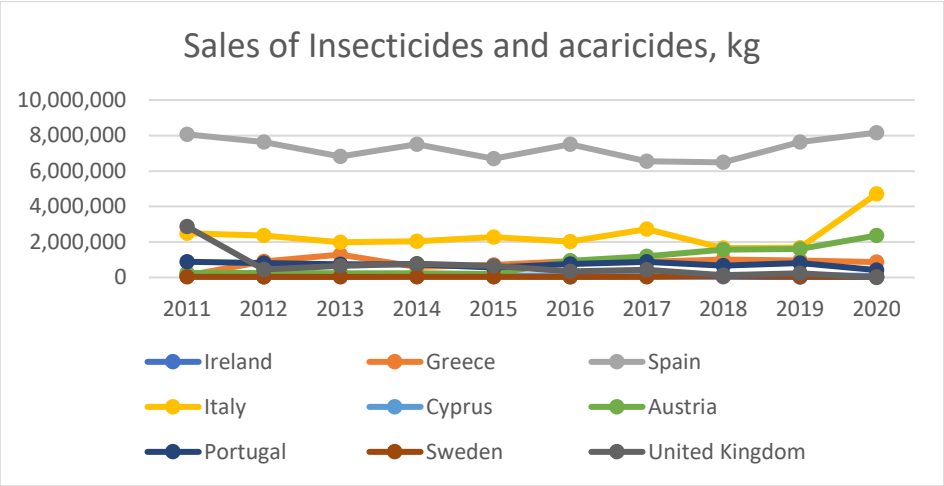


Figure 8 Sales of insecticides and acaricides in partner countries 2011-2020 (kg)[6]

Spain has the highest sales of insecticides and acaricides with sales of about 8,000 tonnes annually (Figure 8). Italy had a distinct increase to more than 4,000 tonnes in 2020 from about 2,000 tonnes in previous years. Also Austria have had an increase in recent years. The remaining PestNu partner countries had a sale of a few hundred tonnes in 2020.

2.2 Data and Statistics about the use of fertilisers in EU

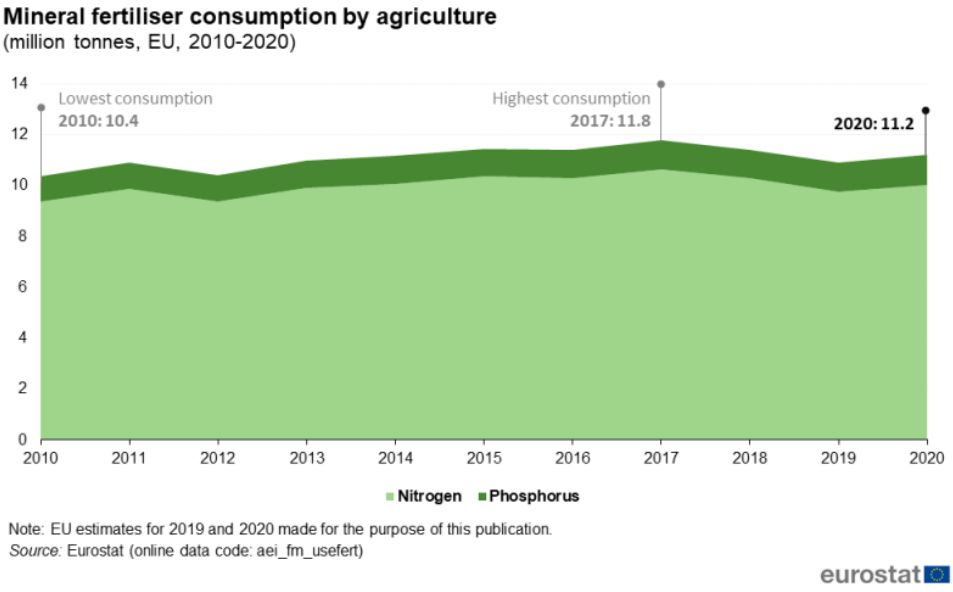


Figure 9. Consumption of mineral fertilizers in EU 2011-2020[6]

[6] Eurostat, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=aei_fm_salpest09&lang=en

The amount of mineral fertilisers, nitrogen (N) and phosphorus (P), used in agricultural production in the EU was 11.2 million tonnes in 2020 (Figure 9). This represented an increase of 8.3% compared with the level in 2010, when use was impacted by relatively high prices.

Nitrogenous fertilisers (ammonia, urea, ammonium nitrate) are produced with energy input from natural gas, the price of which is strongly linked to oil prices. Phosphates are mined outside of the EU, which results in high production and transportation costs, also linked to oil prices. The EU's nitrogen-based fertiliser industry is heavily dependent on gas of Russian origin and Russia and Belarus are key players in the world production of rock-based fertilisers (phosphates and particularly potassium). The military aggression in Ukraine and application of sanctions on Russia has led to sharply increased fertiliser prices which will likely have an impact on the use of fertilisers in agriculture in the EU.

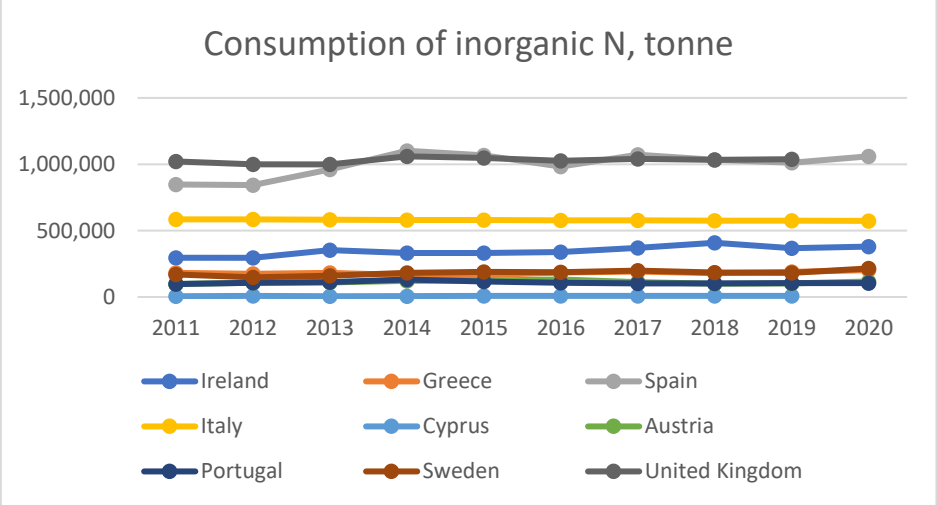


Figure 10 consumption of inorganic N in partner countries 2011-2020 (tonne)[6]

The EU average consumption between 2010 and 2019 of nitrogen fertiliser for agricultural use is 10,0 million tonnes. United Kingdom, Spain and Italy are the PestNu partner countries with highest consumption of inorganic nitrogen (Figure 10). UK and Spain have a stable consumption of approximately 1,000,000 tonnes each in recent years. Italy has an annual consumption of 600,000 tonnes since 2011. Ireland's consumption has increased since 2011 from about 300,000 tonnes to around 400,000 tonnes in 2020. Greece and Sweden have a consumption of approximately 200,000 tonnes each while Portugal and Austrias' consumption is about 100,000 tonnes. Cyprus has a consumption of only 7,000 tonnes.

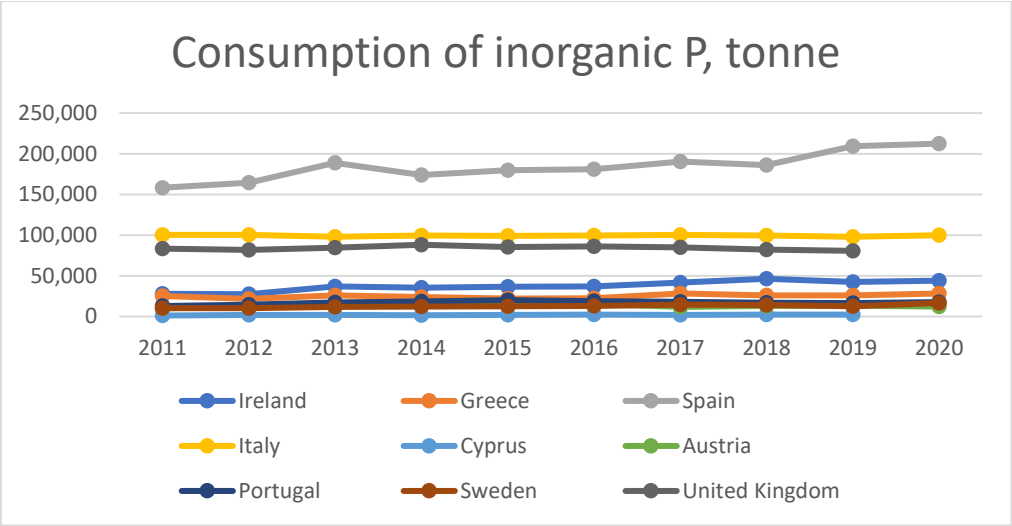


Figure 11 consumption of inorganic P in partner countries 2011-2020 (tonne)[7]

The EU average consumption between 2010 and 2019 of phosphorus fertiliser for agricultural use was 1,1 million tonnes. In 2020, the consumption of phosphorus fertilisers by agriculture in the EU was 1.2 million tonnes. Spain has a consumption of approximately 200,000 tonnes in 2020 with an increasing trend since 2011 (Figure 11). Italy has an annual consumption of 100,000 tonnes since 2011 and also UK has a stable annual consumption of approximately 80,000 tonnes. Ireland has an increasing trend since 2011 from about 300,000 tonnes to around 400,000 tonnes in 2020.

2.3 Data and Statistics about organic production in EU

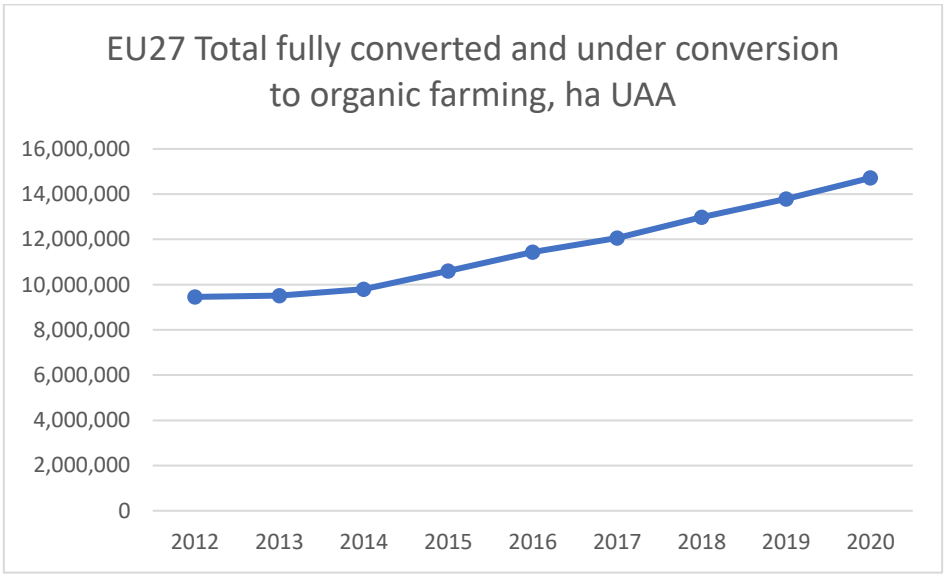


Figure 12 Fully converted and under conversion to organic farming in partner countries 2011-2020 (ha utilised agricultural area excluding kitchen gardens)[7]

The total organic area in EU was 14.7 million hectares in 2020 corresponding to 9,1% of the utilised agricultural area. The organic area increased from 9.5 million hectares in 2012, which corresponds to 56 % increase (Figure 12). The total organic area is the sum of the area under conversion and the certified area. Before an area can be certified as organic, it must undergo a conversion process, which take 2-3 years depending on the crop.

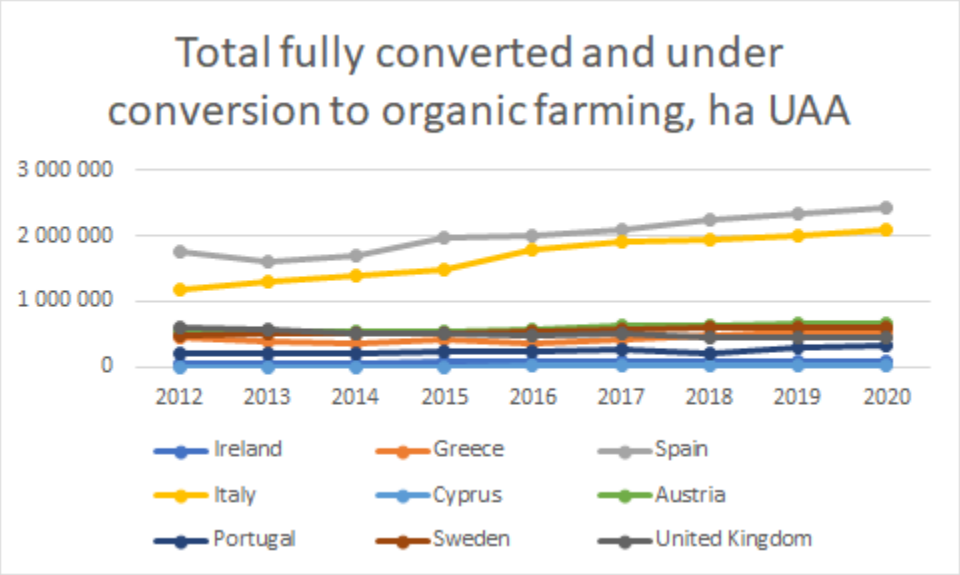


Figure 13 Fully converted and under conversion to organic farming in partner countries 2011-2020 (ha utilised agricultural area excluding kitchen gardens)[8]

Spain has the largest organically farmed area with almost 2,5 million ha and Italy has about 2 million hectares. The four countries United Kingdom, Austria, Greece and Sweden have an area of around 500,000 ha while Cyprus and Ireland have significantly smaller areas (Figure 13, Table 1).

Table 1 Organically farmed areas in EU member states 2012 and 2020 (ha)

	2012	2020	Change
Ireland	52,793	74,666	41%
Greece	46,2618	534,629	16%
Spain	1,756,548	2,437,891	39%
Italy	1,167,362	2,095,364	79%
Cyprus	3,923	5,918	51%
Austria*	533,230	671,703	26%
Portugal	200,833	319,540	59%
Sweden	477,684	610,543	28%

[7] Eurostat, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=org_cropar&lang=en

United Kingdom*	590,011	459,275	-22%
European Union - 27 (from 2020)	9,457,886	14,719,036	56%

* Data from 2019

2.4 Data and Statistics from Brazil, China, India, Russia and USA in comparison with EU

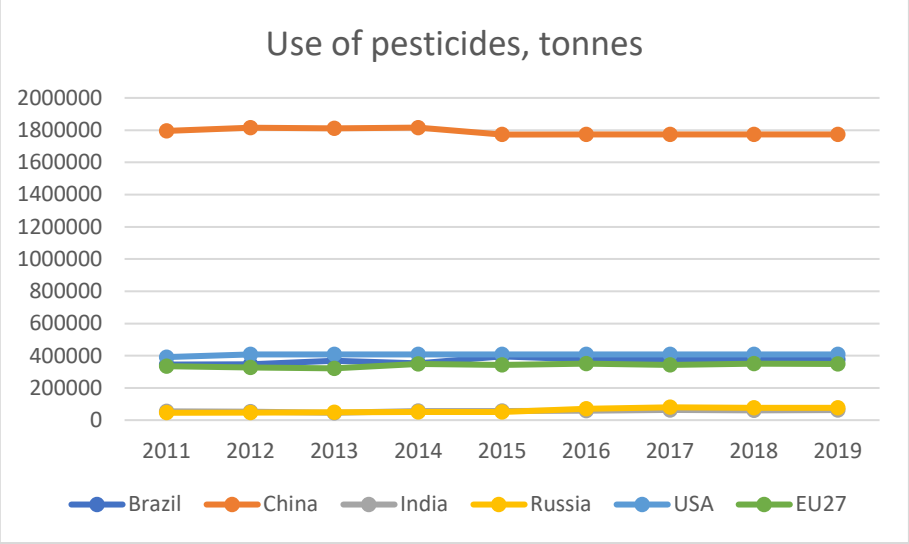


Figure 14 Usage of pesticides in Brazil, China, India, Russia, USA and EU27 2011-2019 (tonnes)[8]

China has an annual pesticide use of approximately 1.8 million tonnes which is significantly higher than EU, USA and Brazil, each country with an approximate use of 0,4 million tonnes per year (Figure 14). Russia has an annual consumption of about 77,000 tonnes and India 62,000 tonnes. The usage has been fairly stable between 2011 and 2019.

[8] FAO, https://www.fao.org/faostat/en/#data/RFN

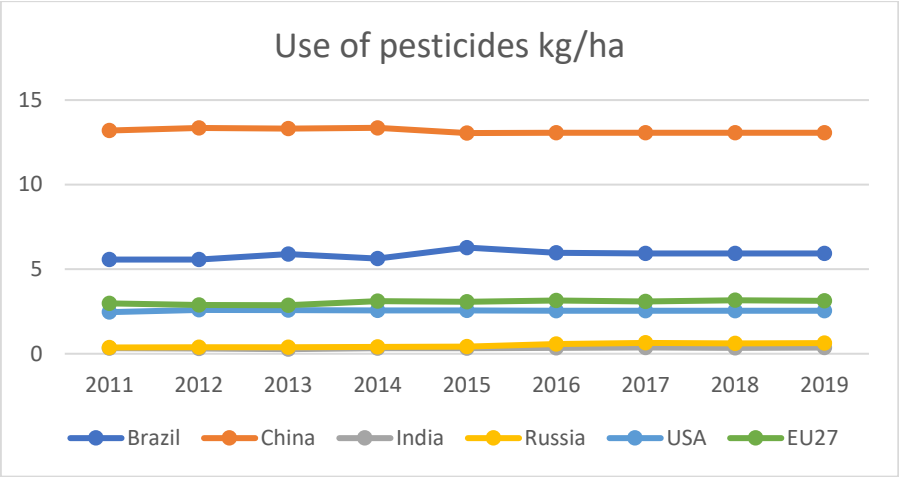


Figure 15 Usage of pesticides in Brazil, China, India, Russia, USA and EU27 2011-2019 (kg/ha)[9]

China has the highest use of pesticides per hectare with 13 kg/ha while Brazil has the second highest usage of 6 kg/ha. EU has a usage of 3 kg/ha and USA 2,5 kg/ha. Both India and Russia have significantly lower usage per hectare.

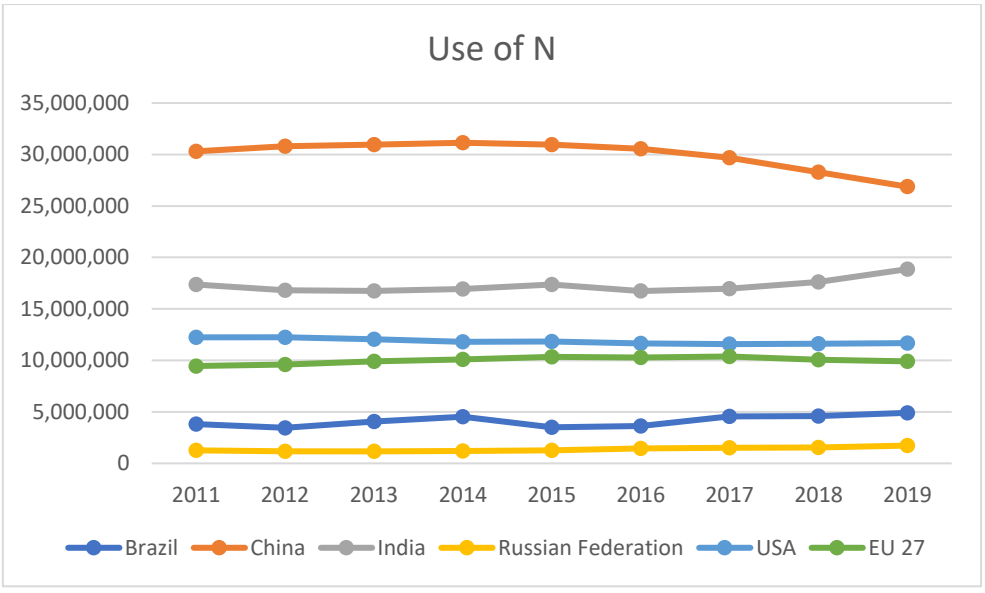


Figure 16 Usage of N in Brazil, China, India, Russia, USA and EU27 2011-2019 (tonnes)[8]

China has an annual use of approximately 27 million tonnes of N in mineral fertilizers with a slightly decreasing trend the last years. India has an annual use of almost 19 million tonnes with a slight increase since 2017. USA and EU have a use of 11,5 and 10 million tonnes respectively. Both Brazil and Russia have a stable usage of 5 million and 1.7 million tonnes respectively.

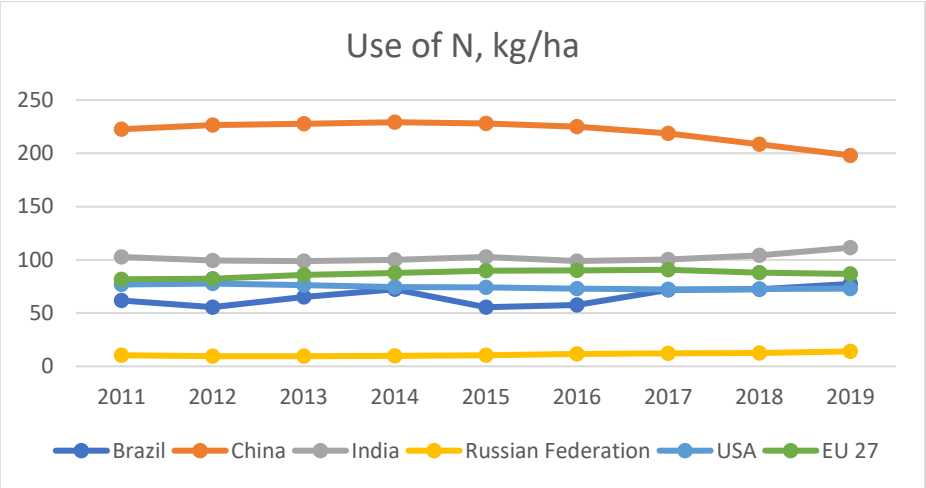


Figure 17 Usage of N in Brazil, China, India, Russia, USA and EU27 2011-2019 (kg/ha)[10]

China has an annual use of approximately 200 kg nitrogen per hectare cropland in 2019 with a decreasing trend the last years (Figure 17). India had an annual use of 110 kg N /ha in 2019 with a slight increase since 2017. EU, Brazil, and USA have an annual use of 73- 85 kg N / ha while Russia only uses 14 kg N /ha.

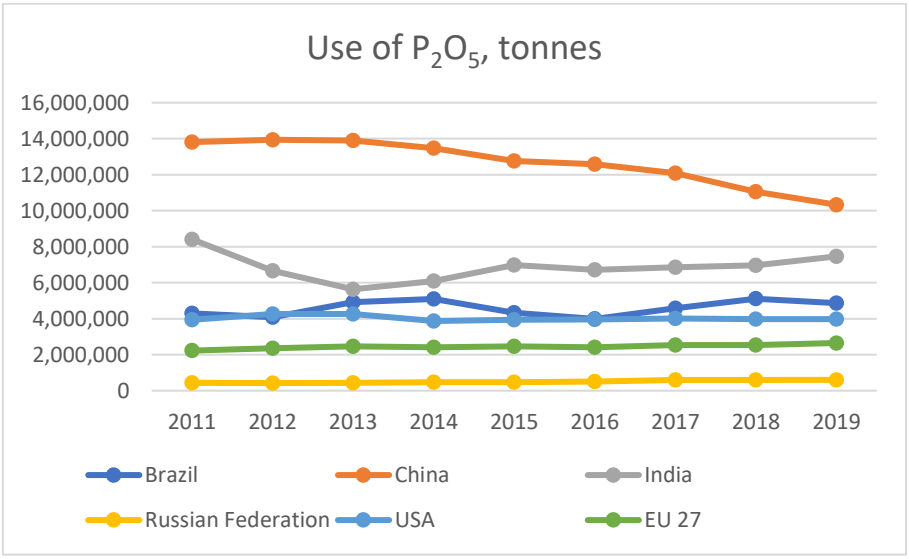


Figure 18 Usage of P205 in Brazil, China, India, Russia, USA and EU27 2011-2019 (tonnes)[8]

China is the largest consumer also of phosphate, P_2O_5, with a usage of more than 10 million tonnes in 2019, with a declining trend since 2013 (Figure 18). India has an annual use of 7.5 million tonnes while EU has a usage of about 2.5 million tonnes. Only Russia has a lower usage than EU.

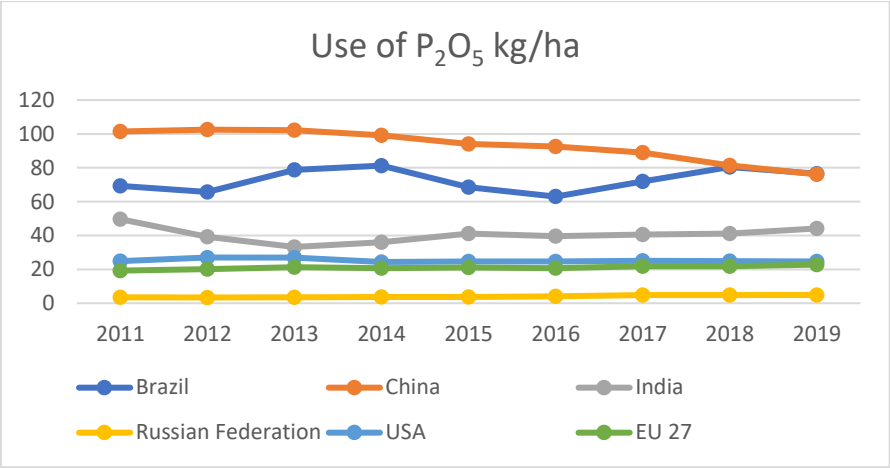


Figure 19 Usage of P205 in Brazil, China, India, Russia, USA and EU27 2011-2019 (kg/ha)[8]

China and Brazil had an annual use of approximately 80 kg P_2O_5 per hectare cropland in 2019, China with a decreasing trend since 2013 and Brazil with a slightly fluctuating use since 2011 (Figure 19). India had a use of almost 45 kg P_2O_5 /ha in 2019 while EU and USA both had an annual use of 23 kg P_2O_5 / ha. Russia's use was only 5 kg P_2O_5 /ha.

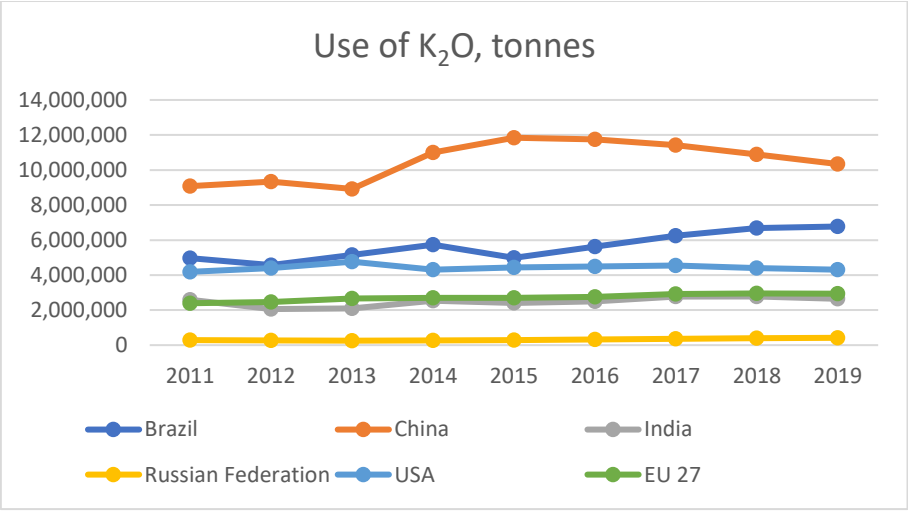


Figure 20 Agricultural usage of K20 in Brazil, China, India, Russia, USA and EU27 2011-2019 (tonnes)[8]

China is the largest consumer also of potash, P_2O_5, with a usage of more than 10 million tonnes in 2019, with a declining trend since 2015 (Figure 20). Brazil had an annual use of 6,7 million tonnes with an increasing trend since 2011. USA has a usage of about 4.3 million tonnes and EU and India had a use of 2.9 and 2.6 million tonnes respectively, all with a stable trend since 2011. Russia had a usage of 0.4 million tonnes.

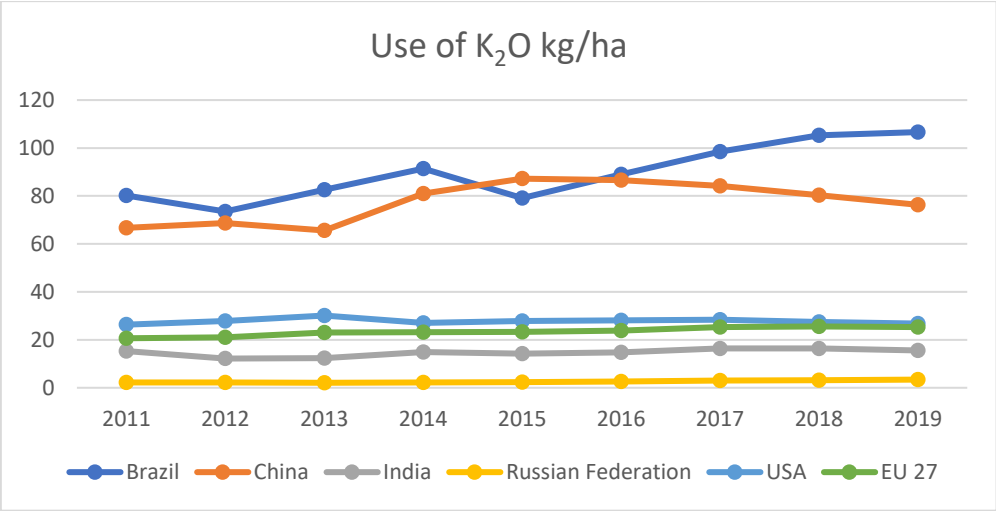


Figure 21 Agricultural usage of K20 in Brazil, China, India, Russia, USA and EU27 2011-2019 (kg/ha)[8]

Brazil had an annual use of 105 kg K_2O per hectare cropland in 2019, with an increasing trend since 2011 and China had an annual use of 76 kg K_2O/ha in 2019 and the use has been slightly fluctuating since 2011 (Figure 21). EU and USA both had an annual use of 25 kg K_2O / ha. Russia had a low usage of only 3 kg K_2O /ha.

2.5 Long term agricultural use of pesticides and inorganic fertilisers

The global use of both pesticides and inorganic fertilisers have been increasing steadily for many years and it is obvious that the use has to be reduced, both for environmental and human health reasons.

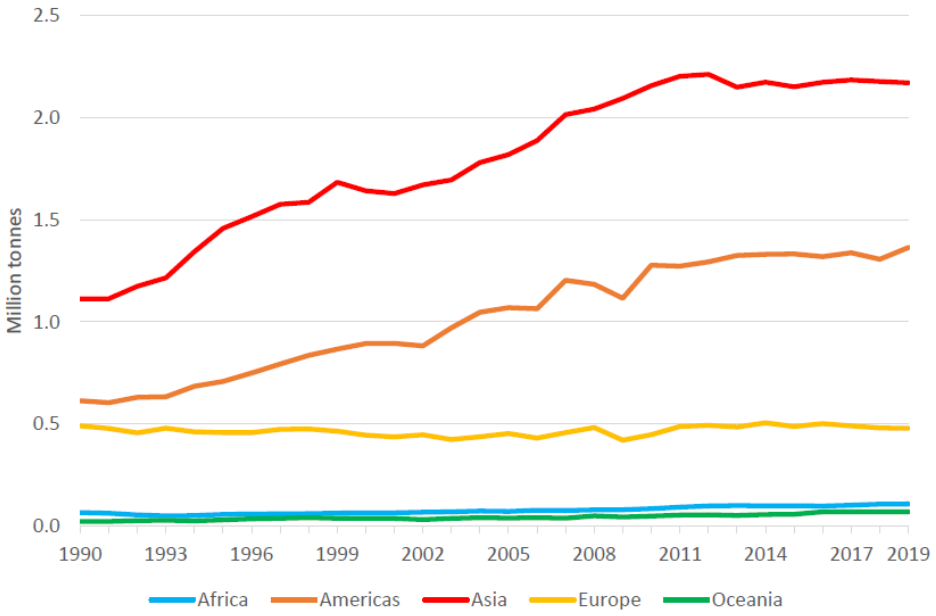


Figure 22. Total use of pesticides by region 1990-2019 (Mtons).[9]

Globally there has been a steady growth of the use of pesticides since the 1990s (Figure 22). Europe have had a relatively stable use since then, but most other parts of the world, especially Asia have had a large increase.

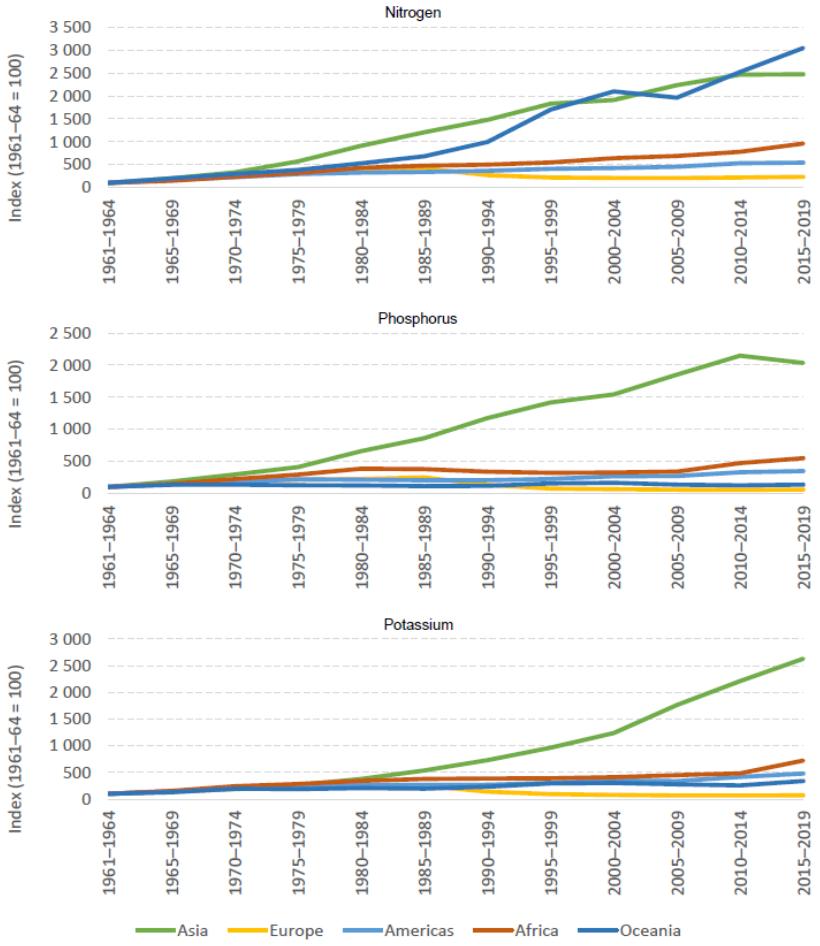


Figure 23. Agricultural use of inorganic fertilisers by region (as index, 100 = 1960-64 average)[10]

Globally there has been a steady growth of the use of inorganic fertilisers since the 1960s. Europe have had a relatively stable use since then, but most other parts of the world, especially Asia have had a large increase.

[9] https://www.fao.org/3/cb6034en/cb6034en.pdf
[10] https://www.fao.org/3/cb5738en/cb5738en.pdf

2.6 Discussion on the use of pesticides and fertilizers both at European and Global level

Based on Eurostat's data it is observed that in the countries of the European Union, Organic farming is constantly gaining ground. Overall organic agriculture covered area is constantly increasing, as it can be illustrated in figure 12. The covered area of organic agriculture is expected to grow even further in the next years. Considering the new CAP, as well as EU's legislation, guidelines and suggested good practices, new technologies, products, methods and tools are being developed, in this direction, supporting and enhancing productivity and quality of organic agriculture. Thanks to recent scientific achievements but also to the change in behavior and demands of consumers and society, organic agriculture has become more efficient, desirable and accepted both from the customers and the producers.

Some of the most organically farmed countries of the EU are Spain and Italy, as it can be seen in figure 13, both regions with contribution in PestNu's activities, which can be explained by the size of both countries, as well as by climate conditions.

As it can be confirmed by the data in table 1, in EU27 the organically farmed areas have increased almost 60% during the last decade, compared to the area organically farmed in 2012. The biggest change compared to other countries has been observed in Italy (79% more organic farming), Portugal (59%), Cyprus (51%), Ireland (41%) and Spain (39%). The described data are being illustrated in figure 24

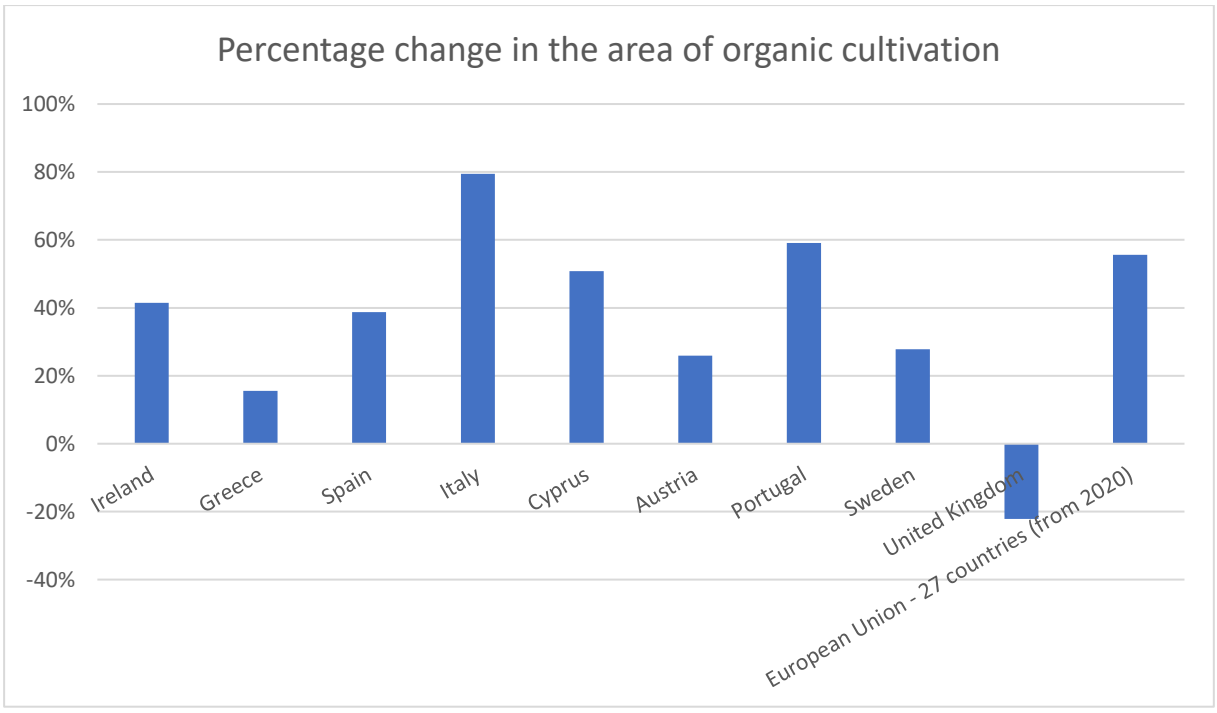


Figure 24. Percentage change in the area of organic cultivation in the year 2020 compared to the year 2012

Globally the use of pesticides is not uniform in all regions. As it can be seen in figure 14, the major user of pesticides is China. This phenomenon is explained by the vast area of the country of China, the very large population whose nutritional needs need to be met, the intense industrial activity that increases the need for raw materials, as well as the legal framework for the use and circulation of pesticides, the controls and the country's general policy. Additionally, based on the data, illustrated in figure 14, in western regions (EU27, USA, Brazil) the use of pesticides tends to be similar. Even though there are huge differences, among every region, in the general legislation on circulation and usage of agricultural supplies, the goal of Western countries is to reduce the use of pesticides, based on the data of the last decade.

Looking at the status of worldwide usage of pesticides (figure 22) it is observed that in Asia and America the yearly amounts of pesticides used have doubled since the year 1990. In contrast, the yearly amounts of pesticides used in Europe remained stable and approximately equal to that used in the year 1990.

In order to enhance sustainability, the total amounts of pesticides used per year shall be eliminated, all across the globe. This target can be achieved by:

- Developing and implementing new precision agriculture technologies
- Developing early disease and insect detection tools
- Local/spot deposition of pesticides in early infection stages
- Developing and applying efficient agro-ecological practices
- Designing effective nutritional plans based on the crop, the region, the soil and the climate, providing maximum nutrient uptake, minimizing nutrient loss
- Developing circular economy systems to fully exploit agricultural inputs to produce food with minimum nutrient losses
- Developing laws, regulations and suggestions in EU and at Global level to promote new methods and tools that support sustainability both in the environment and agriculture

PestNu, promotes sustainability by implementing and supporting all the aforementioned routes for healthy crops, environment, nature and society.

3 Technologies and methods similar to PestNu

In section 3 technologies and products similar to the ones developed by the technical partners in PestNu are presented with examples from various countries in the world. The techniques developed in PestNu are also benchmarked against similar technologies.

3.1 Robotic traps

Today, there seem to be two major challenges to get an effective and sustainable plant protection, which is to find the right pests and get the information at the right time to do a correct and effective control. If at an early stage the growth of a pest can be detected in its development cycle, then the possibility of coping with the problem of biological control may increase. The development of plant protection is therefore moving more and more towards finding methods to recognize relevant pests in real time. This can be done in several different ways, more or less automated. This may apply to connected sensors where data can be collected digitally or analogue and processed with or without AI. Here are several more or less smart traps and systems available on the market today.

Today the development of precision agriculture around pesticides strolls towards online traps; smart traps with AI and sensors connected to advisory systems. Below is a selection of the traps that exist and other developments regarding plant protection.

3.1.1 Trapview[11] - EFOs Company, Slovenia (Italy, Netherlands, Brazil, USA)

From apples in Poland, soybeans in Brazil, almonds in California, to lentils in Australia: Trapview solutions are present in more than 40 countries around the world. They are monitoring more than 50 insect species, bringing value to a large spectrum of agriculture and food-chain organisations.

Trapview's traps, which can self-clean, thus ensuring high catching efficiency and consequently high data quality, send images to the cloud at least daily. These images are processed and then analysed by machine learning to identify each of the insects pictured. To ensure accuracy, the team had trained the AI neural networks by introducing tens of thousands of images of positively identified insect species. As project coordinator Mr Matej Štefančič explains, "Even though our traps give us reliable data, interpretation is difficult, as is finding patterns for predictions. This is where machine learning comes into play, using historical data combined with data from multiple sources." Pest identification is denoted by a label around the targeted insect, with a corresponding 'trust' level percentage, indicating identification certainty. Users only see those above certain thresholds. The Trapview model then combines daily information extracted from the insect images, with local weather data, historical trends and forecasting, to predict pest dynamics. "This approach is highly efficient, with over 90 % identification accuracy, better on average than human. Additionally, forecasting accuracy was over 80 %, better than anything else on

[11] https://trapview.com/

the market," Štefančič says "Considering our model actually integrates the results of crop protection during the season, forecasting gives us a key competitive advantage."

3.1.2 SightTrap - USA

The SightTrap is an indoor system that works in industry. The SightTrap™ provides a daily image of captured insects attracted by pheromones. Since the launch of the SightTrap, the company worked closely with all parties involved to refine the device and software, ForesightIPM so it can become an optimal device to equip their partners with information that will free their time to provide a service that is centred around facility inspections and creating solutions rather than simply counting insects in traps to identify the simple and obvious fact that there is a problem[12].

3.1.3 FarmSense FlightSensor – USA. California

FarmSense uses sensors and machine learning to bug-proof crops. The FarmSense, a Riverside, California-based agtech startup attempting to solve the insect pest problem. The company creates optical sensors and novel classification systems based on machine learning algorithms to identify and track insects in real time. The key here: real-time information.

They claim real-time information provided by their sensors allows for early detection and thus the timely deployment of pest-management tools, such as insecticide or biocontrols. The current mechanical traps used for monitoring may only yield important results until 10 to 14 days after the bugs' arrival[13].

The FlightSensor uses light curtains and shadows within a small tunnel that the insects are drawn into by attractants. On one side of the sensor is a light source and on the other the optical sensor. The sensor measures how much light is occluded, or rather how much light that reaches the sensor, when an insect flies inside. That data is turned into audio and analysed by machine learning algorithms in the cloud. Currently the technique is being tested in almond orchards in Southern California.

3.1.4 Tarvos – Argentina

Monitoring of pests in real time, powered by solar panels and connected to satellite. Tarvos LD™ automatic traps monitor pests in the crop for round-the-clock operations, in addition to collecting local weather data from certified partners via API. It has its own solar energy system and satellite communications, which means that it does not need to be installed in an existing network.

The automatic pest monitoring system gives constant indications of the presence of pests in the crop. The accuracy provided by data collected directly from the field by electronic traps exponentially

[12] https://www.insectslimited.com/sighttrap
[13]https://techcrunch.com/2022/01/07/farmsense-agtech-machine-learning-crops/?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAALtHOkQZr96OWqKjKF9nm3fF2PyZzBtB-Pf4m-YfE7lhxPhKqD0QVe7Q-blmQ4sU-qJ1rp4OXQjy10zcJbbwQF7vYNEosgLxiaPnSuBaDEdqpQB_Tz1L34vC4q07CMaHAusHbvDqrOjzHv5jioH5GJXOMJC5-XoFp6kqvfs0veq3

increases the quality and feasibility of decision-making on the farm. The system sends alerts through WhatsApp.[14]

3.1.5 FaunaPhotonics, Danmark

FaunaPhotonics is positioned at the intersection of two global megatrends: Precision agriculture and biodiversity.

The company say they are building next generation real-time insect monitoring technology. By bringing a new technology to the market, they say they will fill gaps in knowledge of insect populations. “We are unmatched in product scale and breadth within automated optical sensing of flying insects in precision agriculture and beyond, uniquely positioned vs competition to providing missing data for optimizing/protecting crop yield and biodiversity while pursuing mobile solutions for autonomous monitoring and precision spraying. Our technology is continuously tested in the field by leading commercial companies within ag-chem, seed and food production as well as equipment manufacturers, and by globally renowned academic institutions and testing authorities. These tests provide us with the technical and scientific validation needed to develop our commercial business at scale. Our mission is to become the leader in delivering data enabling solutions for sustainable and smarter crop management and biodiversity monitoring, with additional opportunities in public health (vector control) and aquaculture.”

The Volito. Volito is a latin term meaning “to flutter” and is the name of FaunaPhotonics stationary sensor. The Volitos see all flying insects as data, and you can train Volitos to identify individual insects based on wing beat frequency, body size, and other features unique to each insect, according to the company.[15]

3.1.6 Wadhwani AI – Indien

Pest Management for Cotton Farming, the CottonAce solution guides smallholder cotton farmers on the optimal time to take preventive action and protect their farm against avoidable crop losses due to pests such as the Pink and American bollworm.

CottonAce is an AI-powered early warning system available through an app on Android smartphones. It helps farmers protect their crops by determining the right time to spray pesticides through immediate, localized advice.

The primary user of our solution is a cotton farmer who has installed pest traps and works closely with farmer welfare programs to manage pest infestations – referred to as a ‘Lead Farmer’.

Lead farmers or extension workers will install the CottonAce app and upload a photo of pests collected in commonly used pheromone traps to the CottonAce app. The AI algorithm identifies and counts the pests in the photo and determines the level of infestation, based on which a set of actionable advisory

[14] https://tarvos.ag/
[15] https://faunaphotonics.com/

is given to the farmer. This information is shared with neighbouring 'cascade' farmers, for whom no additional tools, including smartphone, are necessary.[16]

3.1.7 Plant Village Nuru – AI for pest & disease monitoring - Kenya

PlantVillage Nuru is an app that helps growers with plant protection problems. The app is trained on plant diseases and pests for crops in the southern hemisphere, such as cassava, corn, wheat, potatoes, and sweet potatoes. The initiative has also worked with different models to get good spread and use among growers.[17]

The project expects to radically transform pest and disease monitoring by using artificial intelligence (AI), advanced sensor technology and crowdsourcing capable of connecting the global agricultural community to help smallholder farmers. It aims to increase the effectiveness of farm-level advice by leveraging three critical advances:

The development of massive communication and money exchange platforms such as M-Pesa that allow rural extension to scale as a viable economic model enabling last mile delivery in local languages

Besides the solutions presented above there are a number of other companies all over the world that present similar techniques. However, it has not been possible to get enough information about these regarding crops, techniques used and how close to commercialisation they are.

3.1.8 Benchmarking analysis of technologies for insect recognition

Table 2 shows that in comparison with the aforementioned technologies PestNu's AI Robotic trap, developed by Agrorobotica, supported by CERTH, consists of a complete solution for insect recognition and early infection stage alerting, thanks to its accuracy. The accuracy of Pestnu's Robotic trap is promoted by robust AI models for insect recognition trained by big volume data sets, collected from different lighting conditions and backgrounds. The device's autonomy is based on the low energy consumption of all electronic parts as well as the battery's capacity. The durability of PestNu's trap is established thanks to selected materials, the design and the manufacturing process ensuring resistance to all weather conditions.

[16] https://www.wadhwaniai.org/programs/pest-management/pest-management-ai-solution/
[17] https://bigdata.cgiar.org/inspire/inspire-challenge-2017/pest-and-disease-monitoring-by-using-artificial-intelligence/

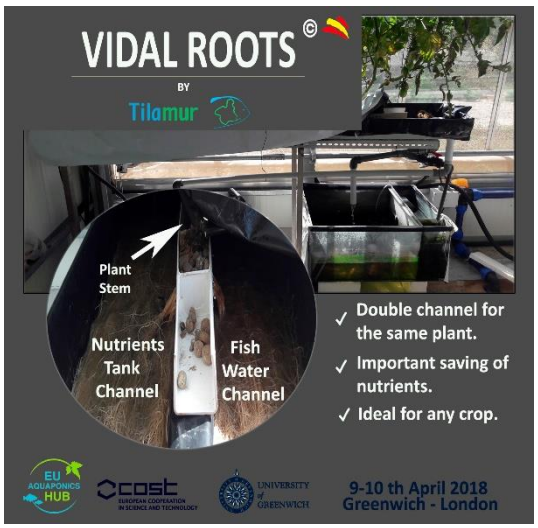
Table 2. Comparisons of technologies for insect recognition

	Trapview	SightTrap	FarmSense FlightSensor	Tarvos	FaunaPhotonics	Wadhwani AI	Plant Village Nuru	Pestnu's AI Robotic trap
Accuracy	-	-	-	-	✓	-	-	✓
Autonomy	✓	-	-	✓	✓	✗	-	✓
Durability	-	-	✓	-	✓	✗	-	✓
Suitable for vegetable cultivation	✓	✗	✓	✓	✓	✓	NA	✓
Complete device	✓	✓	✓	✓	✓	✗	✗	✓
Cost effective	NA	NA	NA	NA	NA	NA	NA	✓
Available on the market	✗	✗	✗	✗	✗	✗	✗	✗

According to MarketsandMarkets[18], the global insect pest control market size is estimated to be valued at USD 12.3 billion in 2021 and projected to reach USD 15.8 billion by 2026, recording a CAGR of 5.1% during the period 2021-2026. Based on the market forecasts it can be foreseen that PestNu's AI Robotic trap will easily be adopted from the market, considering also the fact that there isn't any other similar technology commercialized, since all the technologies mentioned above are under development.

3.2 Aquaponics

Aquaponics, the symbiotic growing of fish and vegetables in recirculating water systems – is emerging as one of the most important areas of sustainable agriculture, as it helps reduce the environmental impact of intensive and monoculture farming. The working principle of aquaponics is to provide nutrient-rich aquaculture water to a hydroponic plant culture unit, which in turn depurates the water returned to the aquaculture tanks. In particular, the nitrogen cycle is the biological process involved in aquaponics. Fish release ammonia through their metabolism which is oxidized through nitrification to nitrate ions. Nitrate ions are absorbed by the roots of plants and thus, water free of ammonia, nitrite and phosphate ions is recirculated to the fish tanks to continue the cycle.



The combined hydroponic and aquaculture system reduces water consumption by up to 90% and Nitrogen use by 40% compared to traditional agriculture Water Usage Effectiveness (WUE). Over the last few years, companies such as TILAMUR have developed new and more effective methods (Vidal Roots (R)) capable of creating totally suitable growth conditions for plants without affecting animal welfare. This type of system called decoupled takes advantage of the total residual water coming from the filtering systems located in the fish area, to be channelled and isolated from the rest of the necessary nutrients through a double channel system to be returned to the fish tanks. In this way, the plants are nourished and watered with the optimum nutrient solution for their growth. In this way, any harmful nutrient contamination option for the fish is eliminated.

[18] https://www.marketsandmarkets.com/Market-Reports/insect-pest-control-market-26785207.html

The global aquaponics market is growing rapidly and has done so in recent years, according to a report by Meticulous Research, growth is expected to increase by a CAGR of 12.8% from 2019 to reach $1,375.6 million by 2025 from $668.5 million in 2019[19]. Between the years 2000-2010, several companies have been established on the market, with different services, from vegetable production, sales of equipment for aquaponics to training and courses of the method of cultivation. Worldwide the report from Meticulous Research mentions several companies from US that are engaged in development and manufacturing of aquaponic systems, including *Pentair Aquatic Eco-System, Inc.*[20], *Nelson and Pade, Inc.*[21], *Green Life Aquaponics*[22], but also from *Japan, Japan Aquaponics*[23] *and from Australia, Practical Aquaponics*[24].

Aquaponics can be seen as sustainable on several points, including:

The low water consumption compared to traditional cultivation

The low nutrient consumption compared to traditional cultivation

The ability to produce food near the customer

Daily produce of fresh vegetables and fish

Production is kept in a circular, controlled, and closed system with low or no use of plant protection products

Recirculation of nutrition between fish and vegetables

3.3 Agroradar

Agroradar algorithms power the next generation of European Space Agency (ESA) EO missions (Sentinel-1, radar sensor, and Sentinel- 2, optical sensor), making use of big data in proprietary machine learning algorithms and data models, to provide tailor-made decision support reports to farmers and other stakeholders. AgroInsider is enhancing its algorithms processing EO Data by integrating 3rd-party data and validate its platform with pilots in different geographies.

The Agromap is a powerful software tool as it can: i) detect a soil-water-plant anomalies in agriculture plots; ii) divide plots or different geographic units in different management zones; iii) produce and develop smart sampling strategies; iv) forecast yields considering benchmark curves for each crop type; v) forecast biomass/carbon considering benchmark curves for each soil occupation; vi) calculate the spatial structure of any region being observed and with this calculate different spectral bio-diversity indexes; vii) detect changes in land occupation; viii) record events in the field, e.g. related to pests.

The reference curves of each crop are obtained from real customers plots and represent the greatest productive potential, validated in the field, with the lowest associated risk. With these benchmark curves AgroInsider and its technology, firstly detect the deviations of the reference curve for the plot real curve and secondly alert the producer about the problems that may be happening in it. The goal is that

[19] https://meticulousblog.org/top-10-companies-in-aquaponics-market/
[20] https://pentairaes.com/
[21] https://aquaponics.com/
[22] https://www.greenlifeaquaponics.com/
[23] https://japan-aquaponics.com/
[24] https://www.aquaponics.net.au/

AgroInsider technology allows each client to “Benchmark” their parcels with each other in space and time or compare them with reference parcels in the region or with the best reference parcel in the entire AgroInsider database. This type of benchmarking system allows producers to question themselves about the type of production system they use, as well as studying the Return on Investment (RoI) controlling factors and constantly improve, increasing their economic return and decreasing the risk associated with the activity. AgroRadar supports the farmer in managing their parcels/crops in a sustainable way, by simplifying metrics and data collection processes, identifying opportunities for improvement, and creating accountability. It allows to transform data into decisions per parcel/crop.

3.3.1 Food sustainability index

There are several different indexes available worldwide and below are some of the ones found in a survey. The first one has been developed by Dataväxt in Sweden[25] The idea behind this product is to estimate all climate affecting activities and to put them in relation to the grain yield. The data can be collected from the crop management program, that is also run by Dataväxt, and if a customer want to run the climate calculation, data can be collected as soon as this is approved by the customer. Among the data collected is crop type, yield, amount and type of fertilizers, type of energy used for drying and fuel used in agricultural machinery. It is also possible to add data on fuel consumption a cultivation practices that can be logged with the additional product, LOG Master. The product has partly been developed within the EU-project Smart Agri Hubs[26] and more specifically in the Flagship Innovation Experiment Valued Grain Chain[27]. In the Valued Grain Chain, a bookkeeping system has been developed, where grain lots were followed all the way from the field and to a potential customer in an electronic grain marketplace.

ARLA has developed a similar system for dairy farmers[28]. The inputs here are data from a questionnaire to the farmers. For instance data on land use (grassland is sequestering CO_2), applications of fertilizers and type energy used are collected. The data is then handled by scientist to end up in a carbon footprint at the farm-level.

Globally, FoodNavigator[29] spreads information on how food carbon footprint can be reduced, among others in an upcoming event “Climate Smart Food Digital Summit”.

In PestNu project, AgroInsider supported by CERTH is creating a Food Sustainable index (FSi) based on recorded evidence from the production system related to nutrients and pesticides with the application developed and protected by blockchain which will be shared in the value chain.

3.3.2 Diagnose anomalies such as diseases

Much of the work in this area is still in research phase, however, some companies have also launched products where these tasks can be performed. There are examples of the use of both drones and satellite data to detect anomalies. When using drones, the obvious advantage is the possibility of collecting data at exactly the correct date/development stage of the crop and as many times as a farmer

[25] https://datavaxt.com/sv/produkter/klimatkalkyl/

[26] https://www.smartagrihubs.eu/

[27] https://valuedgrainchain.eu/

[28]https://www.arla.com/sustainability/sustainable-dairy-farming/how-we-measure-dairy-farmings-carbon-footprint/#what-parameters-does-the-arla-climate-check-include-in-its-calculations

[29] https://www.foodnavigator.com/

wants/can, while it demands so far that the operator is physically present and the difficulty associated with the images processing. While the user receives a high spatial resolution, the number of spectral bands are normally lower (e.g., visible bands – Red, Green and/or Blue - and Near InfraRed band) than that available when using satellite data. Satellite data on the other hand, often have a larger number of spectral bands i.e., up to about 13 in the case of the Sentinel-2 (S2).

S2 is an optical remote sensor (RS) which aims monitoring variability in land surface conditions, and its wide swath width (290 km) and high revisit time (10 days at the equator with one satellite, and 5 days with 2 satellites under cloud-free conditions which results in 2-3 days at mid-latitudes) help monitor the earth's surface changes. As a passive sensor, S2 needs a light source (e.g., sunlight), and the quality of the images is dependent on the weather and daylight. It carries an optical instrument payload that samples 13 spectral bands: four bands at 10 m, six bands at 20 m and three bands at 60 m spatial resolution.

These sensors record a variety of electromagnetic spectrum radiation frequency, especially at wavelengths of visible light and infra-red. Optical RS record the reflectance of the electromagnetic spectrum of earth objects in the visible (blue, green, and red) and infrared regions (near infrared – NIR and short wave infrared – SWIR). Visible and NIR (VNIR), and SWIR are the wavelengths more sensitive to vegetation characteristics. These spectral bands reflect the vegetation structure, texture, and shadow, related with leaf cellular structure and plant pigments, which are correlated with biomass[30]. The red region occurs due to absorption by chlorophyll, while in the NIR region, there is a pronounced reflection by mesophyll cells[31].

Based on NIR, Red and SWIR bands, vegetation index is calculated based on the ratio between two or more bands to contrast the high absorption by leaf pigments (chlorophylls, carotenoids, and xanthophylls) in the visible spectral region (400–700 nm), high reflectance by leaves in the NIR region (700–1300 nm), and moderate water absorption in the SWIR (1300–2100 nm) (Ustin et al., 2004). Two common vegetation indexes used in biomass estimation are the Normalised Difference Vegetation Index (NDVI) and the Normalised Difference Water Index (NDWI). NDVI is the fraction of the difference and the sum of the NIR and red bands where chlorophyll absorbs red whereas the mesophyll leaf structure scatters NIR[32]. It varies between 1 and -1, where 1 corresponds to high photosynthetic activity and -1 to the absence of vegetation. NDWI is related to NIR and SWIR bands and quantifies the canopy moisture content through vegetation water indices[33]. It varies between 1 and -1, with 1 corresponding to a high amount of water in the leaves (no water stress) and -1 no water in the leaves (high water stress).

Sentinel-1 (S1)1 is a Synthetic Aperture Radar (SAR) sensor with two polar-orbiting satellites, operating day and night performing C-band synthetic aperture radar imaging, enabling them to acquire imagery regardless of the weather, offering reliable, repeated wide area monitoring. SAR imagery provides much more information than just an image to be visually analysed because of being characterised by two data values for each pixel, a magnitude value (image analogous to one collected by an optical sensor) and

[30] Baccini, A., Laporte, N., Goetz, S. J., Sun, M., & Dong, H. (2008). A first map of tropical Africa's above-ground biomass derived from satellite imagery. Environmental Research Letters, 3(4), 045011. https://doi.org/10.1088/1748-9326/3/4/045011

[31] Chao, Z., Liu, N., Zhang, P., Ying, T., & Song, K. (2019). Estimation methods developing with remote sensing information for energy crop biomass: A comparative review. Biomass and Bioenergy, 122, 414-425. https://doi.org/10.1016/J.BIOMBIOE.2019.02.002

[32] Myneni RB, Hall FG, Sellers PJ, et al. The interpretation of spectral vegetation indexes. IEEE Transactions on Geoscience and Remote Sensing. 1995;33:481-486

[33] Gao B-C. NDWI—A normalized difference water index for remote sensing of vegetation liquid water from space. Remote Sensing of Environment. 1996;58:257-266

a phase value (it cannot be visually interpreted). As an active sensor, S1 has the advantage of providing its light source and enabling it to operate 24 hours a day. Interpretation of SAR sensor imagery data is not always straightforward because of the signal being responsive to surface characteristics, like structure and moisture, and consequently to have the non-intuitive and side-looking geometry. Sentinel-1 have been used to estimate forest biomass and crop anomalies to complement the spectral reflectance characteristics of vegetation in the optical regions and are very useful in regions often covered by clouds (Sinha et al., 2015). This sensor is sensitive to water content in vegetation and registers information independently of the weather conditions (Kasischke et al., 1997) through the interaction of the radar waves with tree scattering elements (Le Toanet al., 2011).

Integration of multi-source RS data, that is, optical, SAR or/and LiDAR and/or drone data, is important to improve crop anomalies detection because more information about vegetation structure features is integrated than just by a sensor. In PestNu, Copernicus data/services existing Earth Observation based AgroRadar system are being used to precisely map agricultural anomalies, as soil/plant nutrients (e.g. fertilizers) and plant inputs (e.g. pesticides), through smart sampling & differentiated management of its Copernicus programme data/services.

The sentinel satellites, which are run by ESA have also the advantage that the data can be used free of charge all over the world.

An example of the use of drone data to detect anomalies is the Swedish company Solvi[34]. In Solvi`s application, it is possible to use different indices to get an overview of within-field differences in plant health (NDVI (Normalized Difference Vegetation Index), NDRE (Normalized Difference Red Edge), or VARI (Visual Atmospherically Resistant Index).

An example of the use of Sentinel 2- satellite data for the same purpose is published by Datadragon, (a cooperation between different research institutes in Europe with the aim of developing Precision farming tools)[35]. The vegetation indices used in one Datadragon study are NDVI, WDRVI (Wide Dynamic Range Vegetation Index), EVI (Enhanced Vegetation Index), MSR (Modified Simple Ratio), and GARI (Green Atmospherically Resistant Vegetation Index). Unsupervised segmentation of Sentinel-2 satellite images were performed using machine learning and computer vision algorithms based on index images in order to map stress-affected regions of agricultural land that could lead to reduced yields. Further work on the topic should rely on the proposed segmentation method to develop a system for classifying different types of anomalies that are of interest for a particular crop type.

There are numerous examples of other scientific reports in this area, a recent example is the use of Sentinel- and Planet Labs (a commercial satellite) data to detect anomalies in irrigated rice[36] The authors conclude that for instance by using a NDVI index it was possible to detect parts of the fields with shortage of water supply and sub-optimal plant density. Both satellites were equally good at detecting the anomalies.

Of particular importance in warmer climate is the detection of water stress, which Ihuoma and Madramootoo (2017) have reviewed[37]. Water stressed plants have reduced transpiration and higher leaf temperature compared to non-stressed crops[38]. Researchers used variability of canopy temperature to indicate water stress and emphasised the need to quantify the complex relationship between canopy

[34] https://solvi.ag/
[35] https://datadragon.eu/
[36] https://www.sciencedirect.com/science/article/pii/S0303243421002427?via%3Dihub
[37] https://www.sciencedirect.com/science/article/abs/pii/S0168169916310766?via%3Dihub
[38] https://link.springer.com/article/10.1007/s00271-005-0022-8

temperature, water stress, and spatial water availability[39]. Revealed that canopy temperature-based algorithms are strongly correlated to crop outputs such as yield, water use efficiency, irrigation rates, seasonal evapotranspiration, and midday leaf water potential. Transpiration cools the leaf surface and as root zone soil moisture is depleted, stomatal conductance and transpiration decrease and leaf temperature increases. Many indices have been established for evaluating water stress using infrared canopy temperature. One of the most common vegetation water indexes to evaluate the canopy moisture content and leaf water stress is the NDWI which is related with NIR and SWIR bands*. This is one of the indexes used in AgroRadar to detect crop anomalies.

An example of researchers using NDVi-type indices to detect water stress is Van Beek et al., who found that ReNDVI was a good indicator of water stress in pear plantations in Belgium[40].

Besides NDVI-type indices, the socalled Photochemical Reflectance Index, (PRI, (R570-R531)(R570+R531), has also been proposed[41].Ihuoma and Madramootoo concludes that although many studies on plant water stress report relatively significant relationships (with R^2 values of 0.5 or less) between a remotely sensed parameter such as NDVI or PRI and a measure such as leaf area index, stomatal conductance, and leaf water potential, this sort of precision is inadequate to allow the use of single measurements of the parameters (e.g., NDVI or PRI) for estimation of plant water status. They claim that data management techniques that would integrate data from soil-based and plant-based approaches are needed to widen the scientific knowledge on the use of crop stress parameters to schedule irrigation and provide irrigators with advanced tools for decision making. Furthermore, since water stress detections are crop and climate specific, it is imperative to investigate the spectral vegetation indices needed to improve the productivity and yields of vegetable crops.

They also conclude that the potential is enormous based on recent advances in sensor technologies, image analysis and processing, computer-based decision making, and in the measurement of hyperspectral indices from Unmanned Aircraft Systems.

One company that are one its way to launch products were satellite data is used to predict water stress is ConstellR[42]. They use data from the newly launched Sentinel 3 satellite and more specifically a thermal imaging camera on board the satellite and together with an algorithm that compensate for interfering heat from other sources besides the leaf surface itself. They claim that this is a much faster technique than to use for instance the NDVI-indices that detect water stress when the damage is already done.

There are also companies that provide satellite data to optimize distribution of N-fertilizers. An example is Dataväxt and the product CropSAT[43].

To overcome the S2 limitations, AgroInsider identified that the satellite optical data, currently being used by the best precision agriculture (PA) companies around the world, is not enough to obtain the best results. From a technological point of view, Agroinsider uses the SAR that others do not use with the advantages of studying soil quality and vegetation structure. In addition, AgroInsider uses benchmark algorithms based on "big data" analysis and agronomic knowledge. Thus, in the last 6 years, AgroInsider has developed proprietary AgroRadar algorithms that process Copernicus EO Synthetic Aperture Radar

[39] https://digitalcommons.unl.edu/usdaarsfacpub/1147/
[40] https://pubmed.ncbi.nlm.nih.gov/22558768/
[41] https://www.sciencedirect.com/science/article/abs/pii/S0168169916310766?casa_token=kHT1x5m37_oAAAAA:WM2mt8IVn7-E_XxUMMH2naLtaWc187lv2h9EiND8hlL0aPNn6wXoGaPnTpew1DvjlmxsVUl8yUw#b0175
[42] https://constellr.space/
[4343] https://cropsat.com/

(SAR) data (Sentinel-1; S1), which has the advantage, when compared to other remote sensing technologies, of also working in bad weather conditions. AgroInsider made use of EO Data to develop AgroRadar which integrates, aggregates and analyses collected big data provided by Copernicus (S1 and S2), meteorological 2nd generation satellites (Land Surface Temperature - LST) and 3rd party data integration for the development of reference curves for each crop for different regions or/and geographies to develop value-added information for its various customers. In agriculture, the validity of decision-making usually has a life expectancy of around 5 to 7 days, adjusting perfectly to the temporal resolution of S1 and S2 of the Copernicus Program. In this way, AgroRadar supports the farmer in managing their crop in a sustainable way, by simplifying metrics and data collection processes, identifying opportunities for improvement, and creating accountability. It transforms data into decisions per plot. On the AgroRadar, the farmer can find their plot data, comparing them to reference plot curves (from the producer, from the region, from all AgroInsider database) with the plots requiring attention positioned at the top of the list.

The main goal of AgroInsider is the creation of new services for customers, while creating the basis to ensure its product's market debut, with a clear and scalable commercialisation strategy. From the product's capabilities, it presents alerts of anomalies associated with soil-water-plant relationships, as well as equipment malfunctions. In addition, it allows the recording of important evidence for any type of certification at the food production and/or environmental level. This technology is affordable, from a value of €250/year for autonomous uses to a price of €5,000/year for uses supported by Agroinsider technicians, offering a turnkey service (support in smart sampling, definition of and fertilization plans, calculation of CO2, water and NPK footprints). AgroInsider can define the Economic Injury Level of fungicide and bactericide to be applied. The AgroRadar runs in any browser and using a smartphone user in the field can access: a) the satellite indexes values; b) different clusters; and c) the suggested sampling points. The user can register coordinates where field samples (soil, plants, fruits, water) were taken and at the same time georeferenced photos and voice comments about any phenomenon can be saved in the database.

Over the past years, the customer may find: a) All the plot to plot deviations (solving the agronomic problem); b) The respective economic impacts expected if nothing is done to correct the identified deviations (the economic problem). These advantages give AgroInsider the ability to i) obtain more precise and detailed agronomic information in cloudy geographies where normally agriculture and biomass production (forest) has a great importance and ii) step forward in PA services, making use of valuable data, namely going beyond optical imagery and demonstrating the cutting-edge added value of SAR. AgroRadar has pilot-demonstrated (TRL6) through the project AgroRadar (ALT20-03-FEDER 2019-2020) pilot -demonstration and AGRORADAR funded by ESA in different geographies around the world, 2 in Central America (El Salvador, Nicaragua), 1 in South America (Brazil), 1 in Africa (Mozambique), and 3 in EU (Portugal, Spain), to collect valuable insights on how the product should be developed (characteristics, functionalities, outputs, features, etc.) with the main focus of offering the highest value for customers, independent of their geography, culture, crop and production cycle. AgroINS users experienced a 15-30% production increase.

To achieve further success, AgroInsider will develop a business model based on the AgroRadar associated with: i) a business-to-consumer (B2C; farmers) and business-to-business (B2B; farmers cooperatives) relationship in a perspective of operational management of agronomic activity; and ii) a B2B (industry and distribution) and B2C (final consumer) relationship in a perspective of valuing the evidence associated with sustainable products, by valorizing the big data collected, registered and locked during production. The upgraded AgroRadar will contribute to a balanced territorial development

of the EU rural areas and their communities by making PA services affordable to medium and small farms.

3.4 Autonomous robots

Development around autonomous robots is at a stage where the technology is tested in several different areas in agriculture. There are now robots that are tested for mechanical and chemical weeding, spreading fertilizer, pesticides, and water, and harvesting – both robots that pick crops and those that are load carriers.

Just like the areas of application, the working methods of today's robots also differ greatly. There are small robots working in rows between crops, large robots working across multiple rows, robots working in greenhouses, load carriers with several areas of use and drones operating in the air. The robots use different techniques for their work, several of them also collect data, both to perform the task and as part of improving the production of the crop.

For this new technology, laws and regulations can become a barrier to entry into the market, such as the question of liability when spreading plant protection products and how and when drones are allowed to fly in the airspace.

The Global Robotics market is moderately competitive, with a considerable number of regional and global players and moderately fragmented. The market vendors are focusing on expanding their customer base across foreign countries. The companies are leveraging strategic collaborative initiatives to increase market share and profitability.

3.4.1 Key Robot Manufacturers

1. *Fanuc Corporation*[44], (JAPAN) 2021: Sales: 4 bil Euro, EBITDA margin: 28.6%, ROE: 6,8%, Empl: 8.256
2. *Kuka AG*[45] (GERMANY) 2021: Sales: 3,6 bil Euro, EBITDA margin: 5,8%, EPS/Sales: 6,6%, Empl: 14.310
3. *Yaskawa Electric Corporation*[46] , (JAPAN) 2021: Sales: 3,4 bil Euro, EBITDA margin: 11% ROE: 14,3%, Empl: 14.890
4. *ABB Ltd*[47] (SWEDEN) 2021: Sales: 28.9 bil Euro, EBITDA margin: 9.7% ROE: 32.95%, Empl: 105.000
5. *Denso Corporation*[48], (JAPAN) 2021: Sales: 45 bil Euro, EBITDA margin: 7.2% ROE: 6,48%, Empl: 167.950
6. *Universal Robots*[49], (DENMARK) 2021: Sales: 298 mil Euro, EBITDA margin: -% ROE: -%, Empl: 800+

[44] https://www.fanuc.co.jp/#
[45] https://www.kuka.com/
[46] https://www.yaskawa-global.com/
[47] https://global.abb/group/en
[48] https://www.denso.com/global/en/
[4949] https://www.universal-robots.com/

3.4.2 Strategic Coop Developments

The sector is moving towards strategic cooperations to position in the rapidly evolving market scene. Two examples are:

- February 2021 - Wipro Limited and Yaskawa India Pvt. Ltd., a subsidiary of Yaskawa Electric Corporation, announced the alliance by exchanging the signed Memorandum of Understanding (MOU) on co-operation commitment to target global automation projects jointly. The partnership enables the company to deliver supplies of Yaskawa robots in India and abroad (including an international warranty).
- January 2021 - OMRON Corporation announced that it has started selling the i4 series SCARA robot, which automates high-speed, high-precision assembly and transportation while being simple to install.

3.4.2.1 Strategic statement

Robotics is a diverse sector with many moving parts, and what its future will look like is a complex question. To offer an insight we again looked to well-known and established international consultants. So, BCG[50] did a deep dive into the robotics industry and the potential for old and new players to grow over the next decade. BCG's very concise conclusion: robotics has significant upside potential. But a more-nuanced analysis is that to succeed, established companies manufacturing machinery and industrial automation hardware and software must be both dexterous and aggressive, prepared to take advantage of new strategic and technological directions that will likely become more important as 2030 approaches but may not be their traditional strengths. Meanwhile, smaller rivals and startups will be pushing innovation in areas that have the potential to generate high profits and alter the dimensions of the robotics industry. But the speed with which they will be able to transform the trajectory of the field is still a wildcard.

3.4.2.2 Strategic Advantage

Scaling artificial intelligence can create a massive competitive advantage, but it's not enough to invest in cutting-edge technologies and algorithms. You need to rewire decision making and operations to extract value—and invest in human capabilities to make it stick. BCG refers to this as AI at scale.

According to BCG[51], *"…the pioneers of AI at scale —the companies that have scaled AI across the business and achieved meaningful value from their investments—typically dedicate 10% of their AI investment to algorithms, 20% to technologies, and 70% to embedding AI into business processes and agile ways of working. In other words, these organizations invest twice as much in people and processes as they do in technologies".* Taking into account robotic technologies complexity and scarcity of specialized scientific staff as well as PestNu's overall approach to the Farm2Fork objectives, the above statement becomes more prevalent

[50]https://www.bcg.com/publications/2021/how-intelligence-and-mobility-will-shape-the-future-of-the-robotics-industry
[51] https://www.bcg.com/capabilities/digital-technology-data/artificial-intelligence

3.4.3 Modular Robot Platforms

The trend in the market of Professional Service Robots are multi-platforms that can serve many jobs in structured as well as un-structured environments.

The following examples of the two most dynamic robotics companies in the global market prove the assumption.

- Ready to use Robots to develop Robotic Applications (*Universal Robotics*[52])

Universal Robots message is “Automate faster with certified UR+ application kits and components”. The UR+ ecosystem provide access to more than 400 certified kits, components, grippers, software, and safety accessories that seamlessly integrate with Universal Robotics..

- Modular Construction (*SagaRobotics-Thorvald platform*[53])

Thorvald is several different robots rolled into one, all built using the same basic modules, and rebuilt using only basic hand tools. The modules are designed to enable high quality robots that can quickly be customised for a given application in a given environment, such as a greenhouse, tunnel, open field and vineyard.

Further we present spotted the following three representative business opportunity groups for which we provide some additional insights and exemplary cases.

3.4.3.1 Niche Markets & Focused Apps

Focusing on high-value crops like premium wine vineyards Thorvald tackles Powdery Mildew in vineyards with a custom robotic solution. It protects valuable vines through the application of UV-C light, each and every night. Efficient, autonomous, sustainable and cost-effective, the robotic solution is a reliable partner for every viticulturist trying to match the best of traditional practices with the best of what technology can provide. *Thorvald robotic platform*[54] can operate in closed as well as open-field environments.

3.4.3.2 Precision Agriculture Integrators

Provide services to Farm Management software vendors (integration partners include *ProbeSchedule*[55], *Ranch Systems*[56] and *WiseConn®*[57], Deere, AquaSpy[58], Sentek[59], Climate Field View[60]) providing services like:

[52] https://www.universal-robots.com/plus/products/?
[53] https://sagarobotics.com/thorvald-platform/
[54] https://sagarobotics.com/thorvald-platform/
[5555] https://site.probeschedule.com/
[56] https://www.google.com/search?q=ranch+systems&rlz=1C5CHFA_enUS857US857&oq=ranch+systems&aqs=chrome.0.69i59j0i433i512j46i199i433i465i512j0i433i512j46i433i512j0i433i512j69i61j69i60.1383j0j4&sourceid=chrome&ie=UTF-8
[57] https://www.wiseconn.com/
[58] https://aquaspy.com/
[59] https://sentektechnologies.com/
[60] https://climate.com/

Targeted Sampling: Accurate yield estimation is becoming simpler and more efficient with sampling recommendations. Targeted sampling tools use inspection data to identify the best locations for sampling and the most streamlined approach to collecting measurements—saving time and preventing costly errors.

Adopt Variable Rate Application Zones: As the costs of key inputs rise, many growers are adopting Variable Rate Application (VRA) strategies to minimize expenses without compromising yields.

Precision Spraying: Precision spraying, defined as the targeted spraying, obtains the target information (e.g., size, shape, structure, and canopy density, etc.) of the plant and then apply pesticides as needed.

3.4.3.3 Conclusions

It is obvious that competition is building up with many new players providing innovative solutions with the use of robotics technologies.

The above findings show clear signs and point towards a multi-robot which would undertake and precisely perform many other works in the greenhouse and out on the open field, supporting completely the approach of PestNu.

Additionally, newcomers are looking into financially viable application therefore are focusing on high value crops like vine growing, cannabis but also organic farming.

3.5 UVC nutrient analysers

Over the last decades, *in situ* nutrient sensors have been developed gradually. Manufacturers and research institutions have developed more compact devices that are simpler to operate, with lower power and reagent consumption and requiring less maintenance. Various detection technologies have been employed including spectrophotometry, fluorometry and electrochemistry.

There is a variety of products on the market with different detection technologies, portability and so on and subsequently also various price levels. Available analysers come from brands like In-Situ, ChemScan and Wiz probe. Important features for nutrient analysers are portability which enables the user to utilise the analyser in various locations, no need for recalibration which saves time, high data accuracy so the results are fully reliable and real time data accessible.

Regarding the regulatory framework there does not seem to be any legislation which applies directly to the nutrient analysers as such, it is rather certifications on analytical accuracy and reliability which is important for this type of products. On the other hand, the levels of nutrients in the water are well regulated, for example through nitrates Directive so the analysers are indirectly affected by this legislation.

A benchmarking analysis was carried out to provide a good understanding of the competitors within the marketplace and how the Tellab analyser developed during the project is positioned. Tellab Nitrate and Nitrite Analyser offers unique advantages from all other products in both simultaneous detection of nitrate and nitrite and use in a broad range of water sample matrices (Table 3). Additionally, the Analyser has other advantages and is well positioned against competitors in cost, use of non-toxic chemicals, low power requirement, high accuracy and precision, long deployment on site, maintenance interval, in situ monitoring and no additional analyser accessories needed. The scope within PestNu is to develop the

Tellab Analyser further, which has taken place within the first 12 months of the project, and to redesign and develop the analyser to enable a low-cost version (€5,000) while maintaining the same competitive advantages and incorporating the detection of phosphate and ammonium based on the same technology and providing the same key features. This development work is currently on schedule as per the project plan.

Table 3 Benchmarking analysis of Tellab nitrate and nitrite analyser and additional developments taking place through the PestNu project

Feature	OTT ecoN	Wiz Probe (NO_3+NO_2) (Systea)	Suna V2 UV Nitrate Sensor (Seabird)	Nitratax (NO_2–N NO_3-N) (Hach)	Ammo::lyser (NH_4-N NO_3-N) (MestenchnikGmbh)	Nico Optical Sensor (NO^3) (Trios)	TelLab Nitrite and Nitrate Analyser
Can detect nitrite and nitrate simultaneously	✗	✓	✗	✗	✗	✗	✓
Low cost	€20,000	€30,000	~ €30,000	€20,000	€25,000	€6000 for sensor only	Launch price: €20,000
Uses non-toxic chemicals for analysis	✓	✗	✓	✓	✗	✓	✓
Can be used for direct monitoring of waste water and effluents	✗	✗	✗	✗	✗	✗	✓
Low power	✗	✓	✗	✗	✗	✗	✓
Accuracy	+/- 5 %	<+/-10%	10-30%	+/-5%	+/-3%	± 5 %	+/- 5%
Precision	Not specified	<+/-10%	Drift occurs per hour of lamp time	+/-5%	+/-3%	Not specified	+/-5%
Long Deployment length on site	Up to one year	< 3 months	Not specified	Online	Online and in situ	Not specified	3 -6 months
Maintenance interval	Annual	<10 weeks	Not specified	1-2 hrs / month	6 months	Daily	3 -6 monthly intervals
In situ monitoring	✓	✓	✓	✓	✗ (Requires prefiltration systtem)	✓	✓
No additional analyser accessories need to be purchased for analysis	✗	✗	✗	✗	✗	✗	✓

PestNu Analyser
- Development of low-cost version (€5,000)
- Same competitive advantages
- Incorporation of phosphate and ammonium detection based upon the same technology

Based on the Benchmarking analysis of Tellab's portable analyser, compared to other competitive products, PestNu's instrument appears to be effective, efficient and accurate, providing an attractive low cost solution.

3.6 Flow cytometer for real-time algae and bacteria monitoring

Flow cytometry has, so far, a very limited use for detection of bacteria or micro algae/cyanobacteria outside the laboratory. There are few commercial instruments designed for automatic sampling and analyses that can be applied for measurements in the field. Starting with bacterial detection, the instruments presently on the market are only designed for counting total number of bacteria and to determine if they are dead or alive. Here can be mentioned BactSense from bNovate technologies *BactoSense | Online Monitoring | bNovate Technologies* and Metanor from Metanor AG. These instruments are in a price range starting at Euro 11,000 (on the Indian market) for the Metanor instrument. Today there is not any flow cytometer system on the market that can 1) work autonomously; 2) take out a samples, 3) detect specific bacteria (e.g., *E. coli*) and differentiate them from the myriad of other bacteria present in environmental water, and 4) communicate the result for central processing.

The flow cytometer from RISE has been developed to fulfil these four demands, before PestNu it was applied for detection of *E. coli* in drinking water, now it will be adapted for new bacterial targets for agricultural needs. Thus, we see a market niche for an affordable instrument that autonomously sample water to detect specific bacteria and communicate results from a remote location.

Detection, quantification, and characterization of microalgae is of interest for industrial/agricultural production of microalgae. Here, the main interest is to follow growth rate of algae and possible also the morphology of the individual organisms to optimize the culture conditions and thereby also the production yield. The basic analysis is to measure bulk absorbance at certain wavelength where chlorophyll absorb light. Systems with more advanced data analyses also measure chlorophyll concentration, algae class, and estimates photosynthetic activity, such as *bbe-moldaenke's AlgaeLabAnalyser*[61].

Even more advanced systems are based on imaging, such as *DeNovix CellDrop automatic cell counter*[62]. However, this instrument requires manual sampling and insertion into the instrument. Another example is the Amnis ImageStreamxMKII, an imaging flow cytometer that can provide detailed information. However, these examples are expensive instruments only for laboratory use.

Some sensor systems are intended for field use, such as McLane Imaging flowcytobot that is developed for underwater use, this is an advanced and very expensive instrument.

In summary, the available instruments on the market for analyses of microalgae are either relatively limited, such as measurement of absorbance, or more sophisticated and either laboratory instruments, or instruments for scientific research in the field. Common for all more advanced instruments is the high cost, and thus not suitable for use in agriculture or marine applications

RISE's flow cytometer is based on capturing and analyses of video images, this makes it possible to combine counting of microalgae with basic image analyses and thus fill a niche with an instrument "in the middle" that can give more information than the simple instruments but still with a cost-efficient pricing.

3.7 Automated circular system for agro-wastewater treatment for production of bioalgae biomass / aquaponics

Microalgae can treat aqueous residues by using solar energy and CO_2, transforming pollutants of concern into added-value compounds. Thus, microalgae join the sanitation sector as a promising tool for including several types of residues into the circular economy paradigm. According to the current wastewater treatment processes, microalgae enter into the secondary and tertiary phase, focused on the biodegradation of organic substances and removal of pathogen agents. As a consequence, microalgae are a promising alternative to improve the sustainability of traditional wastewater treatments.

Microalgae have biostimulant potential to stimulate plant development and growth. Moreover, several microalgal compounds have shown biostimulatory activity, such as amino acids, phytohormones and vitamins, among other. On this basis, some fertilizer companies have started to include microalgal extracts into their formulations, such as Plagron, specially as a sustainable source of biostimulant compounds. On the other hand, some companies include raw microalgal biomass into their formulations

[61] https://www.bbe-moldaenke.de/en/products/chlorophyll/details/algaelabanalyser.html
[62] https://www.denovix.com/products/celldrop/

in order to use it as a slow-releasing nitrogen source, such as Cultivers. Furthermore, some companies have focused their activity into microalgal bioremediation of different types of wastewater, such as SeaGrass Technologies.

Previous published studies have focused on microalgae wastewater treatment and added-value compounds extraction, which have shown promising results. Nevertheless, to the best of our knowledge, there are no companies that merge these two both concepts into one paradigm. The fusion of these technologies can reduce the final costs significantly, so deeper development of them is a need. Accordingly, Neoalgae aims to be pioneer in this approach through PestNu project. Accordingly, this is the first attempt to produce biostimulants and biofertilizers from agrowaste waters at a commercial scale.

Detection, quantification, and characterization of microalgae is of interest for industrial/agricultural production of microalgae. Here, the main interest is to follow growth rate of algae and possibly also the morphology of the individual organisms to optimize the culture conditions and thereby also the production yield. The basic analysis is to measure bulk absorbance at certain wavelength where chlorophyll absorb light. Systems with more advanced data analyses also measure chlorophyll concentration, algae class, and estimates photosynthetic activity, such as bbe Moldaenke.

Still other systems are based on imaging, such as DeNovix CellDrop automatic cell counter. However, this instrument requires manual sampling and insertion into the instrument. More advanced instruments, such as the Amnis ImageStreamxMKll is an imaging flow cytometer and can provide detailed information but is a laboratory instrument.

Other applications for analyses of microalgae are dedicated to use in the field, such as McLane Imaging flowcytobot that is developed for underwater use, this is an advanced and expensive instrument. We see a lack of autonomous and affordable instruments for early warning of algae blooming.

In summary, the available instruments on the market for analyses of microalgae are either relatively limited, such as measurement of absorbance, or more sophisticated and either laboratory instruments, or instruments for scientific research in the field. The more sophisticated instruments are expensive and thus less suitable for use in agriculture and as disseminated sensors in aquatic environment. There is a niche for an instrument “in the middle” that can give more information but with a cost efficient pricing.

3.8 Microalgae based biofertilizer production from organic waste streams

Biofertilizers may provide almost all the nutrients necessary for the growth of the cultures, minimizing the environmental impact of land use. Formulations based on photosynthetic microorganisms, such as microalgae, are of particular interest due to the valuable biomass production. If these microorganisms can be developed and concentrated from organic waste streams additional value is added as it could be integrated in waste management, providing cheap and renewable sources of nutrients for sustainable use.

Several different research programs and pilots are ongoing around the world. In Europe, around 60 companies are producing microalgae, mainly in photobioreactors and only a minor share in open ponds. Worldwide, the most prominent microalgae that are cultivated commercially are Chlorella, Arthrospira (since 2018 also known as Limnospira and earlier as Spirulina), Haematococcus, and Dunaliella. These

are often used as supplements in diets for humans and animals [63]. In India trials have been caried out with the microalgae *C. minutissima, N. muscorum* and *Scendesmus* spp in sewage wastewater[64].

3.9 Biopesticide for organic farming

Fungal diseases are ones of the most difficult problems to treat on horticultural crops. In addition to that most of the sources which compose the actual available products are not under the organic rules or are composed of molecules or formulates that will be banned in the coming years.

To develop organic pesticides is a must, but complicated goal. Nowadays, most of the biopesticides existing on the market are based on one molecule, or one component that fights the disease or pest. Usually, they are focused on targeting one microorganism to stop or inhibit their growth. In the project Fertinagro proposes dual products, for fighting the pest or disease, but also by protecting and biostimulating the plant to activate their inherent mechanisms of protection and increasing their tolerance to stress. New formulates of biopesticides will have a nutritional component for the plant, in addition of the biopesticide effect. In addition, the components of the new formulates can come from by-products form other industries, so being a biobased pesticide. This can be possible by using raw materials coming from circular bioeconomy operations, derived from waste or by-products of agronomic and food industries

The biopesticide that will be produced in the project will be formulated with components from organic origin, formulated with biomolecules and vegetable and microbial origin biomolecules that control pests and activates the natural mechanisms of vegetables to protect themselves. The advanced biopesticide is a product that, when applied in a foliar way, has both antifungal (Imre J. Holb, 2016[65]) and nutritional (Rania A. Taha et al 2014[66]) capacities. In this way, the application of a single product already carries by itself the dual effect, protective and nutritional. Protective effect against abiotic stress that some substances such as amino acids or extracts of microorganisms have is widely known (Ana L. García-García et al. 2011[67]) and are widely recognized as plant biostimulants.

The actual potential market for a product like that, in Spain, is about 54.500 Ha for tomato and lettuce crops (taking into account the different correction factors as competitiveness, effectiveness, easy to use, easy to handle, registration, certifications…) with a turnover potential of 6,500,000€ (taking into account a price of 10€/kg of product, a dosage of 5 kg/ha and 2 or 3 repetitions per ha – depending on the crop). The actual products available in the market have an average price of 24 €, but the range of prices goes from 3 €/kg to 85 €/kg of product for fungal diseases. Among the different available products we find a great diversity of active ingredients. Some based on microorganisms, basic active substances or biostimulants or combinations of these substances, and not all of them are registered for organic farming.

[63] https://www.mdpi.com/2076-3417/11/3/1056/htm
[64] https://www.sciencedirect.com/science/article/abs/pii/S0959652618336849
[65] Holb IJ, Kunz S.(2016) Integrated Control of Apple Scab and Powdery Mildew in an Organic Apple Orchard by Combining Potassium Carbonates with Wettable Sulfur, Pruning, and Cultivar Susceptibility. Plant Dis. 2016 Sep;100(9):1894-1905. doi: 10.1094/PDIS-12-15-1416-RE. Epub 2016 Jun 27. PMID: 30682978.
[66] RA Taha, HSA Hassan, EA Shaaban. (2014) Effect of different potassium fertilizer forms on yield, fruit quality and leaf mineral content of Zebda mango trees. Middle-East Journal of Scientific Research 21 (3): 518-524, 2014 DOI: 10.5829/idosi.mejsr.2014.21.03.21483
[67] GarciaA. L., MadridR., GimenoV., Rodriguez-OrtegaW. M., NicolasN., & Garcia-SanchezF. (2011). The effects of amino acids fertilization incorporated to the nutrient solution on mineral composition and growth in tomato seedlings. Spanish Journal of Agricultural Research, 9(3), 852-861. https://doi.org/10.5424/sjar/20110903-399-10

4 Survey among PestNu Partners

All consortium members were asked to submit information about the regulations, protocols, datasets, standards, good practices and guidelines that affect their product, technology or business. They were also asked to submit any revisions or changes they would like to be done in these regulations, protocols, datasets, standards, good practices and guidelines. The full answers from the consortium members are listed in Annex 1, in this section only data related to i) digital and space based technologies, DST ii) agro-ecological and organic practices AOP, iii) modern circular systems and iv) organic farming is presented.

4.1 Regulations

The regulations affecting PestNu partners product, technology or business are listed below (Table 4) and the full list is presented in Annex 1.

Table 4 Regulations affecting Project Partners product / technology

1. DST	
CERTH	GDPR (Hyperledger, Agriculture DSS) (Greece)
CERTH	ISOBUS ISO11783 (Agriculture DSS) (Greece)
TRILATERAL	Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL LAYING DOWN HARMONISED RULES ON ARTIFICIAL INTELLIGENCE (ARTIFICIAL INTELLIGENCE ACT) AND AMENDING CERTAIN UNION LEGISLATIVE ACTS *COM/2021/206*
2. AOP	
APEMETA	National decree 103/2015, Establishes the rules for introduction of non-harmonised fertilizers in the market (excludes those fertilisers working simultaneously as phytopharmaceutical products) (Portugal)
APEMETA	National Decree 37/2013 that establishes the technical procedures for Integrated Protection, Integrated Production and Biologic Production Mode (Portugal)
3. Modern circular economy systems [Hydroponics/Aquaponics]	
STAM	*Regulation (EU) 2020/741* on minimum requirements for water reuse
STAM	D.lgs. n. 185 del 2003 (ITA)
STAM	Joint Ministerial Decree 145116/11 (Greece)
APEMETA	National Law Decree 119/2019, Establishes the legal regime for the production of water for reuse (WfR), obtained from the treatment of wastewater, as well as its use. (Portugal)
APEMETA	*Regulation (EU) 2020/741* of the European Parliament and of the Council of 25 May 2020 on minimum requirements for water reuse
4. organic farming	
NEOALGAE	*(EU) 2019/2164* laying down detailed rules for the implementation of organic production and labelling of organic products with regard to organic production, labelling and control

Comments from the respondents regarding regulations are presented below

STAM: Law about hydroponic and aquaponic still in the phase of proposal

IKH: It would be nice to see a kind of certification entering the agriculture domain when it comes to robotics. For example a BIO certification that a certain amount of pesticides have been used for this specific crops. Since it was done automatically through the robot, the quantity could easily be verified.

GLOBAL: We would like to further develop the Ecotox Index and produce an Ecotox catalogue for the industry.

NEOALGAE: The protocols to develop a new fertilizer or biostimulant based on new substances or microorganisms is long and expensive (for example, REACH regulation). We need to have easier procedures and legislations that help to put new product in the market.

FERTINAGRO: Concerning both fertilizers and pesticides, the procedures to accept a new molecule, substance, or microorganism to be used as fertilizer or pesticide for biocontrol are too long and expensive. The administrative procedures can take up to 8-10 years for substances to be used as pesticides and many times, the companies decide not to put the effort on them because of the "difficulties" on that, as you have to spend a lot of money, time and PM on that and maybe, after 10 years it can be not profit-making. Concerning the use of microorganisms (bacteria, fungi and virus) in biofertilizers or biostimulants, the registration and inclusion of microorganisms not listed in the current regulation is not easy.

4.2 Protocols

The protocols affecting PestNu partners product, technology or business are listed below (Table 3).

Table 5. Protocols affecting Project Partners product / technology.

1. DST	
CERTH	"Practical Byzantine Fault Tolerance (PBFT) [CL02] addressed by Sieve protocol [CSV16] (Hyperledger)" Enrollment certificates (E-Cert, issued by E-CA) (Hyperledger) Transaction certificates (T-Cert, issued by T-CA) (Hyperledger) ANSI/ISA-95 (Hyperledger)
SIDROCCO	IEC 60870-5-104
SIDROCCO	Modbus
SIDROCCO	DICOM
2. AOP	
MASOUTIS and SEVT	*EFSA* Pesticide Residue Intake Model
GLOBAL2000	“PRP procedure”: The Pesticide Reduction Program (Team PRP) has designed a program to alleviate the pesticide residue situation for agricultural products. The PRP has set its own upper limits (PRP-UL) for residues of pesticides on fresh fruits and vegetables. The basis for the calculation of the PRP-UL and the Sum Of Exposure (SOE) is the Acceptable Daily Intake (ADI) The ADI (Acceptable Daily Intake) is defined as the amount of a substance in relation to body weight that can be ingested daily during lifetime without any measurable health hazards. https://www.port-international.de/wp-content/uploads/2019/03/PRP-Prozedere-und-Obergrenzenlimits-2019_englisch.pdff

	Additionally, the ecotoxicological properties of the used pesticides will be assessed by the PRP. The core of the evaluation is an index describing the environmental impact – the "Ecotox Index" (EI). The following aspects are included in the calculation of the ecotox index: - Retention time in soil - Dwell time in water - Toxicity to: - Mammals & humans - Birds - Fish - Water organisms - Bees - Earthworms - Potential for accumulation in organic tissue: - Octanol-water partition coefficient - Bioconcentration factor Based on the assessment of the individual aspects, an index is determined for each active ingredient, which reflects its environmental toxicity. In the course of the project the index will be developed to be applicable not only on single substances but also on whole plant protection strategies.
FERTINAGRO	*ENAC* for Fertinagro Biotech S.L.
FERTINAGRO	UNE-EN 15662:2019 Method for the determination of pesticide residues by GC/LC. QuECheRS Method.
3. Modern circular economy systems [Hydroponics/Aquaponics]	
	N/A
4. organic farming	
NEOALGAE	*UNE 142500:2017*, Inputs to be used in organic plant production. Fertilizers, soil conditioners and substrates

4.3 Datasets

The datasets affecting PestNu partners product, technology or business are listed below (Table 6).

Table 6. Datasets affecting PestNu partners product, technology or business are listed below.

1. DST	
AGROINSIDER	Sentinel 1
AGROINSIDER	Sentinel 2
AGROINSIDER	LST (Land Surface Temperature)
SIDROCCO	SPEAR dataset (closed)
SIDROCCO	CyberSANE dataset (closed)
2. AOP	
MASOUTIS	EU *Pesticides Database*

GLOBAL2000	The analysation is based on maximum residue levels defined by the EU and stricter upper limits, based on the ADI. Info can be found in the open source protocol on the left. Most important dataset is the *EU Pesticide Database* Most important Dataset for the calculation of the Ecotox Index is the *Pesticide Properties Database*
3. Modern circular economy systems [Hydroponics/Aquaponics]	
	N/A
4. organic farming	
APEMETA	List of validated non harmonised fertilisers (accepted in Portugal) last update 13/12/2021
APEMETA	*List of basic substances* authorized for use as pesticides for Organic Agriculture last update 11/12/2018

4.4 Standards

The standards affecting PestNu partners product, technology or business are listed below (Table 7).

Table 7. Standards affecting PestNu partners product, technology or business.

1. DST	
CERTH	ISO/TC 307 (Blockchain and distributed ledger technologies)
CERTH	ISO 20022 (Hyperledger)
CERTH	GAEC standards (Agriculure DSS)
AGROINSIDER	Management of RDI activities and certification standards - *NP 4457: 2007*
2. AOP	
MASOUTIS	*https://pp1.eppo.int/*
3. Modern circular economy systems [Hydroponics/Aquaponics]	
STAM	ISO/TC 282/SC1 (Treated wastewater reuse for irrigation)
4. organic farming	
NEOALGAE	Ecological certification (CAAE), agricultural inputs for organic farming

4.5 Good practices

The good practices affecting PestNu partners product, technology or business are listed below (Table 6).

Table 8. Good practices affecting PestNu partners product, technology or business.

1. DST	
CERTH	Comprehensive DLT security approach to provide guidance and practices respective to securing account access with the use of cryptographic hash functions, standard

	authentication methods, and bridging the security gap between DLT and traditional IT environments. (Hyperledger)
CERTH	Identify Stakeholders, Objectives, and Risk Tolerance (Problem Formulation or Decision Structuring) (Agriculture DSS)
CERTH	Model Linkages Across Interventions, Physical Outcomes, and Objectives (Agriculture DSS)
CERTH	Analyze Tradeoffs in Criteria Across Alternatives (Agriculture DSS)
TRILATERAL	*Ethics by Design and Ethics by Use approaches for Artificial Intelligence* - This Guidance concerns all research activities involving the development or/and use of artificial intelligence (AI)-based systems or techniques, including robotics.1 It builds on the work of the Independent High-Level Expert Group on AI and their 'Ethics Guidelines for Trustworthy AI' as well as on the results of the EU-funded SHERPA and SIENNA projects.2 This document offers guidance for adopting an ethically-focused approach while designing, developing, and deploying and/or using AI based solutions. It explains the ethical principles which AI systems must support and discusses the key characteristics that an AI-based system/ applications must have in order to preserve and promote.
SIDROCCO	Regular data backups are performed on suitable systems.
SIDROCCO	Access to SiVi tool is granted only to authorised personnel.
SIDROCCO	SiVi offers a role-based access control (R-BAC).
2. AOP	
TILAMUR	Use of doses of minimal fertilizer, yet sufficient to meet the demands of crops.
TILAMUR	Phytosanitary treatment equipment not registered in the Register will not be used. Agricultural Machinery Officer (R.O.M.A.), as indicated in the Royal Decrees 1702/2011 and 1311/2012
APEMETA	*Good practices Code for Agriculture* (2018) to be used on Vulnerable Areas, identifying the measures that have been established to prevent and reduce water pollution by nitrates from agricultural sources, however some also contribute to soil protection and to reduce air pollution. Main focus are General principles of rational fertilization; Fertilizers containing nitrogen and their behavior in the soil; Fertilizers containing phosphorus and their behavior in the soil; Application of fertilizers containing nitrogen (quantities, times and techniques); Application of fertilizers containing phosphorus (quantities, times and techniques); Application of organic correctives; Application of fertilizers in special situations, namely on sloping terrain; saturated with water, flooded, frozen or covered with snow and in the vicinity of water courses; Aspects of land use and management related to nitrogen and phosphorus dynamics; irrigation management; Fertilization plans and registration of fertilizers used on the farm; Storage and handling of inorganic fertilizers; Storage and handling of livestock effluents. "
FERTINAGRO	Reducing the loss of nutrients
FERTINAGRO	Multiresidual tests on all raw materials to avoid any hazardous or potentially hazardous residue on them.
FERTINAGRO	Increase soil biodiversity
3. Modern circular economy systems [Hydroponics/Aquaponics]	
FERTINAGRO	The use of bio circular economy materials
4. organic farming	
	N/A

Comments from the respondents regarding regulations are presented below

IKH: A list of good practises of when an automated robot is beneficial in agriculture is very much needed. The robots are not suited for all tasks.

SID: Add more good practices to protect the privacy of the clients

4.6 Guidelines

The guidelines affecting PestNu partners product, technology or business are listed below (Table 8).

Table 9. Guidelines affecting PestNu partners product, technology or business.

1. DST	
	N/A
2. AOP	
APEMETA	2019 *Guide for water reuse* for non potable uses which complements the National Law Decree 119/2019, framing the models for WfR production and use, defining procedures for licensing and guidelines for risk assessement and management. Considers water reuse from hidroponics
3. Modern circular economy systems [Hydroponics/Aquaponics]	
	N/A
4. organic farming	
APEMETA	2016 *Procedure for conformity validation* of fertilisers to be used in Organic Agriculture for non harmonised fertilisers
APEMETA	Information *Notice 1/2018* on Organic Agriculture and the of Phytoparmaceuticals and Basic Substances
APEMETA	Information *Notice 1/2017* on Organic Agriculture - use phytopharmaceutical products, that briefly explains the regulatory framework for phytopharmaceuticals use and how to proceed for requiring authorization for introducing new phytopharmaceuticals in the market

5 Questionnaire to technical partners and selection of IAB members

To identify the main reasons behind the current lack of adoption of similar innovations as developed in PestNu and identify the key barriers to implementation of these technologies a survey via questionnaire was carried out among the project's developing partners and IAB members. The questionnaire covered topics such as the development of new technology, new products and circular farming, see Appendix 2.

The purpose was for partners to propose system thinking approaches for PestNu solutions and innovative system features, to roadmap and come up with a list of recommendations to give further directions for the PestNu work according to regional, national and EU contexts. To broaden the perspective, the project's IAB members were also offered to respond to the questionnaire. In total 24 respondents answered the questionnaire and in question 1, the respondents were asked to categorize their field of operation in three categories; i) Developer of Precision Farming tools, ii) Precision Agriculture Software or iii) Organic Farming Products. All categories received about the same number of answers. It was permitted to select more than one field of operation (Figure 25).

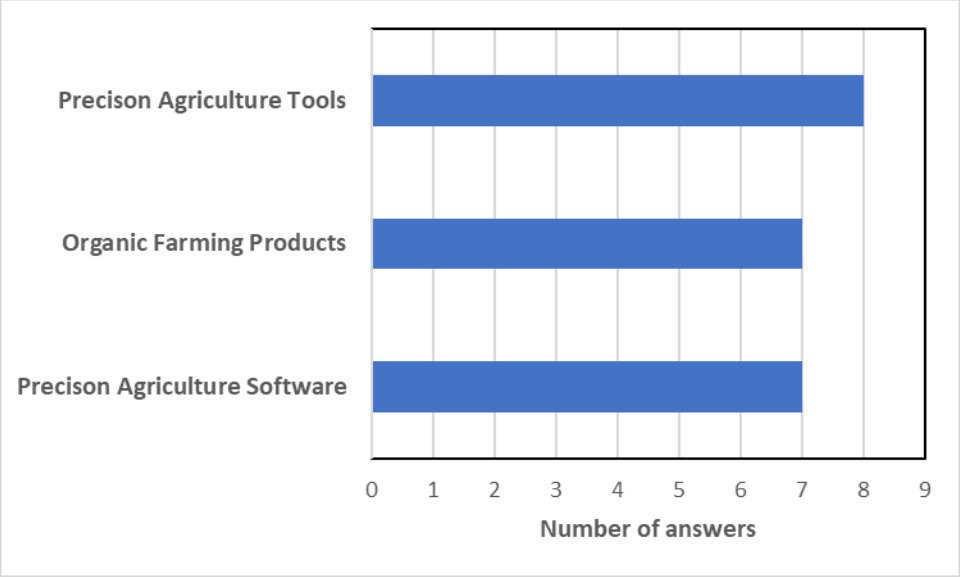


Figure 25. Answers on question 1: What is your filed of operation?

Some companies also reported an optional individual description of their field of operation, which is reported in appendix 2.

In the second question, the respondents were asked to give a more precise description of their technology/product/service. The responses are listed in Table 10.

Table 10.Technologies represented by the partners taking part in the questionnaire.

Technology

Nutrient Analyser for Monitoring of Water Systems and Environments
SiVi (Sidroco Visualization)
Circular food systems, with at its heart aquaponics
Fruit orchards surveillance robotics
Wastewater treatment with microalgae
Biostimulants from microalgae
Robotic solutions; service robots H/W and S/W
Consulting Advice and sharing products for DIY (do it yourself) Aquaponic Gardening
Analytical and consulting services.
Waste treatment
SmartAG - a smart precision agricultural tool, that combines a carbon map and a biodiversity tools.
Fertilisers, biostimulants and biocontrol products
SpyFly AI Remote Pest Monitoring System
We create end to end service robotics and specifically robots for precision agriculture
Fish / Vegetables in an closed circle
Formulation of plant protection products that can be used in conventional or organic farming
Indoor fish farming in RAS (recirculating aquaculture system) recirculation systems
Flow cytometers for detection of bacteria and microalgea
Soil reports / biochar / fermented compound
AI Virtual Industrial Assistant
E-books, products and service of small-scale aquaponics

As new technologies and new ways of working develop, there are those who immediately test the new products and ways of working, but to get the large mass of users on board, there are several obstacles. In the third question, respondents have been asked which of given obstacles they see as the main barrier for introduction of the product/technology on the market.

The results accordingly to the 24 respondents are seen in Figure 26. Here, respondents could select any suggestions they saw as relevant and add more barriers if they thought something was missing. They could also mark more than one alternative. The barriers most marked was "The customer's lack of knowledge about the economic advantage and benefits" which received fourteen markings closely followed by "Lack of interest or uncertainty in new technologies or methods" which received 13 markings. Ten marked “Price” as a barrier and” Lack of knowledge on handling and operating new devices/instruments/technologies” got nine marks. Besides the answers given in Figure 26, the respondents also added four additional individual barriers that are seen as relevant in this context, see details in Appendix 2.

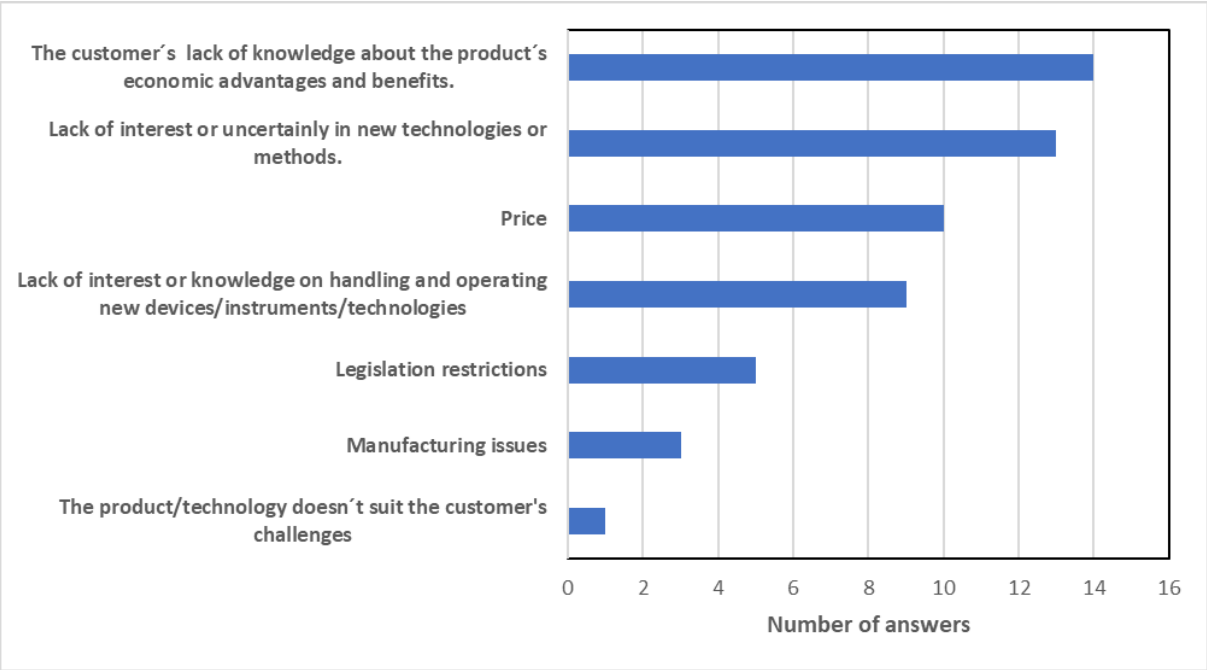


Figure 26. Answers on question 3: What are the main barriers for introduction of your product/technology on the market?

The third question was about which solutions the respondents think are appropriate to apply in integrating new development in the field.

The respondents could select any solution they saw as relevant (more than one alternative) and add more solutions if they thought something was missing. Twenty of the respondents think that "Validate and demonstrate in practice on more commercial farms" can be one solution. Eight thought that "Testing and experimenting on more crops" as well as "Improve the technology/product" could be appropriate to apply. Six and five, respectively, thought that "Testing and experimenting on geographic areas" and "Testing and experimenting on different climate conditions" could be suitable solutions (Figure 27). The respondents' own proposals are reported in Appendix 2

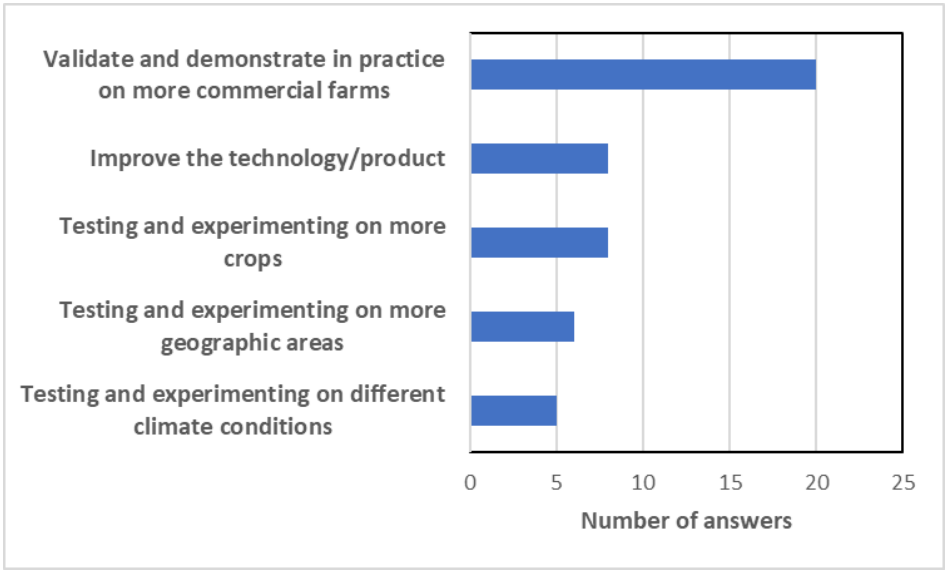


Figure 27. Answers on question 4: What solutions do you believe are appropriate to apply to solve problems in integrating your technology on the field?

To see what possible paths there are to development, the respondents have had to show which suggested actions they prefer, and the answer options are shown in Figure 28.

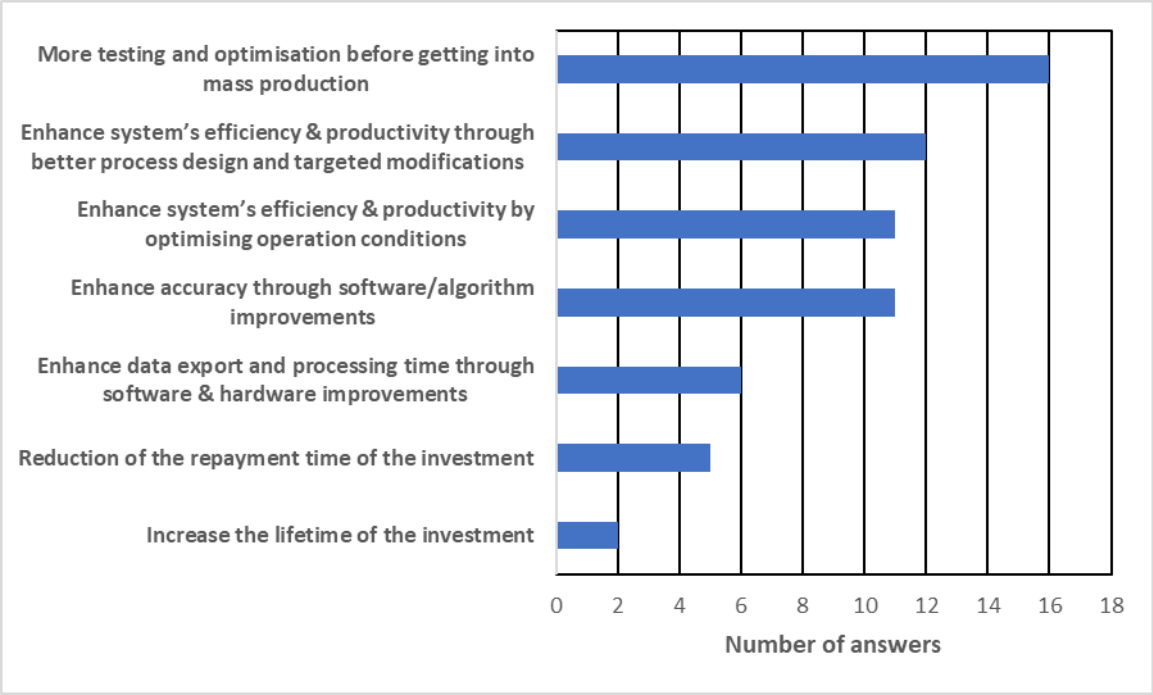


Figure 28. Answers on the question 5: What actions do you take in order to improve your product or technology?

The action "More testing and optimization before getting into mass production" is the one that most respondents, sixteen, see as an opportunity to improve their product. Twelve see "Enhance system's efficiency & productivity through better process design and targeted modifications" as a possibility and ten think that the actions "Enhance accuracy through software/algorithm improvements" and "Enhance system's efficiency & productivity by optimizing operation conditions" are actions to take in order. "Enhance data export and processing time through software & hardware improvements" and "Reduction of the repayment time of the investment" there are six and five respectively that see as a good action for improvement. Three actions have been added by the respondents, see Appendix 2, and one respondent also added, that all the actions need to take in order. And goes on, "Firstly you must define the customer requirements and the requirements for your system. You then build and develop your system to these requirements and then test and validate. Your Beta testing should identify weaknesses and issues associated with your system, you should then redesign and modify your system to address the weaknesses and issues. Design freeze and production of the system cannot take place until extensive beta testing is performed". All the results are seen in Appendix 2.

To get more people to embrace new developments, price can be a barrier. The technology partners were therefore asked as question 5 what activities they do to reduce their production costs and price of the product out to the customer. The question was: What actions will you take in order to reduce the products or technologies production cost and sales price?

According to the answer options in Figure 29, partners were able to choose as many as they thought matched out of five options. They were also able to add their own options that they felt were missing, giving three more activities.

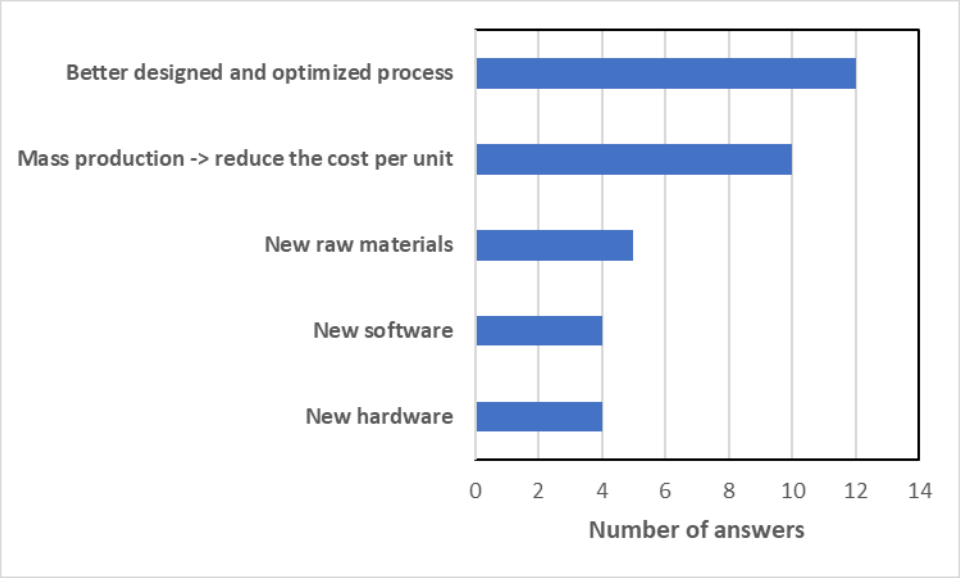


Figure 29. Answers on question 6: What actions to take to reduce the products or technologies production cost and sales price.

Most, twelve, see " Better designed and optimized process" as an activity to reduce costs and the final price", followed by " Mass production - > reduce the cost per unit" which ten see as a suitable action. The option "New raw materials" has been chosen by five partners and the options "new hardware" and "New software" have been chosen by four partners as a way to lower the costs. The three options that were added by the respondents were "NA", "motivate people implementing their own systems (small scale aquaponics) themselves" and "Our calculation is based on a competitive market price, with no intention of generating more income by increasing the stocking numbers".

Another step to bring new technology and products to market is to increase sales. Here, too, our partners received five answer suggestions to choose from and seven additional options were given by the respondents, see Figure 30. The question answered was: What actions will you take in order to increase your sales?

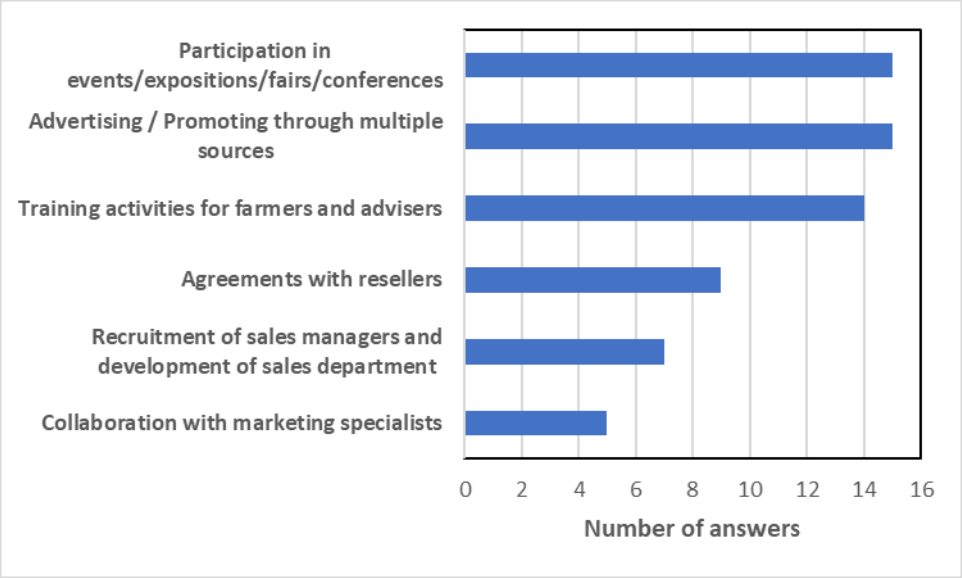


Figure 30. Answers on question 7: What actions will you take in order to increase your sales?

According to Figure 30, we can see that fifteen partners say that both "Advertising / Promoting through multiple sources" and "Participation in events / expositions / fairs / conferences" are ways to increase sales. Fourteen see "Training activities for farmers and advisers" as an option and nine choose "Agreements with resellers". "Recruitment of sales managers and development of the sales department" is chosen by seven while five see "Cooperation with marketing specialists" as part of sales growth. The seven alternatives added by the respondents are five about business development; “Scale up our pilot facility to a more automated PoC before scaling up to a much larger facility”, "Promotion of research activities”, “Expansion of marketing measures”, “Employee training”, “Maintaining the customer base" and two on cooperation with schools "School cooperation in a kind of class project" and "Cooperation with primary schools".

To introduce new products and new technologies, it is also important to show that the product is on the market. Figure 31 shows how respondents view different strategies and activities to raise awareness of the product on the market. The question answered was: What actions or strategy to take in order to increase the awareness of the product or technology to farmers?

Figure 31. Answers on question 8: Options on what actions or strategy to take in order to increase the awareness of the product or technology to farmers

Figure 31 shows that the "B2B strategy" is the way most used by respondents to make farmers aware of their products, thirteen do this. Twelve of the respondents say that they all use these four ways " Training activities for farmers in different regions", " Social media campaigns", " Meetings with farmers associations and big farming companies" and " Agreements and collaborations with advisors, agronomists and with stores selling agricultural supplies". One of the respondents sees "Contracts with marketing managers" as a way to go. Three alternatives were added by the respondents “Working closely with leading Aquaculture organisations”, “Look for a franchising option in the long term” and “Information events in own visitor centre for everyone and seminars for gastronomy and hotel industry, seminars for specially interested audiences’ and events for schools”.

To see how the respondents view their position in the market, there were a question number 9 that asked about their product’s/technology's competitive advantage compared with competitors. Table 11 shows the free answers. All 24 respondents filled in at least one sentence to describe this.

Table 11. The respondents’ answers about what´s the product´s or technology´s competitive advantage compared with competitors.

Respondent no.	Answer
1	Only deployable analyser in the world to provide nitrite and nitrate measurement in a single run. Accredited system to ISO 14034 in terms of accuracy and precision. More robust, more easily installed and maintained. Can be deployed in any water matrix
2	Custom solutions to the needs of each client. Continuous technical support.

3	Novelty product, autonomous cable bot
4	Combining modern fish farming with new vertical growing technology, use of insects in our fish food and a very strong team = truly circular food production
5	Higher data rate, better quality of sensor data and immediate awareness and orchard status
6	Modularity and flexibility, off-grid system
7	Improvement of crops production and decrease the environmental impact
8	Bigger Production
9	AI-based software robust and efficient enough for field/agricultural robots
10	Small scale aquaponic is not widely spread in Austria, there are only a few companies which are dealing with that topic
11	Solving and managing quality problems-troubleshooting.
12	High quality of products, post sales follow-up, custom sale
13	User friendly; data updated at least once a week; includes radar data that is very useful in cloudy areas; can be used in offline mode in areas without cellular service or internet.
14	Organic certified
15	Reliability Quality Design Accuracy of detection
16	Robotics in precision agriculture is a technology on the rise. Our solution has the competitive advantage of being able to operate in unstructured environment, fully autonomous and with high level of accuracy.
17	Improve efficiency and decrease carbon footprint
18	Only Aquaponic system
19	Best fit will current market request
20	Innovations in fish farming in general. Adoption of our own research results in the rearing programs of the individual sections
21	Price and performance to match the needs and resources of the user
22	Knowledge of soil microbiology and knowledge of spectral readings
23	Artificial Intelligence
24	Different technology

In question 10, it was asked what kind of feedback they received on their development from customers, the question was: What feedback have you received from your customers about the product or technology? Here the respondents got six answer opportunities and could add their own alternatives as well.

According to figure 32, seventeen of the respondents have received feedback that the product is "Useful" and eight have received feedback that it "Increases productivity". Seven state that their products received the response "Accurate" and five "User friendly". Four products are considered "Need to be cheaper" and two "Need improvement". Two of the respondents do not have their products on the market yet, aquaponics is not considered so well known, and customers may find that it is "no use when you can do the same things in soil ".

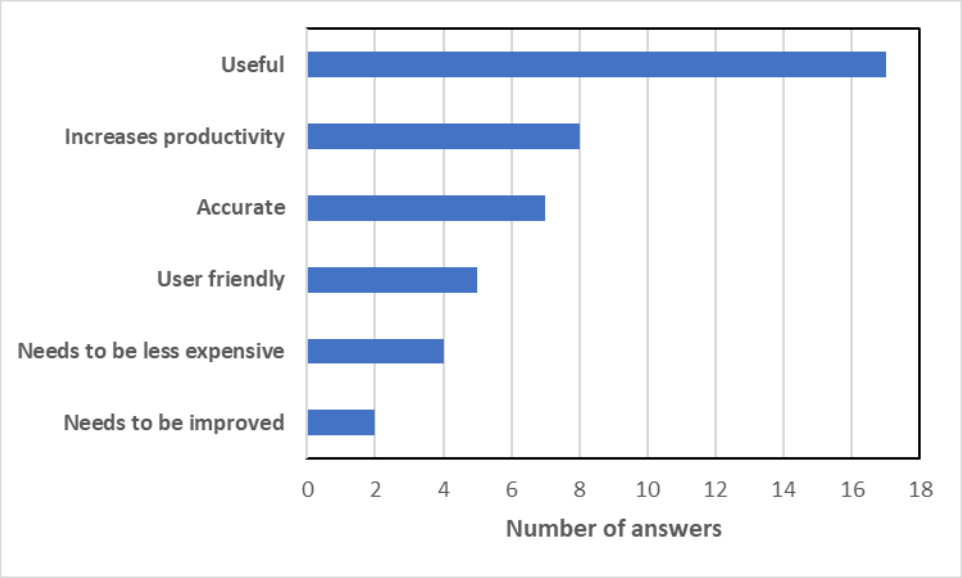


Figure 32. Answers on question 10: What feedback have you received from your customers about the product or technology?

To see how those who develop new products view why customers implement new methods or new technologies, the question was asked "What are the main reasons why the customer implements a new method or buy new technologies?". The answer options are presented in Figure 33 and nineteen of those surveyed, chose the option "To increase efficiency and productivity" as a reason for their customers to implement new products or technologies. Eleven sees " To reduce operational costs" as a reason and nine chooses the reason "To minimize production time and labour". Eight think that it could be because “New legislation or regulation require a replacement” and seven think it is because “The customer is curious of new development “. Three see that one reason could be that “Something has broken and needs to be replaced” and two think it could be because “The company expands”. Three respondents also added their own answers on this question: “To meet rising requirements for bio-products more easily”, “Market request (food with low residues)” and “We assume that our customers will only set the quality standard for our products”.

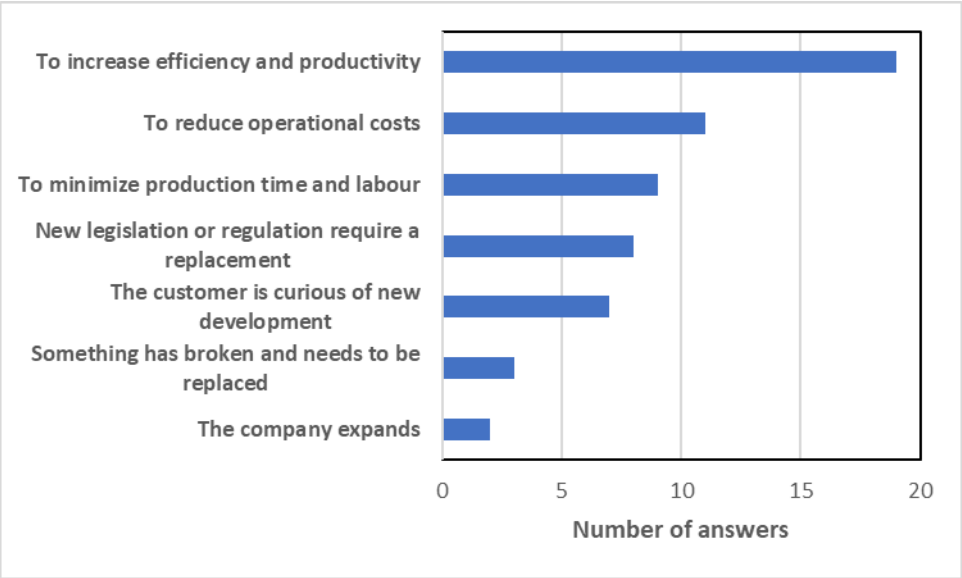


Figure 33. How respondents think about which are the main reasons why the customer implements a new method or new technology

In questions 12a and b, respondents were asked to specify what interesting trends they are aware of, in their market segment (12a) and what opportunities they see coming from changes in technology, government policy or regulations (12b).

Answers on question 12a are presented in Table 11 and on question 12b in Table 1. With one exception, the respondents were giving one sentence as an answer on question 12a, with one respondent giving two answers.

Table 12: Answers on the question what interesting trends are you aware of in your market segment?

Respondent no.	Answer
1	N20 emissions is a growing area of concern in terms of climate change and nitrite and nitrate monitoring aids in mitigating N20 emissions. Having information on nitrite and nitrate in Aquaculture systems allows for optimisation of the process in terms of feed and treatment by the biofilter in RAS.
2	1) The agriculture drones market is projected to grow at a Compound Annual Growth Rate (CAGR) of 32.49%.
2	2) The adoption of analytics in agriculture has been increasing consistently; its market size is expected to grow from USD 585 million in 2018 to USD 1236 million by 2023, at a CAGR of 16.2%
3	prefer not to answer
4	customer awareness for locally grown food in Sweden is increasing very fast – both private consumers and the restaurants we supply are willing to pay a higher price for this
5	None
6	The global market for Algae estimated at US$782.9 Million in the year 2020, is projected to reach a revised size of US$1.2 Billion by 2027, growing at a CAGR of 6.2% over the analysis period 2020-2027. *https://www.prnewswire.com/news-releases/global-algae-market-growth-trends-to-2027-stringent-regulations-for-wastewater-remediation-drives-increased-demand-for-algae-as-a-eco-friendly-substitute-for-chemicals-301192046.html*
7	abiotic stress tolerance, crop quality improvement, nutrition efficiency improvement
8	Price Increase
9	the growth rate for robotic solutions in agriculture increases
10	traditional farming will change in future, so we will improve and develop additional methods for example aquaponics in cities for getting enough food and vegetables for the whole world population
11	Efsa Primo guidelines.
12	sustainability philosophy of the company applied in the develop of new products
13	Carbon farming, evidence record, blockchain, certification, innovation.
14	growth market, production, price changes

15	Italian Precision farming market is growing at 23% over the last 2 years. In numbers the market has exploded, going from 540 million euros in turnover in the first half of 2020 to 1.3 billion at the end of 2020, up to 1.6 billion in 2021 (+ 23%)
16	According to Boston Consulting Group (BCG) Robotics Outlook 2030, professional services robots will dominate the sector. Professional services robots will have sales that may be more than double those of conventional and logistics robots. BCG expects the global robotics market to climb from about $25 billion this year to between $160 billion and $260 billion by 2030, with market share for professional services robots hitting up to $170 billion and industrial and logistics robot sales topping off at about $80 billion
17	Awareness regarding emissions impact in cattle production.
18	None
19	Global population growth rate forces an increase of food production. Plant protection product is a critical component to improve productivity.
20	The production volumes in aquaculture are increasing to a significant extent. Fishing from wild catches is declining more and more, as the stocks are overfished to the point of threatening their existence
21	An increased interest (and many new companies) in the field of cultured microalgea with applications in different fields (e.g. nutrition, cosmetics, fertilisers etc.) as well as concern for increased occurrence of toxic algea blooming in sweet and sea water. For both fields, it will be useful to have access to an affordable and autonomous instrumentation for quantification/identification of microalgea/cyanobacteria that can measure and communicate the result from remote locations. The other main field for our flow cytometer is bacterial detection. Here, a large interest lies in quality of drinking water and on-line detection of contamination of drinking water with sewage. This can be achieved by a general bacterial live/dead detection, such as by Metanor AG detection but even better with a specific detection of E. coli with our flow cytometer as a marker for sewage.
22	Sustainability; biologic;
23	Predictive Maintenance Automation Virtual Assistants
24	Environmentally friendly, future technology, a part of the solution to feed the expanding world population

In Table 13 the answers on question 12b are reported. Here 23 respondents were answering, while one commented that they prefer not to answer.

Table 13: Answers on the question which opportunities you see coming from changes in technology, government policy or regulations?

Respondent no.	Answer

1	Tighter legislation on emissions from wastewater treatment plants and agricultural sites are needed and deployable analysers to monitor emissions in real time are needed
2	The new regulations to minimise water consumption could create an opportunity for us to establish a smart farming solution.
3	prefer not to answer
4	The price of grow lights will hopefully come down in the near future
5	better yield using new tech
6	It is in line with the Common Agricultural Policy (CAP) that takes action on the protection of nature and safeguarding the biodiversity.
7	to be able to market new products in a easier way
8	Local production
9	help in the boost of AI and robotics solutions utilization in agriculture
10	see question above
11	Production on ECO friendly products for human consumption.
12	increase of organic farm
13	SmartAG will be an essential tool to meet European (Green Deal and Farm to fork) and national policies because allows to calculate a farmer's carbon balance by farm, plot or type of crop, records evidence via blockchain that will serve to certify the farmer to buy or sell carbon credits on the voluntary carbon market.
14	Shorter processes for certification and regulation of products, substances, molecules and microorganisms to be used in organic farming
15	Most of all a substantial sales increase, after a substantial interest by the regulator on Biological food.
16	Robotics is a diverse sector with many moving parts, and what its future will look like is a complex question. To offer an insight we again looked to well-known and established international consultants. So, BCG did a deep dive into the robotics industry and the potential for old and new players to grow over the next decade. BCG's very concise conclusion: robotics has significant upside potential. But a more-nuanced analysis is that to succeed, established companies manufacturing machinery and industrial automation hardware and software must be both dexterous and aggressive, prepared to take advantage of new strategic and technological directions that will likely become more important as 2030 approaches but may not be their traditional strengths. Meanwhile, smaller rivals and start-ups will be pushing innovation in areas that have the potential to generate high profits and alter the dimensions of the robotics industry. But the speed with which they will be able to transform the trajectory of the field is still a wildcard.
17	Decrease products carbon footprint.
18	None
19	In EU Future regulatory restrictions will force a change in market of PPP
20	A change in government policy would improve almost everything, but this is hardly to be expected under the current constellations

21	Development in technology will make it possible to make devices smaller, cheaper and more user friendly. New technology also makes it possible to come up with and implement new regulations that in turn booster the market. Government policy can play a role in stimulating specific areas of technology development, or more generally such as promoting "digitalization".
22	increased demand for organic products; Concern about soil degradation
23	I don't know yet. We're working to find out.
24	Environmentally friendly technologies are going to be supported, to feed the cities with growing food in the cities to avoid transport of CO_2 emissions in the future

According to the answers to the question "Are standards or specifications need to be changed in order to adapt your technology or product to current customer needs" (question 13, Figure 34), most people answer no, but close to 17% answer yes and one comment that it is "Insignificant, they only have to be adapted to the actual circumstances and requirements". Those who answered yes to the question have commented on reasons for this, see Table 6.

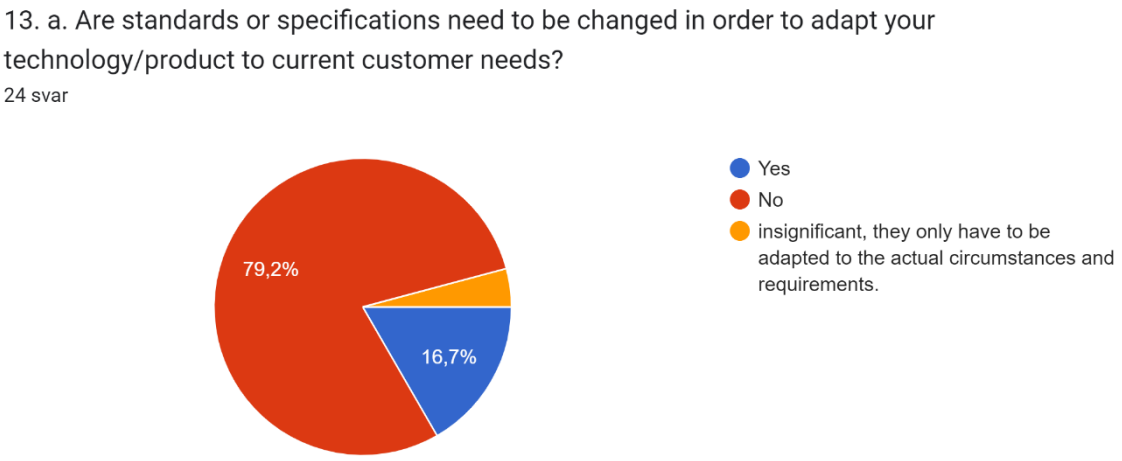


Figure 34. How the respondents view if standards or specifications need to be changed in order to adapt their product or technology

Respondents were also asked to suggest what should be changed in standards and specifications:

- New Organic Directive
- To respond to the problems that farmers come up with daily.
- Feed supply, grazing methods, animal selection and additives.
- Especially in the field of fish farming, the subject of factory farming.
- a) what is factory farming in fish farming
- b) Feeding / processing of slaughterhouse residues into fish feed It is a phase that the BSE law applies to fish finds!!!
- Detection of microalgae and specific bacteria.

When asked "Do current EU and regional legislation and regulations help market release of your product or technology?" (question14, Figure 35) one-third answer no and of the remaining two-thirds, most answer yes and two comments are:

- Even though we do not pollute the waters or surrounding land (we re-use 99.5% of our water), we are not allowed to call our product organic as it's not grown in soil. We don't use pesticides or artificial nutrients – all nutrients for the leafy greens is provided by the fish.
- Need more knowledge to the people and especially to the farmers what kind of agriculture is possible

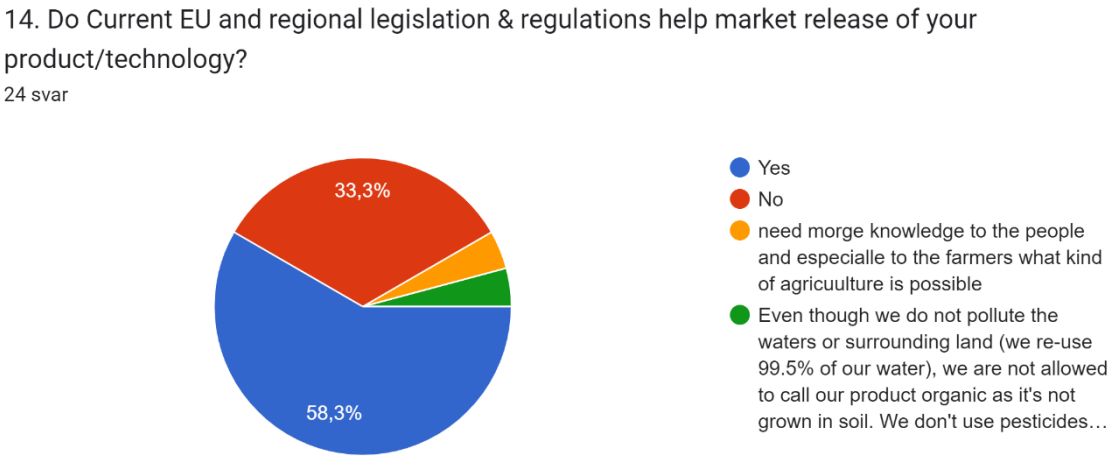


Figure 35. Answers on question 14: Do current EU and regional legislation and regulations help market release of your product or technology?

Question 15 was formulated as follows: Are there any specific actions that need to be taken from European and National policy making bodies in order to help market release and boost sales of your technologies and products in the near future? (Specify what actions shall be taken and what regulations need to be changed).

Several specific actions were listed (Table 14) but six respondents also replied that there was nothing specific they saw a need for.

Table 14. Specific actions that need to be taken by European or national policy makers.

-In concrete terms, neither the EU nor national authorities should constantly interfere in economic processes. The EU's homework is to protect stocks in the seas, lakes and rivers, should abuse be put under strict control. Impossible husbandry conditions in the Southeast Asian countries should be put under control, here the impossible pricing is generated, which has a ruinous effect on the local fishing industry. So, there would be a wide field of activity for the EU to bring about improvements!
-New Organic Directive so that aquaponic system is also organic

-Regulation (EU) 2020/74; D.lgs. n. 185 del 2003 (ITA);
-Simplify the application and admission procedure of the product as category 4.0, granting a tax incentive in the form of a tax credit for buyers
-The actual framework (Green Deal and Farm to Fork) will be a game changer in near future
-The rules and regulations with regard to organic certification should be updated or a new label should be created to reflect aquaponic, circular food production
-This is secondary. A good boost of the technology is still needed.
-We have deployed units analysing the final effluent of a range of WWTPs and the nitrite and nitrate levels were nearly 5 times above EU legislative level, yet no action was taken as the facility was not required to monitor for nutrients in the final effluent. Real-time, continuous monitoring of nutrient pollutants from and in water systems and facilities should be a legislative requirement to effectively battle eutrophication and environmental destruction and economic impact.
- Autonomous systems need to be OK to use anywhere if run below 5 km/h
- Bring the knowledge of aquaponic gardening to schools
-Help companies to put in the market new products or molecules, and get organic certifications
-Less bureaucracy
-Use drones to spray crops; streamline the law to place biological products on the market

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The last question, number 16, was about if there are any specific legislation or regulations that acts as an obstacle to the free movement or launching of your products and technologies in the market.

Here only a few concrete answers were given: “GDPR is a problem because we are not allowed to use data from previous clients in new models”, “Regulation (EU) 2020/(74; D.lgs.n. 185 del 2003 (ITA)”, “There are a myriad of regulations and laws that are difficult for the producer to understand and certainly not comprehensible! Lengthy approval procedures that lead to massive delays due to lack of knowledge among officials. I don't know of any official who is directly involved in an approval process and knows about aquaculture!!!! Therefore, everything is put on the back burner so as not to have to make a decision, ”New European regulation will difficult negotiations with customers” and “Yes because it's so complicated the new rules for fertilizer products - new law July 16th”

6 Conclusions and recommendations

6.1 Conclusions

The sales of pesticide in EU have been relatively stable since the 1990s, but since low dose products were introduced in the 1990 and often replaced older products, it could be reasonable to believe that the number of applications increased slightly in the 90s and early 2000s. However, the use of pesticides measured in kg/ha have not increased since 2011 so most likely the number of applications has been stable the last decade. The new techniques used in precision agriculture will enable the farmers to use pesticides only when there is a real need for it and subsequently the use of pesticides will decrease. Hopefully these techniques will be exported from EU and become more widely used also in other parts of the world as there is an extremely high use of pesticides in China and probably also in other countries in Asia.

The amount of mineral fertilisers used in agricultural production have had a slight increase between 2010 and 2020. Taking into consideration that the nitrogen based fertiliser industry in EU is heavily dependent on gas of Russian origin and also phosphate and potassium are produced in Russia it is very likely that the usage in EU will decrease significantly the coming years. Therefore, it is of great importance that the usage of fertilisers is optimised so only the specific crops or specific parts of the fields in need of nutrients are fertilised. The new techniques developed within precision agriculture will provide farmers and advisors with information so the right measures can be taken, saving both the environment and the farmers' economy.

The possibility of producing fertilisers from algae and other biological material contributes to less dependence on products produced with origin outside EU at the same time as the impact on the environment is decreased. Also, the modern circular economy systems enable agricultural production with optimisation of resources and less dependence of scarce resources and less negative impact on the environment

The regulations, besides development of protocols and procedures for new biofertiliser, biopesticide or biostimulant makes the approval of new products very long and expensive. It can take up to 8-10 years and often the companies do not proceed with the potential new products as they will not make any profit out of them. Regarding biostimulants and fertilizers since July 2022, *EU Regulation 2019/1009* is the one enforcing the landscape of the marketing of fertilising materials in the European Union replacing EC Regulation 2003/2003, and in addition to current national MS rules, will define the settings to market fertiliser and plant biostimulant products. Its adoption is part of the *Circular Economy Action Plan* and introduces new definitions for fertilizing product and biostimulant which are expected to facilitate the marketing and boost this sector.

Common regulation within EU, for example on biofertilisers, facilitates and enables export to other EU countries which in the long run will make the bioproducts more profitable and therefore it is more likely that companies will spend time and resources to develop these.

For the aquaponic systems there seems to be a challenge in the fact that discharge water is differently regulated in different countries, making it difficult to set up systems that fulfil the regulations in all countries and still are considered price worthy in all countries in EU.

In some countries there seems to be a need to clarify whether application of pesticides by autonomous robots or drones is allowed by law or not. But for most of the technical partners it seems to be technical challenges rather than regulatory issues that are the problems. However, considering the time needed

for possible regulatory changes to be implemented, it might be wise to address the question immediately.

There is a need for the development of satellite-based tools for vegetable productions in order to save pesticides, get a more precise application of nutrients and to optimize irrigation. There are also no constraints in using and satellite data from ESA such as the Sentinel satellites. They are available for free and no regulations are either hindering the use of these data. However, still the applications have not been extensively commercialized and one reason is probably that the stability of the readings need to be verified to a larger extent.

In general terms, the results from the questionnaire can summarized as optimistic: Most companies believe that they have products that are of interest to customers, but that they need to make the benefits more known and that the main obstacles are to test them in more diverse environments and to optimize them for these environments.

6.2 Recommendations

EU regulations need to be modernized to meet the needs the bioeconomy. Smoother and faster procedures and legislations for biostimulants, biopesticides and biofertilisers to offer new products in the market.

It is recommended to increase the number of occasions where the products can be tested out in practice by potential customers.

Optimized design and processes are important success criteria.

It is recommended to use many different channels to reach the target groups. While some are very active in social media, others need personal contacts to be reached.

For most customers, the price is not so important. It is recommended to focus more on efficiency and productivity than on the price.

Certification or labelling for products produces with precision agriculture.

7 Annex 1: Full answers from consortium members

Table 15. Full list of regulations affecting product or technology

1. CERTH
GDPR (Hyperledger, Agriculture DSS)
Directive 2009/128/EC (Agriculture DSS)
(CAP Strategic Plans) Regulation (EU) No 1305/2013 (Agriculture DSS)
(CAP Strategic Plans) Regulation (EU) No 1307/2013 (Agriculture DSS)
ISOBUS ISO11783 (Agriculture DSS)
Regulation (EU) No 526/2013 (Cybersecurity Act) (Agriculture DSS)
Requlation (EU) 2019/1937 (Hyperledger)
2. CDTA
Ley 4/2021, de 16 de septiembre, por la que se modifica la Ley 3/2020, de 27 de julio, de Recuperación y Protección del Mar Menor.
National and international regulations agriculturally speaking
3.RISE
N/A
4. UTH
N/A
5. TILAMUR
Decreto nº 31/2013, de 12 de abril, which regulates periodic inspections of application equipment of phytosanitary products, the census of equipment is created to inspect and registration of technical inspection stations in the Autonomous Community of the Region of Murcia
6. AGROINSIDER
AgroInsider follows the internal Policies and Procedures document (last update-December 2021)
7. TRILATERAL
Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL LAYING DOWN HARMONISED RULES ON ARTIFICIAL INTELLIGENCE (ARTIFICIAL INTELLIGENCE ACT) AND AMENDING CERTAIN UNION LEGISLATIVE ACTS *COM/2021/206*
8. MASOUTIS
(EC) No 178/2002-laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety
(EU) 2019/1381 - on the transparency and sustainability of the EU risk assessment in the food chain and its amendments
(EC) No 1881/2006 - setting maximum levels for certain contaminants in foodstuffs
(EU) 2017/625 - on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products and its amendments
(EC) NO 396/2005 - on maximum residue levels of pesticides in or on food and feed of plant and animal origin and its amendments
(EC) NO 0052/2003 - on maximum residue levels of pesticides in products of plant and animal origin
EU) No 519/2014 - amending Regulation (EC) No 401/2006 as regards methods of sampling of large lots, spices and food supplements, performance criteria for T-2, HT-2 toxin and citrinin and screening methods of analysis
(EU) 2015/786 - defining acceptability criteria for detoxification processes applied to products intended for animal feed as provided for in Directive 2002/32/EC of the European Parliament and of the Council
COMMISSION DIRECTIVE 2003/13/EC amending Directive 96/5/EC on processed cereal-based foods and baby foods for infants and young children

COMMISSION DIRECTIVE 2006/141/EC on infant formulae and follow-on formulae and amending Directive 1999/21/EC
Commission Regulation (EU) No 284/2013 , implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council regarding the data requirements for plant protection products.
9. STRATA
N/A
10. STAM
Regulation (EU) 2020/741 on minimum requirements for water reuse
D.lgs. n. 185 del 2003 (ITA)
Regulation (EU) 2019/1009 laying down rules on the making available on the market of EU fertilising products
Joint Ministerial Decree 145116/11 (Greece)
11. AGROROBOTICA
N/A
12. TELLAB
N/A
13. APEMETA
National Law Decree 119/2019, Establishes the legal regime for the production of water for reuse (WfR), obtained from the treatment of wastewater, as well as its use. It comprises the possibility of using 'Remaining water', which means leftover water from certain types of agricultural crops, including off-ground crops, which can be used to meet the water requirements of other agricultural crops; in 'Decentralized systems in symbiosis', which are systems for the production of WfR from 'remaining water'; These systems require licensing, and can use their own 'remaining waters' or those received from third parties. The transport of such waters by land has to be documented, and if by piping systems has to be controled by installing flowmeters.
Minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge
Regulation (EU) 2020/741 of the European Parliament and of the Council of 25 May 2020 on minimum requirements for water reuse
Commission notice on guidance document on addressing microbiological risks in fresh fruits and vegetables at primary production through good hygiene (2017/C 163/01)
National decree 103/2015, Establishes the rules for introduction of non harmonised fertilizers in the market (excludes those fertilisers workin simultaneously as phytopharmaceutical products)
National Decree 37/2013 that establishes the technical procedures for Integrated Protection, Integrated Production and Biologic Production Mode
14. SEVT
(EC) No 178/2002-laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety
(EU) 2019/1381 - on the transparency and sustainability of the EU risk assessment in the food chain and its amendments
(EC) No 1881/2006 - setting maximum levels for certain contaminants in foodstuffs
(EU) 2017/625 - on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products and its amendments
(EC) NO 396/2005 - on maximum residue levels of pesticides in or on food and feed of plant and animal origin and its amendments
(EC) NO 0052/2003 - on maximum residue levels of pesticides in products of plant and animal origin
EU) No 519/2014 - amending Regulation (EC) No 401/2006 as regards methods of sampling of large lots, spices and food supplements, performance criteria for T-2, HT-2 toxin and citrinin and screening methods of analysis
(EU) 2015/786 - defining acceptability criteria for detoxification processes applied to products intended for animal feed as provided for in Directive 2002/32/EC of the European Parliament and of the Council
COMMISSION DIRECTIVE 2003/13/EC amending Directive 96/5/EC on processed cereal-based foods and baby foods for infants and young children

COMMISSION DIRECTIVE 2006/141/EC on infant formulae and follow-on formulae and amending Directive 1999/21/EC
Commission Regulation (EU) No 284/2013 , implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council regarding the data requirements for plant protection products.
15. IKH
N/A
16. GLOBAL2000
Regulation (EC) No 1107/2009 concerning the placing of plant protection products on the market
Directive 2009/128/EC establishing a framework for Community action to achieve the sustainable use of pesticides
Regulation (EC) No 396/2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin
17. NEOALGAE
(EU) 2019/2164 laying down detailed rules for the implementation of organic production and labelling of organic products with regard to organic production, labelling and control
(EU) 2019/1009 laying down rules on the making available on the market of EU fertilising products
(EC) 2003/2003 relating to fertilisers
REACH regulation
Royal Decree 506/2013 on fertilizer products and its amendments
8. FERTINAGRO
Real Decreto 506/2013 on fertliser products (ES)
(EU) 2019/1009 laying down rules on the making available on the market of EU fertilising products
Regulation (EC) No 1107/2009 concerning the placing of plant protection products on the market
Directive 2009/128/EC establishing a framework for Community action to achieve the sustainable use of pesticides
(EU) No 544/2011 regards the data requirements for active substances
(EU) No 284/2013 setting out the data requirements for plant protection products
(EU) No 546/2011 as regards uniform principles for evaluation and authorisation of plant protection products
(EU) No 547/2011 as regards labelling requirements for plant protection products
(EU) 396/2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin
Legislación básica española y sus modificaciones
Real Decreto 971/2014, por el que se regula el procedimiento de evaluación de productos fitosanitarios.
19. SIDROCCO
GDPR
20. AGROVAST
N/A

Below is presented the changes that consortium members would like to see in the regulations affecting their products or technologies:

- STAM: Law about hydroponic and aquaponic still in the phase of proposal
- IKH: It would be nice to see a kind of certification entering the agriculture domain when it comes to robotics. For example a BIO certification that a certain amount of pesticides have been used for this specific crops, since it was done automatically through the robot and thus easily verified about the quantity.

- GLOBAL: We would like to further develope the Ecotox Index and produce an Ecotox catalogue for the industry .
- NEOALGAE: The protocols to develop a new fertilizers or biostimulant based in new substances or microorganisms is long and expensive (for example, REACH regulation). We need to have easier procedures and legislations that help to put new product in the market.
- FERTINAGRO: Concerning both, fertilizers and pesticides, the procedures to accept a new molecule, substance or microorganism to be used as fertilizer or pesticide for biocontrol are too long and expensive. The administrative procedures can take up to 8-10 years for substances to be used as pesticides and many times, the companies decide not to put the effort on them because of the "difficulties" on that, as you have to spend a lot of money, time and PM on that and maybe, after 10 years it can be not profit-making. Concerning the use of microorganisms (bacteria, fungi and virus) in biofertilizers or biostimulants, the registration and inclusion of microorganisms not listed in the current regulation is not easy.

Table 16. Full list of protocols affecting product or technology

1. CERTH
Practical Byzantine Fault Tolerance (PBFT) [CL02] addressed by Sieve protocol [CSV16] (Hyperledger)
Enrollment certificates (E-Cert, issued by E-CA) (Hyperledger)
Transaction certificates (T-Cert, issued by T-CA) (Hyperledger)
ANSI/ISA-95 (Hyperledger)
2. CDTA
N/A
3.RISE
N/A
4. UTH
N/A
5. TILAMUR
N/A
6. AGROINSIDER
AgroInsider delivers consent forms for Participant/stakeholders of the project
7. TRILATERAL
N/A
8. MASOUTIS
EFSA *Pesticide Residue Intake Model*
9. STRATA
N/A
10. STAM
N/A
11. AGROROBOTICA
N/A
12. TELLAB
N/A
13. APEMETA

N/A
14. SEVT
EFSA *Pesticide Residue Intake Model*
15. IKH
The same protocols that are in place for the usage of pesticides apply also for the automated robotic solution for using pesticides.
16. GLOBAL2000
"PRP procedure": The Pesticide Reduction Program (Team PRP) has designed a program to alleviate the pesticide residue situation for agricultural products. The PRP has set its own upper limits (PRP-UL) for residues of pesticides on fresh fruits and vegetables. The basis for the calculation of the PRP-UL and the Sum Of Exposure (SOE) is the Acceptable Daily Intake (ADI) The ADI (Acceptable Daily Intake) is defined as the amount of a substance in relation to body weight that can be ingested daily during lifetime without any measurable health hazards. https://www.port-international.de/wp-content/uploads/2019/03/PRP-Prozedere-und-Obergrenzenlimits-2019_englisch.pdff Additionally, the ecotoxicological properties of the used pesticides will be assessed by the PRP. The core of the evaluation is an index describing the environmental impact – the "Ecotox Index" (EI). The following aspects are included in the calculation of the ecotox index: - Retention time in soil - Dwell time in water - Toxicity to: - Mammals & humans - Birds - Fish - Water organisms - Bees - Earthworms - Potential for accumulation in organic tissue: - Octanol-water partition coefficient - Bioconcentration factor Based on the assessment of the individual aspects, an index is determined for each active ingredient, which reflects its environmental toxicity. In the course of the project the index will be developed to be applicable not only on single substances but also on whole plant protection strategies.
17. NEOALGAE
UNE 142500:2017, Inputs to be used in organic plant production. Fertilizers, soil conditioners and substrates
18. FERTINAGRO
ENAC for Fertinagro Biotech S.L.
UNE-EN 15662:2019 Method for the determination of pesticide residues by GC/LC. QuECheRS Method.
19. SIDROCCO
http/https
IEC 60870-5-104
Modbus
DICOM
20. AGROVAST
N/A

Below is presented the changes that consortium members would like to see in the protocols affecting their products or technologies:

- CERTH: "IoT protocols: LoRaWAN, Mobile Communication: (2G-GSM, CDMA.-3GUMTS, CDMA2000, 4G-LTE) ,SigFox, ZigBee IEEE 802.15.4, Wi-Fi IEEE 802.11 a/c/b/d/g/n
- SID: Add new IoT protocols

Table 17. Full list of Datasets affecting product or technology

1. CERTH
N/A
2. CDTA
N/A
3.RISE
N/A
4. UTH
N/A
5. TILAMUR
N/A
6. AGROINSIDER
Sentinel 1
Sentinel 2
LST
7. TRILATERAL
N/A
8. MASOUTIS
EU *Pesticides Database*
9. STRATA
N/A
10. STAM
N/A
11. AGROROBOTICA
N/A
12. TELLAB
N/A
13. APEMETA
List of validated non harmonised fertilisers (accepted in Portugal) last update 13/12/2021
List of basic substances authorized for use as pesticides for Organic Agriculture last update 11/12/2018
14. SEVT
EU *Pesticides Database*
15. IKH
A number of datasets will be used for training the recognition of algorithms of the different pests and deceases. Some are free and some are paid.
16. GLOBAL2000

"The analysation is based on maximum residue levels defined by the EU and stricter upper limits, based on the ADI. Info can be found in the open source protocol on the left. Most important dataset is the *EU Pesticide Database* Most important Dataset for the calculation of the Ecotox Index is the *Pesticide Properties Database*
17. NEOALGAE
Digital / informatic system (software) for internal control of production, stocks, raw materials, etc.
18. FERTINAGRO
Fertinagro Biotech datasets (Know-How)
EU MRL's for Pesticides
19. SIDROCCO
SPEAR dataset (closed)
CyberSANE dataset (closed)
20. AGROVAST
N/A

Below is presented the changes that consortium members would like to see in the datasets affecting their products or technologies:

- AGROINSIDER: Sentinel 5p satellite data
- IKH: The more datasets we have the better the detection will be. This is a non stop struggle
- SIDROCCO: Add new datasets to enhance the perfomance of the tool and add new datasets to increase the resilience of the tools

Table 18. Full list of Standards affecting product or technology

1. CERTH
ISO/TC 307 (Blockchain and distributed ledger technologies)
ISO 20022 (Hyperledger)
GAEC standards (Agriculure DSS)
2. CDTA
N/A
3.RISE
N/A
4. UTH
N/A
5. TILAMUR
N/A
6. AGROINSIDER
Management of RDI activities and certification standards - *NP 4457: 2007*
7. TRILATERAL
N/A
8. MASOUTIS
BRC Global Food Standard
IFS Food

FSSC 22000
ISO 22000
SQF
ISO 22005:2007
SYNERGY 22000
https://pp1.eppo.int/
9. STRATA
The overall principles, frameworks, requirements, and guidelines that STRATAGEM is following are provided by ISO 14040 and ISO 14044 on life cycle assessment. These are the leading international standards on life cycle assessment (LCA). They focus mainly on the process of performing LCA, following a product's impact from cradle to grave. ISO 14040 describes the "principles and framework for LCA", while the ISO 14044 "specifies requirements and provides guidelines" for LCA.
10. STAM
ISO/TC 282/SC1 (Treated wastewater reuse for irrigation)
11. AGROROBOTICA
N/A
12. TELLAB
ISO 17025 and ISO 9001
13. APEMETA
N/A
14. SEVT
BRC Global Food Standard
IFS Food
FSSC 22000
ISO 22000
SQF
ISO 22005:2007
SYNERGY 22000
https://pp1.eppo.int/
15. IKH
N/A
16. GLOBAL2000
N/A
17. NEOALGAE
Hazard analysis and critical control points or HACCP (this is only for food products)
FSSC 22000, certification Scheme for Food Safety Management Systems based on existing standards for certification (ISO 22000, ISO 22003 and technical specifications for sector PRPs), applies only for food products
Ecological certification (CAAE), agriculutral inputs for organic farming
18. FERTINAGRO
UNE-EN ISO/IEC 17025:2017
ENAC acredited laboratory: 1400/LE2599 Ensayos de productos agroalimentarios
19. SIDROCCO
SiVi follows the guidance of ISO/IEC TS 27008:2019 related to "information security management systems controls" that are selected through a risk-based approach for security management.

20. AGROVAST
N/A

Table 19. Full list of Good practices applying to product or technology

1. CERTH
Comprehensive DLT security approach to provide guidance and practices respective to securing account access with the use of cryptographic hash functions, standard authentication methods, and bridging the security gap between DLT and traditional IT environments. (Hyperledger)
Identify Stakeholders, Objectives, and Risk Tolerance (Problem Formulation or Decision Structuring) (Agriculture DSS)
Model Linkages Across Interventions, Physical Outcomes, and Objectives (Agriculture DSS)
Analyze Tradeoffs in Criteria Across Alternatives (Agriculture DSS)
2. CDTA
Those which are unique to the agricultural framework
3.RISE
N/A
4. UTH
N/A
5. TILAMUR
Use of doses of minimal fertilizer, yet sufficient to meet the demands of crops.
Phytosanitary treatment equipment not registered in the Register will not be used. Agricultural Machinery Officer (R.O.M.A.), as indicated in the Royal Decrees 1702/2011 and 1311/2012
6. AGROINSIDER
The data collected is stored on a secure, private, cloud-based server that is maintained on a routine basis. Regular data backups are performed on suitable systems.
7. TRILATERAL
"*Ethics by Design and Ethics by Use approaches for Artificial Intelligence* - This Guidance concerns all research activities involving the development or/and use of artificial intelligence (AI)-based systems or techniques, including robotics.1 It builds on the work of the Independent High-Level Expert Group on AI and their 'Ethics Guidelines for Trustworthy AI' as well as on the results of the EU-funded SHERPA and SIENNA projects.2 This document offers guidance for adopting an ethically-focused approach while designing, developing, and deploying and/or using AI based solutions. It explains the ethical principles which AI systems must support and discusses the key characteristics that an AI-based system/ applications must have in order to preserve and promote.
8. MASOUTIS
N/A
9. STRATA
N/A
10. STAM
N/A
11. AGROROBOTICA
N/A
12. TELLAB
Good laboratory practice (GLP)

13. APEMETA
"*Good practices Code for Agriculture* (2018) to be used on Vulnerable Areas, identifying the measures that have been established to prevent and reduce water pollution by nitrates from agricultural sources, however some also contribute to soil protection and to reduce air pollution. Main focus are General principles of rational fertilization; Fertilizers containing nitrogen and their behavior in the soil; Fertilizers containing phosphorus and their behavior in the soil; Application of fertilizers containing nitrogen (quantities, times and techniques); Application of fertilizers containing phosphorus (quantities, times and techniques); Application of organic correctives; Application of fertilizers in special situations, namely on sloping terrain; saturated with water, flooded, frozen or covered with snow and in the vicinity of water courses; Aspects of land use and management related to nitrogen and phosphorus dynamics; irrigation management; Fertilization plans and registration of fertilizers used on the farm; Storage and handling of inorganic fertilizers; Storage and handling of livestock effluents. "
14. SEVT
N/A
15. IKH
N/A
16. GLOBAL2000
N/A
17. NEOALGAE
The principles of green Chemical
The principles of circular bioecomy
Compliance with internal work and manufacturing instructions
18. FERTINAGRO
Reducing the loss of nutrients
Multiresidual tests on all raw materials to avoid any hazardous or potentially hazardous residue on them.
Te use of bio circular economy materials
increase soil biodiversity
The ones specified in regulations and protocols
19. SIDROCCO
Regular data backups are performed on suitable systems.
Access to SiVi tool is granted only to authorised personnel.
SiVi offers a role-based access control (R-BAC).
20. AGROVAST
N/A

Below is presented the changes that consortium members would like to see in the good practices affecting their products or technologies:

- IKH: A list of good practises of when an automated robot is beneficial in agricutlure is very much needed. The robots are not suited for all tasks.
- SID: Add more good practices to protect the privacy of the clients

Table 20. Full list of Guidelines applying to product or technology

1. CERTH
N/A
2. CDTA
N/A
3.RISE
N/A
4. UTH
N/A
5. TILAMUR
N/A
6. AGROINSIDER
All information is confidential, only known to workers during the employment relationship for an unlimited period - even after the employment relationship ends. Confidential information is only used by AgroInsider. All access to cloud-based server files is granted by invitation only.
7. TRILATERAL
N/A
8. MASOUTIS
N/A
9. STRATA
ILCD (EU) on life cycle assessment: The International Reference Life Cycle Data System (ILCD) handbook, which was developed by the European Commission Joint Research Centre, offers technical guidelines on conducting detailed LCA studies. It contains detailed descriptions and requirements in order to reduce flexibility in choices and to support the consistency of LCA results and quality assurance related to these. It is consistent with the ISO 14040 and 14044 LCA standards.
Aditionallly for the LCC, it will be used as reference guideline the Code of Practice suggested by SETAC “Environmental Life Cycle Costing”
For the s-LCA, Guidelines and Methodology Sheets provided by the UNEP / UNEP-SETAC related to SLCA, in accordance with the LCA and LCC systems in terms of goal and scope, inventory and boundaries will be followed.
10. STAM
CEAP (Circular Economy Action Plan)
11. AGROROBOTICA
N/A
12. TELLAB
N/A
13. APEMETA
2019 *Guide for water reuse* for non potable uses which complements the National Law Decree 119/2019, framing the models for WfR production and use, defining procedures for licensing and guidelines for risk assessement and management. Considers water reuse from hidroponics
2016 *Procedure for conformity validation* of fertilisers to be used in Organic Agriculture for non harmonised fertilisers
Information *Notice 1/2018* on Organic Agriculture and the of Phytoparmaceuticals and Basic Substances
Information *Notice 1/2017* on Organic Agriculture - use phytopharmaceutical products, that briefly explains the regulatory framework for phytopharmaceuticals use and how to proceed for requiring authorization for introducing new phytopharmaceuticals in the market
14. SEVT
N/A
15. IKH

N/A
16. GLOBAL2000
N/A
17. NEOALGAE
Pest control
Control of raw materials
Control of packaging
Control of microalgae cultures
18. FERTINAGRO
The ones specified in regulations and protocols
19. SIDROCCO
SiVi can be offered as SaaS (Software as as Services) or deployed in-site.
20. AGROVAST
N/A

Below is presented the changes that consortium members would like to see in the good practices affecting their products or technologies:

- SID: Follow additional international guidelines on security and privacy.

8 Annex 2: Questionnaire

PestNu Questionnarie for Technical Partners - key barriers

In Task 1.2 we are trying to identify the main reasons behind the current lack of adoption of similar innovations, and identifying the key barriers to their relevant technologies implementation.

Partners will propose system thinking approaches for PestNu solutions and innovative system features, roadmap and a list of recommendations to give further directions for the PestNu work according to regional, national and EU contexts.

In this qustionnarie we ask you about your product and the market you operate in.

We kindly request answers to the questions by Friday 24 June. Don´t hesitate to contact us for any questions, thanks in advance.

1. E-post *

2. 1. Your company is a developer of: *

Markera alla som gäller.

- ☐ Precision Agriculture tools
- ☐ Precision Agriculture software
- ☐ Organic farming products
- ☐ Övrigt: _____

3. 2. What is your company's technology/product/service? *

1/6

4. 3. What is the main barrier for introduction of your product/technology on the market? *

Markera alla som gäller.

- [ ] The customer´s lack of knowledge about the economic advantage and benefits
- [ ] Price
- [ ] Lack of interest or uncertainty in new technologies or methods
- [ ] Lack of knowledge on handling and operating new devices/instruments/technologies
- [ ] The product/technology doesn´t suit the customers challenges
- [ ] Manufacturing issues
- [ ] Legislation restrictions
- [ ] Övrigt: _____

5. 4. What solutions do you believe is better to apply to solve current problems in integrating your technologies on the field? *

Markera alla som gäller.

- [ ] Validate and demonstrate in practice on more commercial farms
- [ ] Testing and experimenting on more crops
- [ ] Testing and experimenting on geographic areas
- [ ] Testing and experimenting on different climate conditions
- [ ] Improve the technology/product
- [ ] Övrigt: _____

6. 5. What actions do you take in order to improve your product/technology? *

Markera alla som gäller.

- [ ] Enhance accuracy through software/algorithm improvements
- [ ] Enhance data export and processing time though software & hardware improvements
- [ ] More testing and optimisation before getting into mass production
- [ ] Increase the life time of the investment
- [ ] Reduction of the repayment time of the investment
- [ ] Enhance system's efficiency & productivity through better process design and targeted modifications
- [ ] Enhance system's efficiency & productivity by optimising operation conditions
- [ ] Övrigt: _____

7. 6. What actions will you take in order to reduce your product's/technology's production cost and selling price? *

Markera alla som gäller.

- [ ] New raw materials
- [ ] New hardware
- [ ] New software
- [ ] Better designed and optimized process
- [ ] Mass production -> reduce the cost per unit
- [ ] Övrigt: _____

8. 7. What actions will you take in order to increase your sales? *

Markera alla som gäller.

- [ ] Advertising / Promoting though multiple sources
- [ ] Participation in events/expositions/fairs/conferences
- [ ] Agreements with resellers
- [ ] Training activities for farmers and advisers
- [ ] Recruitment of sales managers and development of sales department
- [ ] Collaboration with marketing specialists
- [ ] Övrigt: _____

9. 8. What actions/strategy will you take in order to increase the awareness of your product/technology to farmers? *

Markera alla som gäller.

- [ ] B2B strategy
- [ ] Contracts with marketing managers
- [ ] Training activities for farmers in different regions
- [ ] Social media campaigns
- [ ] Meetings with farmers associations and big farming companies
- [ ] Agreements and collaborations with advisors, agronomists and with stores selling agricultural supplies
- [ ] Övrigt: _____

10. 9. What is your product's/technology's competitive advantage compared to the competition? *

11. 10. What feedback have you received from your customers about your product/technology? *

Markera alla som gäller.

- [ ] Useful
- [ ] Accurate
- [ ] User friendly
- [ ] Increases productivity
- [ ] Needs to be less expensive
- [ ] Needs to be improved
- [ ] Övrigt: _____

12. 11. What are the main reasons for the customer to implement a new method or buy new technologies? *

Markera alla som gäller.

- [ ] Something has broken and needs to be replaced
- [ ] New legislation or regulation require a replacement
- [ ] To increase efficiency and productivity
- [ ] To reduce operational costs
- [ ] To minimize production time and labour
- [ ] The company expands
- [ ] The customer is curious of new development
- [ ] Övrigt: _____

13. 12. a. What interesting trends are you aware of, in your market segment? (Provide some market insights - ie growth rate etc) *

14. 12. b. What opportunities do you see coming from changes in technology, government policy or regulations? *

15. 13. a. Are standards or specifications need to be changed in order to adapt your technology/product to current customer needs? *

Markera endast en oval.

- ◯ Yes
- ◯ No
- ◯ Övrigt: _____

16. 13. b. If yes, what needs to be changed?

17. 14. Do Current EU and regional legislation & regulations help market release of your product/technology? *

Markera endast en oval.

- ◯ Yes
- ◯ No
- ◯ Övrigt: _____

18. 15. Are there any specific actions that need to be taken from European and National policy making bodies in order to help market release and boost sales of your technologies and products in the near future? (Specify what actions shall be taken and what regulations need to be changed) *

_____

19. 16. Is there any specific legislation/regulations that acts as an obstacle to the free movement/launching of your products and technologies in the market? *

_____

1. Your company is a developer of:

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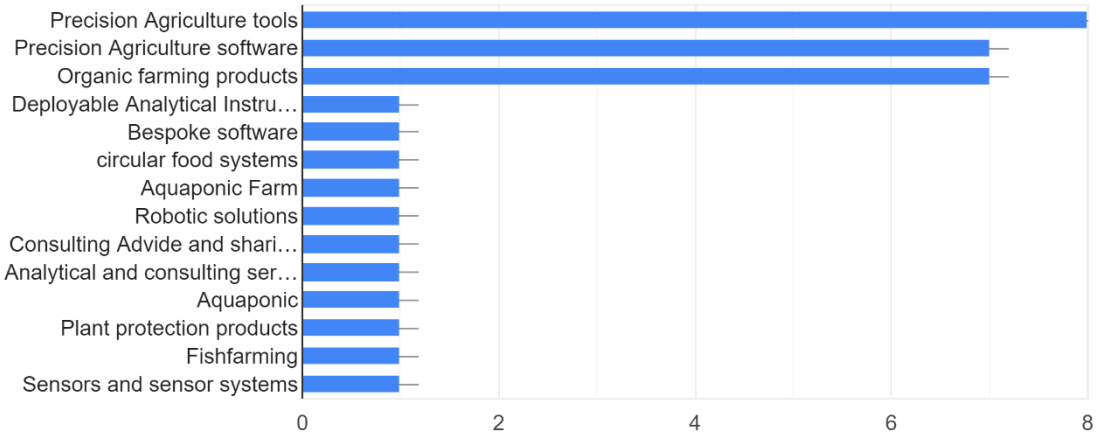
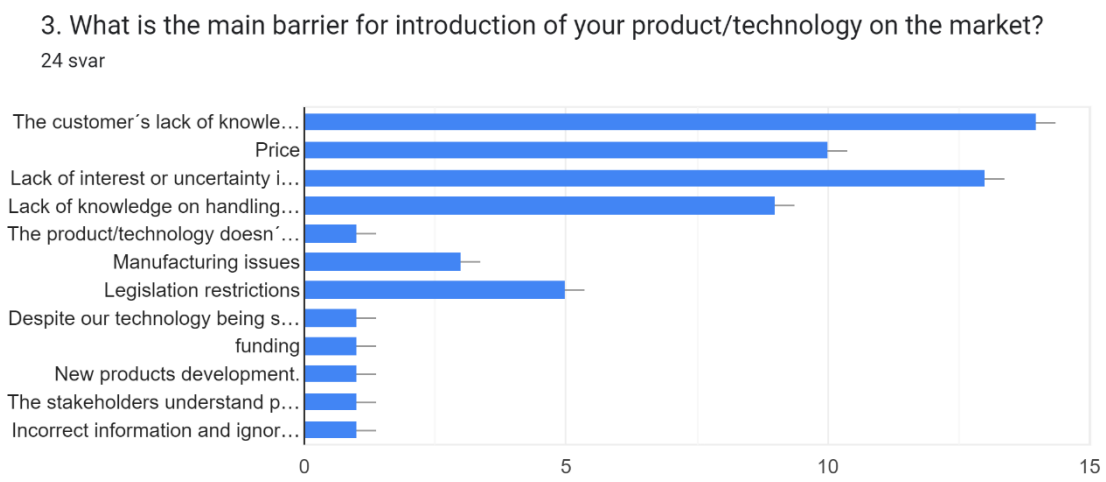


2. What is your company's technology/product/service?

Nutrient Analyser for Monitoring of Water Systems and Environments
SiVi (Sidroco Visualization)
robotic sensors
We produce circular food systems, with at its heart aquaponics
fruit orchards surveillance robotics
Wastewater treatment with microalgae
biostimulants from microalgae
Fish Vegetables
Robotic solutions; service robots H/W and S/W
Consulting Advice and sharing products for DIY Aquaponic Gardening
Analytical and consulting services.
waste treatment
AgroInsider a company specialized in precision agriculture and in the carbon market. AgroInsider´s app - SmartAG - is a smart precision agricultural tool, that combines the carbon map and biodiversity tools.
Fertilisers, biostimulants and biocontrol products
SpyFly AI Remote Pest Monitoring System
We create end to end service robotics and specifically robots for precision agriculture
Beef and Dairy sheep tools
Fisch / Vegetables in an closed circle
Formulation of plant protection products that van be used in conventional or organic farming
Indoor fish farming in RAS recirculation systems
Flow cytometers for detection of bacteria and microalgea
soil reports / biochar / fermented compound
AI Virtual Industrial Assistant
E-books, products and service of small-scale aquaponics



The customer´s lack of knowledge about the economic advantage and benefits
Price
Lack of interest or uncertainty in new technologies or methods
Lack of knowledge on handling and operating new devices/instruments/technologies
The product/technology doesn´t suit the customers challenges
Manufacturing issues
Legislation restrictions
Despite our technology being superior in terms of performance and robustness compared to other commercial systems brand recognition is a challenge and a slow process. Extended trials are requested by customers prior to purchasing of systems. Competition is often against well established brands of large multi-national companies with large financial backing.
Funding
New products development.
The stakeholders understand perfectly our product - SmartAG - however he doesn't have time / doesn't want to waste time with all the information available in the application. He prefers to have a consulting service that tells/confirms him what to do.
Incorrect information and ignorance of the matter

4. What solutions do you believe is better to apply to solve current problems in integrating your technologies on the field?

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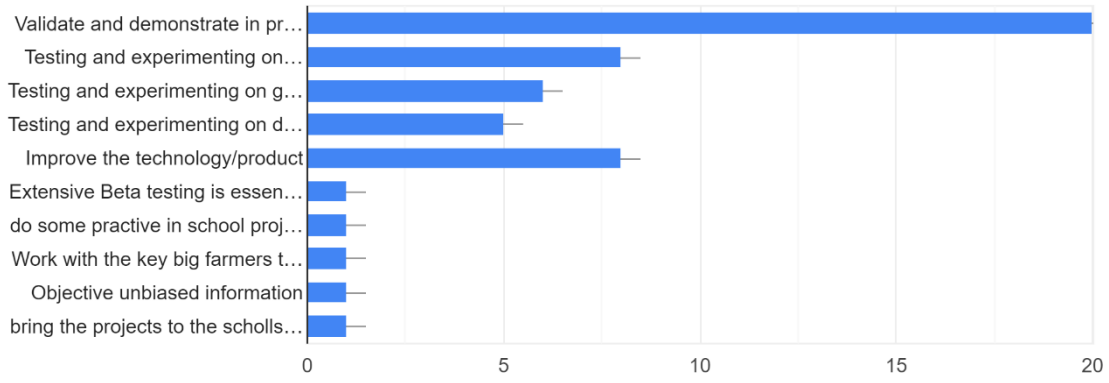

Validate and demonstrate in practice on more commercial farms
Testing and experimenting on more crops
Testing and experimenting on geographic areas
Testing and experimenting on different climate conditions
Improve the technology/product
The respondent's own additions to suggested solutions:
Extensive Beta testing is essential and the learnings from this testing should be implemented into system.
Do practice in school projects (Build small Aquaponic System as a school class project)
Work with the key big farmers that will attract the other target farmers
Objective unbiased information
Bring the projects to schools, work together in class projects

5. What actions do you take in order to improve your product/technology?

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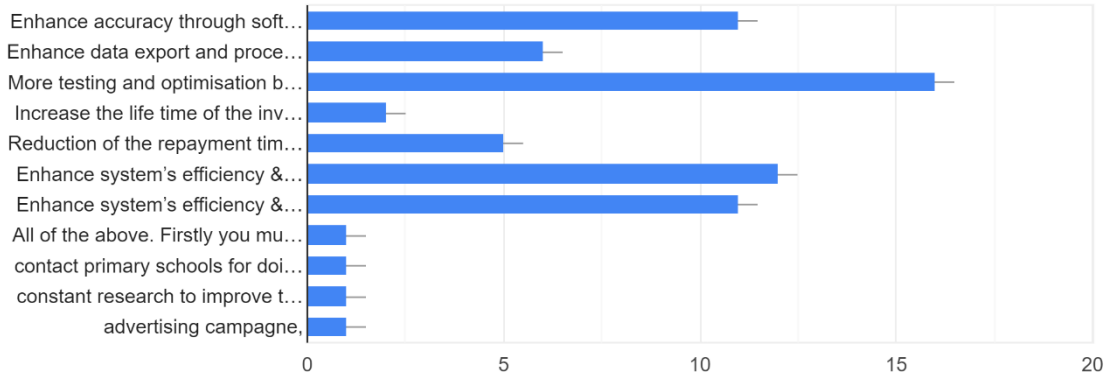

Enhance accuracy through software/algorithm improvements
Enhance data export and processing time through software & hardware improvements
More testing and optimisation before getting into mass production
Increase the lifetime of the investment

Reduction of the repayment time of the investment
Enhance system's efficiency & productivity through better process design and targeted modifications
Enhance system's efficiency & productivity by optimising operation conditions
The respondent's own additions to actions:
Contact primary schools for doing small projects together
Advertising campaign
Constant research to improve the husbandry conditions on the farm

6. What actions will you take in order to reduce your product's/technology's production cost and selling price?

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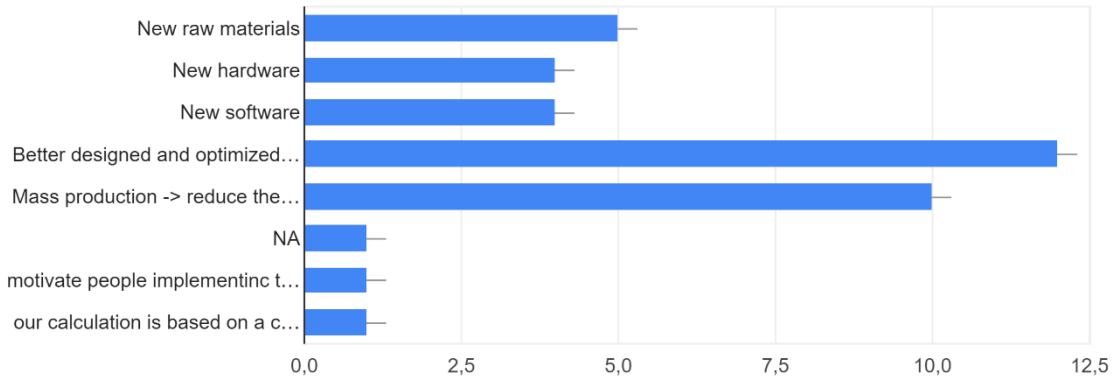
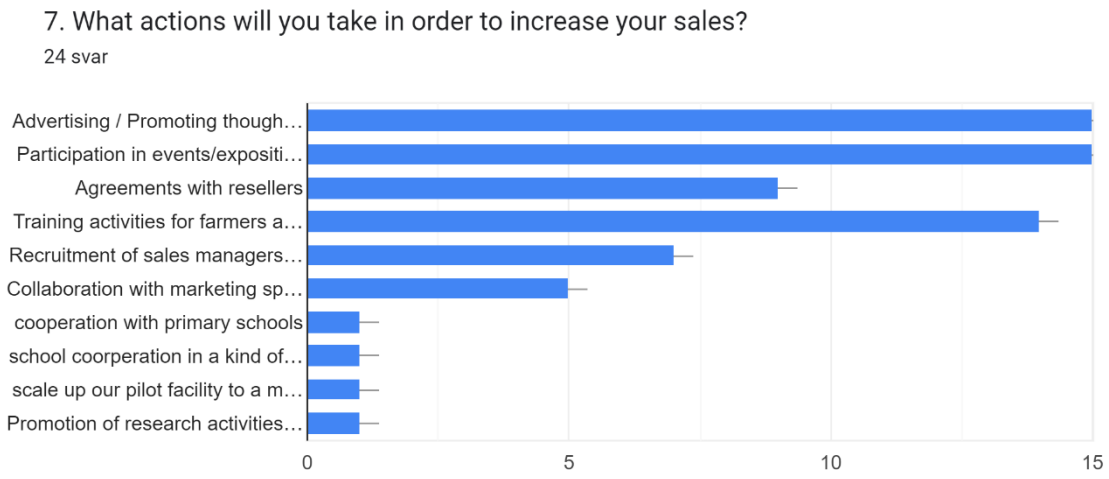
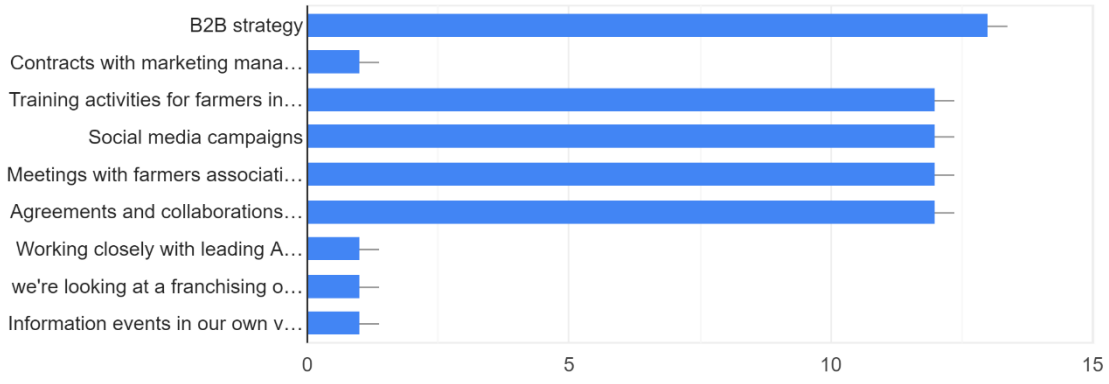


New raw materials
New hardware
New software
Better designed and optimized process
Mass production -> reduce the cost per unit
The respondent's own suggestions:
Motivate people implementing their own systems (Small Scale aquaponics) themselves
NA
Our calculation is based on a competitive market price, with no intention of generating more income by increasing the stocking numbers



Advertising / Promoting through multiple sources
Participation in events/expositions/fairs/conferences
Agreements with resellers
Training activities for farmers and advisers
Recruitment of sales managers and development of sales department
Collaboration with marketing specialists
The respondent's own suggestions:
Scale up our pilot facility to a more automated PoC before scaling up to a much larger facility
Cooperation with primary schools
Promotion of research activities
Expansion of marketing measures
Employee training
Maintaining the customer base
School cooperation in a kind of class project



B2B strategy

Contracts with marketing managers
Training activities for farmers in different regions
Social media campaigns
Meetings with farmers associations and big farming companies
Agreements and collaborations with advisors, agronomists and with stores selling agricultural supplies
The respondent's own suggestions:
Working closely with leading Aquaculture organisations
Look for a franchising option in the long term
Information events in own visitor centre for everyone and seminars for gastronomy and hotel industry, seminars for specially interested audiences' and events for schools

9. What is your product's/technology's competitive advantage compared to the competition?

Only deployable analyser in the world to provide nitrite and nitrate measurement in a single run. Accredited system to ISO 14034 in terms of accuracy and precision. More robust, more easily installed and maintained. Can be deployed in any water matrix
Custom solutions to the needs of each client. Continuous technical support.
novelty product, autonomous cable bot
Combining modern fish farming with new vertical growing technology, use of insects in our fish food and a very strong team = truly circular food production
Higher data rate, better quality of sensor data and immediate awareness and orchard status
Modularity and flexibility, off-grid system
Improvement of crops production and decrease the environmental impact
Bigger Production
AI-based software robust and efficient enough for field/agricultural robots
Small scale aquaponic is not widely spread in Austria, there are only a few companies which are dealing with that topic
Solving and managing quality problems-troubleshooting.
High quality of products, post sales follow-up, custom sale
User friendly; data updated at least once a week; includes radar data that is very useful in cloudy areas; can be used in offline mode in areas without cellular service or internet.
Organic certified
Reliability Quality Design Accuracy of detection
Robotics in precision agriculture is a technology on the rise. Our solution has the competitive advantage of being able to operate in unstructured environment, fully autonomous and with high level of accuracy.
Improve efficiency and decrease carbon footprint
Only Aquaponic system
Bets fit will current market request
Innovations in fish farming in general, Adoption of own research results in the rearing programs of the individual sections
Price and performance to match the needs and resources of the user
knowledge of soil microbiology and knowledge of spectral readings
Artificial Intelligence
Different technology

10. What feedback have you received from your customers about your product/technology?

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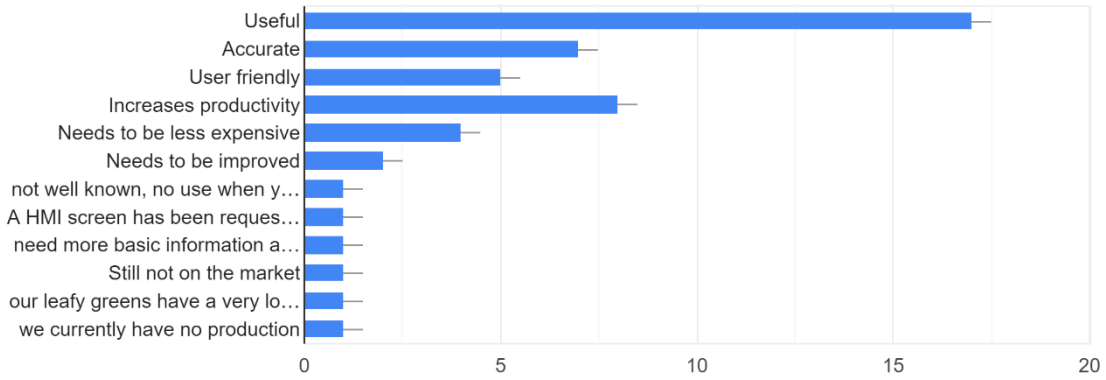

Useful
Accurate
User friendly
Increases productivity
Needs to be less expensive
Needs to be improved
A HMI screen has been requested for inclusion on the analyser
our leafy greens have a very long shelf life, taste fantastic and look good
Still not on the market
not well known, no use when you can do the same things in soil
we currently have no production
need more basic information about fish and plants

11. What are the main reasons for the customer to implement a new method or buy new technologies?

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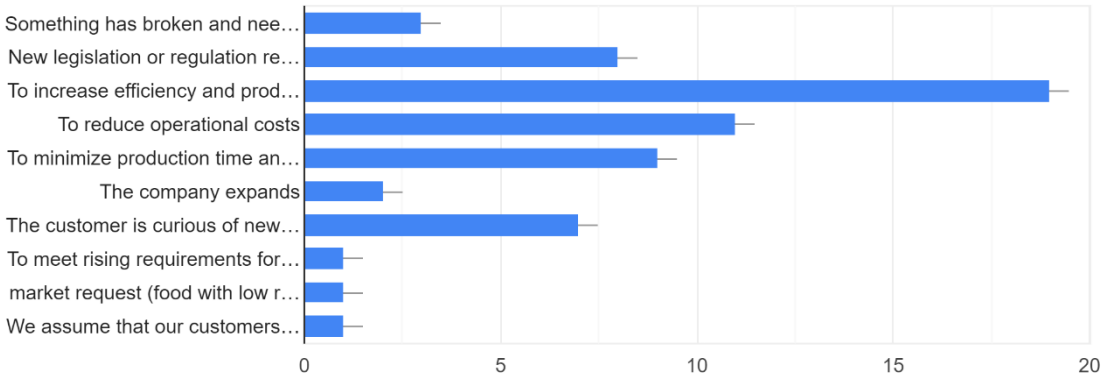

Something has broken and needs to be replaced
New legislation or regulation require a replacement
To increase efficiency and productivity

To reduce operational costs
To minimize production time and labour
The company expands
The customer is curious of new development
To meet rising requirements for bio-products more easily
The respondent's own suggestions:
Market request (food with low residues)
We assume that our customers will only set the quality standard for our products

12. a) What interesting trends are you aware of, in your market segment?

N20 emissions is a growing area of concern in terms of climate change and nitrite and nitrate monitoring aids in mitigating N20 emissions. Having information on nitrite and nitrate in Aquaculture systems allows for optimisation of the process in terms of feed and treatment by the biofilter in RAS.
1) The agriculture drones market is projected to grow at a CAGR of 32.49%. 2) The adoption of analytics in agriculture has been increasing consistently; its market size is expected to grow from USD 585 million in 2018 to USD 1236 million by 2023, at a Compound Annual Growth Rate (CAGR) of 16.2%
prefer not to answer
customer awareness for locally grown food in Sweden is increasing very fast – both private consumers and the restaurants we supply are willing to pay a higher price for this
none
The global market for Algae estimated at US$782.9 Million in the year 2020, is projected to reach a revised size of US$1.2 Billion by 2027, growing at a CAGR of 6.2% over the analysis period 2020-2027. https://www.prnewswire.com/news-releases/global-algae-market-growth-trends-to-2027-stringent-regulations-for-wastewater-remediation-drives-increased-demand-for-algae-as-a-eco-friendly-substitute-for-chemicals-301192046.html
abiotic stress tolerance, crop quality improvement, nutrition efficiency improvement
Price Increase
the growth rate for robotic solutions in agriculture increases
traditional farming will change in future, so we will improve and develop additional methods for example aquaponics in cities for getting enough food and vegetables for the whole world population
Efsa Primo guidelines.
sustainability philosophy of the company applied in the develop of new products
Carbon farming, evidence record, blockchain, certification, innovation.
growth market, production, price changes
Italian Precision farming market is growing at 23% over the last 2 years. In numbers the market has exploded, going from 540 million euros in turnover in the first half of 2020 to 1.3 billion at the end of 2020, up to 1.6 billion in 2021 (+ 23%)
According to Boston Consulting Group (BCG) Robotics Outlook 2030, professional services robots will dominate the sector. Professional services robots will have sales that may be more than double those of conventional and logistics robots. BCG expects the global robotics market to climb from about $25 billion this year to between $160 billion and $260 billion by 2030, with market share for professional services robots hitting up to $170 billion and industrial and logistics robot sales topping off at about $80 billion
Awareness regarding emissions impact in cattle production.
None
Global population growth rate forces an increase of food production. Plant protection product is a critical component to improve productivity.

The production volumes in aquaculture are increasing to a significant extent. Fishing from wild catches is declining more and more, as the stocks are overfished to the point of threatening their existence
An increased interest (and many new companies) in the field of cultured microalgea with applications in different fields (e.g. nutrition, cosmetics, fertilisers etc.) as well as concern for increased occurrence of toxic algea blooming in sweet and sea water. For both fields, it will be useful to have access to an affordable and autonom instrumentation for quantification/identification of microalgea/cyanobacteria that can measure and communicate the result from remote locations. The other main field for our flow cytometer is bacterial detection. Here, a large interest lies in quality of drinking water and on-line detection of contamination of drinking water with sewage. This can be achieved by a general bacterial detection (such as xxxx) but even better with a specific detection of E. coli with our flow cytometer as a marker for sewage.
sustainability; biologic;
Predictive Maintenance Automation Virtual Assistants
Environmentally friendly, future technology, a part of the solution to feed the expanding world population

12. b) What opportunities do you see coming from changes in technology, government policy or regulations?

Tighter legislation on emissions from WTPs and agricultural sites are needed and deployable analysers to monitor emissions in real time are needed
The new regulations to minimise water consumption could create an opportunity for us to establish a smart farming solution.
prefer not to answer
The price of grow lights will hopefully come down in the near future
better yield using new tech
It is in line with the Common Agricultural Policy (CAP) that takes action on the protection of nature and safeguarding the biodiversity.
to be able to market new products in a easier way
Local production
help in the boost of AI and robotics solutions utilization in agriculture
see question above
Production on ECO friendly products for human consumption.
increase of organic farm
SmartAG will be an essential tool to meet European (Green Deal and Farm to fork) and national policies because allows to calculate a farmer's carbon balance by farm, plot or type of crop, records evidence via blockchain that will serve to certify the farmer to buy or sell carbon credits on the voluntary carbon market.
Shorter processes for certification and regulation of products, substances, molecules and microorganisms to be used in organic farming
Most of all an substantial sales increase, after an substantial interest by the regulator on Biological food.
Robotics is a diverse sector with many moving parts, and what its future will look like is a complex question. To offer an insight we again looked to well-known and established international consultants. So, BCG did a deep dive into the robotics industry and the potential for old and new players to grow over the next decade. BCG's very concise conclusion: robotics has significant upside potential. But a more-nuanced analysis is that to succeed, established companies manufacturing machinery and industrial automation hardware and software must be both dexterous and aggressive, prepared to take advantage of new strategic and technological directions that will likely become more important as 2030 approaches but may not be their traditional strengths. Meanwhile, smaller rivals and start-ups will be pushing innovation in areas that

have the potential to generate high profits and alter the dimensions of the robotics industry. But the speed with which they will be able to transform the trajectory of the field is still a wildcard.
Decrease products carbon footprint.
None
In EU Future regulatory restrictions will force a change in market of PPP
A change in government policy would improve almost everything, but this is hardly to be expected under the current constellations
Development in technology will make it possible to make devices smaller, cheaper and more user friendly. New technology also makes it possible to come up with and implement new regulations that in turn booster the market. Government policy can play a role in stimulating specific areas of technology development, or more generally such as promoting "digitalization".
increased demand for organic products; Concern about soil degradation
I don't know yet. We're working to find out.
Environmentally friendly technologies are going to be supported, to feed the cities with growing food in the cities to avoid transport an co2 emissions in the future

13. a. Are standards or specifications need to be changed in order to adapt your technology/product to current customer needs?

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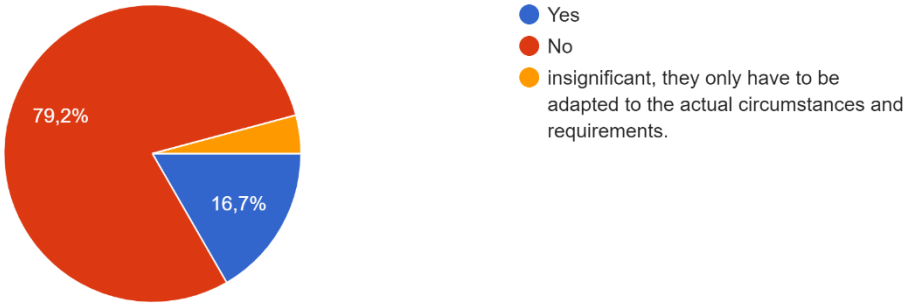

13.b Respondents' suggestions for what should be changed in standards and specifications and If yes, what needs to be changed?

New Organic Directive
To respond to the problems that farmers come up with daily.
Feed supply, grazing methods, animal selection and additives.
especially in the field of fish farming, the subject of factory farming. a) what is factory farming in fish farming b) Feeding / processing of slaughterhouse residues into fish feed It is a phase that the BSE law applies to fish finds!!!
Detection of microalgea and specific bacteria.

14. Do Current EU and regional legislation & regulations help market release of your product/technology?

24 svar

The specific actions that needs to be taken by European or national policy makers.

I don't know yet. We're working to find out.
In concrete terms, neither the EU nor national authorities should constantly interfere in economic processes. The EU's homework is to protect stocks in the seas, lakes and rivers, should abuse be put under strict control. Impossible husbandry conditions in the Southeast Asian countries should be put under control, here the impossible pricing is generated, which has a ruinous effect on the local fishing industry. So, there would be a wide field of activity for the EU to bring about improvements!
New Organic Directive so that aquaponic system is also organic
No
No.
None
Not really.
Regulation (EU) 2020/74; D.lgs. n. 185 del 2003 (ITA);
Simplify the application and admission procedure of the product as category 4.0, granting a tax incentive in the form of a tax credit for buyers
The actual framework (Green Deal and Farm to Fork) will be a game changer in near future
The rules and regulations with regard to organic certification should be updated or a new label should be created to reflect aquaponic, circular food production
This is secondary. a good boost of the technology is still needed.
We have deployed units analysing the final effluent of a range of WWTPs and the nitrite and nitrate levels were nearly 5 times above EU legislative level, yet no action was taken as the facility was not required to monitor for nutrients in the final effluent. Real-time, continuous monitoring of nutrient pollutants from and in water systems and facilities should be a legislative requirement to effectively battle eutrophication and environmental destruction and economic impact.
Autonomous systems need to be OK to use anywhere if run below 5 km/h
Bring the knowledge of aquaponic gardening to schools
Help companies to put in the market new products or molecules, and get organic certifications
Less bureaucracy
not aware of any
not for me
use drones to spray crops; streamline the law to place biological products on the market

Proposals for specific laws and regulations that acts as an obstacle to the free movement/launching of the respondents' products and technologies in the market

GDPR is a problem because we are not allowed to use data from previous clients to new models.
I don't know yet. We're working to find out.

N/A
NO
NO
No
None
Not really
Regulation (EU) 2020/74; D.lgs. n. 185 del 2003 (ITA);
See above
New European regulation will difficult negotiations with customers
no
not aware of any
not sure about that
there are a myriad of regulations and laws that are difficult for the producer to understand and certainly not comprehensible! Lengthy approval procedures that lead to massive delays due to lack of knowledge among officials. I don't know of any official who is directly involved in an approval process and knows about aquaculture!!!! Therefore, everything is put on the back burner so as not to have to make a decision .....
Yes because it's so complicated the new rules for fertilizer products - new law July 16

PestNu

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