Jaarrapportage 2020 – PPS Precisielandbouw 4.0

Project Information

1.1 funding *(select one option)*	WR-PPS (WR-capaciteit)
1.2 Project number	AF 18101
1.3 Project title	Precisielandbouw 4.0 (PL4.0): op naar data-gedreven landbouw door versterking datapositie van de boer. - fase 1 PL4.0: Haalbaarheidsstudie - fase 2 PL4.0: Use cases/Implementatie
1.4 Project leader *(Name and e-mail address)*	Until 31/12 2020: Eisse Luitjens on behalf consortium PL4.0 (e.luitjens@noorderzijlvest.nl) Per 1/1/2021: André Hoogendijk (hoogendijk@bo-akkerbouw.nl) Corné Kempenaar on behalf research institutes (corne.kempenaar@wur.nl) 2e contact Bert Philipsen (bert.philipsen@wur.nl)
1.5 Start date (*dd-mm-yyyy)*	1-09-2019
1.5 End date (*dd-mm-yyyy)*	31-12-2023
1.7 Primary MMIP *(MMIP number and name; see overview in Appendix 1)*	ST1 Smart Technology Agri-Horti-Water-Food
1.8 Secondary MMIP *(only fill this in if there is a second MMIP that the project is contributing to)*	

2. Project Description

2.1 Summary *Provide a brief summary of what the project entails and aims to achieve. It is a publicly available summary (target, contribution to the mission, results to be delivered in terms of knowledge for target group x and the partners in the project).*
The farm data space is relatively poorly developed compared to the tools and infrastructures chain partners have. The PPP aims to develope the farms data space to allow for smart, safe, transparent and ‘ in control’ data use on farms and between farms ad value chain partners. In phase 1 of the project, from sept. 2019 until mid 2020, a feasibility study is done to describe data use in field crop management (focus on arable crops and feed production), issues and solutions. Phase 1 ends with a plan for the PPP for the succeeding 3 years. Below we show the phase 1 partners of PL4.0 (top 3 rows) and the partners that joined end of 2020 (bottom 2 rows)

2.2 Project target *What will the project contribute to the objectives of the KIA, the missions, and the MMIPs?*

PPP PL4.0 is an ST1 project. It contributes to better understanding of the farm and agrifood data space and improvement interoperability of data at farm and chain levels. In this way, it paves the way for mature data-driven agriculture and agrifood.
The results of PL4.0 will contribute to more sustainable and circular agriculture and agrifood.

2.3 Motivation *Describe why this project is appropriate and necessary within the MMIP.*

The unbalanced data position of farmers in the agrifood data space hampers adoption of data-driven farming. There are technical and organizational issues. Issues on both categories will be identified and solutions will be suggested. In phase 2 use cases will be implemented in which we work with technical solutions that comply with code of conduct for data use and sovereignty, and show benefit for farms, agrifood chains and society.

2.4 Result *Describe the intended results of the project as SMART as possible. These include results in terms of content (regarding question 2.2) and results such as meetings and reports. Include the timeline per year whenever possible.*

PPP PL4.0 had three main deliverables in phase 1:

- A feasibility report on issues and solutions for the agrifood data space;
- Extension of the consortium with chain partners;
- A workplan for phase 2 of the PPP.

Annual Report (please also fill this in for the final year)

3. Project Status

3.1 Project status *(select one option)*	Project is on schedule
3.2 Explanation including predicted changes to the original work plan	The feasibility report was delivered in October 2020. And the PPP is extended with more partners and uses cases for phase 2 (2021-2023). A signed addendum to the consortium agreement of the PPP is planned for February 2021.

4. Achieved results

4. Brief description of the results and their contribution to the MMIP (as described in 2.2)
The core of the analysis presented in the feasibility study is that farmers must work with a patchwork of ICT tools that are poorly interconnected, making it virtually impossible to bring together data generated on their farms in a user-friendly data space from which they can use the data for smart farming. Key issues are data sovereignty (control over data) and interoperability (being able to link data and systems). The report describes (1) the current situation of data use on arable and feed production, (2) technical, organizational, ethical and legal aspects of data use and (3) a bottleneck analysis of data use on farms and contracting companies. To resolve the bottlenecks, we make eight recommendations. The most important one is to make public-private agreements on architectural principles of a technical and organizational nature. These agreements form the basis for realizing the desired data space for farmers, making him a full partner in AgriFood chains. And with the desired data space, new opportunities will arise in the field of business and chain optimization, new services, and monitoring options for social goals. space and demonstrate the added value of using smart data in use cases. A workplan for PPP PL4.0 is available.
4.2 Deliverables (meetings and other output, outside of what is listed in 4.3 and 4.4)
All three main deliverables were achieved.
4.3 Communication (lists)
4.3.1 Scientific articles and their DOI (*Digital Object Identifiers)*
-
4.3.2 Reports/articles in journals
Kempenaar, C., Mollema, R., Been, Th., et al., 2020. Haalbaarheidsstudie PL4.0 data-ruimte: knelpuntenanalyse datagebruik op boerenbedrijf en aanbevelingen om de impasse te doorbreken. WPR rapport. https://edepot.wur.nl/532701 (with English summary) Kempenaar, C., 2020. Smart Farming. https://magazines.wur.nl/ko-magazine2020-en/smart-farming/
4.3.3 Other communications (introductory sessions/posters/radio/TV/social media/workshops/exhibitions)
RTLZ Databoeren: https://www.rtlz.nl/tv/video/video/5019571/de-boer-moet-gaan-databoeren RVO Experttafel Digitale landbouw 17 nov. 2020. https://www.rvo.nl/actueel/evenementen/business-week-nabije-markten-energietransitie PPP PL4.0 Steering group meetings on 5 Feb., 6 July and 9 Dec. 2020.
4.4 Other results: techniques, devices, methods
-
4.5 Project website: provide the link to the project website (if available)
https://www.wur.nl/nl/Onderzoek-Resultaten/Onderzoeksprojecten-LNV/Expertisegebieden/kennisonline/Precisielandbouw-4.0.htm

Final report

5. TRL upon project completion

Technology Readiness Level (TRL) of the technology when completing the project. There are two indicators that differ in the level of detail. If possible, fill in the level of detail. If not possible, fill in the main category.

5.1 Main category *(select one option)*	Fundamental research Industrial research Experimental development
5.2 Detail category at the start of the project (*number of the category concerned, see appendix for explanation*)	
5.3 Detail category at the end of the project	

6 Project status upon completion

Project status *(select one option)*	1. The project has been completed in accordance with the original scope and all milestones were achieved. 2. The project has been completed satisfactorily, but the content of the milestones was changed. 3. The project was not completed and has been definitively terminated.

7 Output across the whole project

		Number
7.1	**Number of scientific publications achieved** *Published articles in peer-reviewed journals.*	
7.1 List	See list below 4.3.1, add articles from previous years (including DOI), if any.	
7.2	**Number of anticipated scientific publications** *Publications expected to be published in a peer-reviewed journal.*	
7.2 List		
7.3	**Number of non-scientific publications achieved** *Reports, journal articles.*	
7.3 List	See list below 4.3.2, add publications from previous years, if any.	
7.4	**Number of requested patents** *The number of patents requested on the basis of research within the project.*	
7.4 List	Provide the DOI for each patent, if available.	
7.5	**Number of licences granted** *The number of licences granted on the basis of research within the project.*	
7.5 List		
7.6	**Number of prototypes** *The number of developed prototypes on the basis of research within the project.*	
7.6 List		

7.7	**Number of demonstrators** *The number of developed demonstrators on the basis of research within the project.*	
7.7 List		
7.8	**Number of spin-offs/spin-outs** *The number of spin-offs and spin-outs resulting from research within the project.*	
7.8 List		
7.9	**Number of new or improved products/processes/services introduced** *The number of products, processes, and services that were improved or newly developed on the basis of research within the project.*	
7.9 List		

8 Impact

Impact concerns the story of the project: a qualitative description of how the project has contributed to the missions and/or the realisation of economic opportunities. Indicate what will be done with the developed knowledge/tools from the project. Explain the broader contribution of the project to the social challenge, as described in 1.4b. The impact mentioned may relate to topics such as:

- products, concepts, knowledge, etc. applied in practice by the partners, now or in the foreseeable future;
- an interesting example listed as output (section 7);
- insight into preconditions (other than knowledge and innovation) that are necessary to achieve the mission objectives (e.g. funding, regulations, communication, etc.);
- reaching partners and strengthening the networks that have been created;
- connection with practical education and other methods of dissemination.

Provide a link to the website of the project, video, or infographic (if applicable).

Describe the impact of the project, *provide a link to the project website, a video, or infographic (if applicable).*

Appendix 1 MMIP's

KIA: Landbouw, water en voedsel	
MMIP	A1 Verminderen fossiele nutriënten, water en stikstofdepositie
	A2 Gezonde, robuuste bodem en teeltsystemen gebaseerd op agro-ecologie en zonder schadelijke emissies naar grond- en oppervlaktewater
	A3 Hergebruik zij- en reststromen
	A4 Eiwitvoorziening voor humane consumptie uit (nieuwe) plantaardige bronnen
	A5 Biodiversiteit in de kringlooplandbouw
	B1 Emissiereductie methaan veehouderij
	B2 Landbouwbodems, emissiereductie lachgas en verhoging koolstofvastlegging
	B3 Vermindering veenoxidatie veenweide
	B4 Verhoging vastlegging koolstof in bos en natuur
	B5 Energiebesparing, -productie en -gebruik
	B6 Productie en gebruik van biomassa
	C1 Klimaatbestendig landelijk gebied voorkomen van wateroverlast en watertekort
	C2 Klimaatadaptieve land- en tuinbouwproductiesystemen
	C3 Waterrobuust en klimaatbestendig stedelijk gebied
	C4 Verbeteren waterkwaliteit
	D1 Waardering van voedsel
	D2 Gezonde voeding een makkelijke keuze
	D3 Veilige en duurzame primaire productie
	D4 Duurzame en veilige verwerking
	E1 Duurzame Noordzee
	E2 Natuur-inclusieve landbouw, visserij en waterbeheer in Caribisch Nederland
	E3 Duurzame rivieren, meren en intergetijdengebieden
	E4 Overige zeeën en oceanen
	E5 Visserij
	F1 Verduurzamen en kostenbeheersing uitvoeringsprojecten waterbeheer
	F2 Aanpassen aan versnelde zeespiegelstijging en toenemende weersextremen
	F3 Nederland Digitaal Waterland
	F4 Energie uit water
	ST1 Smart Agri-Horti-Water-Food
	ST2 Biotechnologie en Veredeling

Appendix 2 TRL categories

The detail categories are:
TRL 1 – basic principles have been observed and reported
TRL 2 – technological concept and/or application has been formulated
TRL 3 – critical function or characteristic has been analytically and experimentally proven
TRL 4 – component or experimental model has been validated in a laboratory environment
TRL 5 – component or experimental model has been validated in a relevant environment
TRL 6 – system/sub-system model or prototype has been demonstrated in a relevant environment
TRL 7 – prototype of the system has been demonstrated in an operational environment
TRL 8 – the actual system has been completed and has been qualified through testing and demonstration
TRL 9 – the actual system has been validated by a successful operational company

Appendix 3. Precision Agriculture 4.0: executive summary

Version: July 6, 2020, phase 1 2019-2020
Author/contact: C. Kempenaar, Wageningen University & Research
Partners: PPP PL4.0; see pag. 6,

Introduction

The added value of data-driven AgriFood chains lies in optimization and transparency of all processes from farm to fork. From a farmer's perspective, data-driven agriculture means that the farm management is optimized in a smart way by using data leading to improved economical, ecological and social sustainability. The step towards an integral application of data-driven agriculture as a business management concept, also known as Precision Agriculture 4.0 (PA4.0), is taking off on Dutch open-field crops farms more slowly than expected. The benefits are recognized by many parties, but there are bottlenecks that hamper implementation. As a result, the 'in control' sharing of data between farms and chain parties including governments remains limited. As a result, social benefits such as tracking & tracing, ecological optimization of chains and monitoring of EU CAP goals are not or poorly possible.

On the Dutch open-field crops farms, we see the following data use: **monitoring** of the status of soils, climate, crops using sensor systems, **benchmarking** of crop and farm performance; **accountability** whereby the farm submits digital information to a government, chain partner or controlling institution, and vice versa; and **optimization of operational decisions** in crop cultivations and storage. Data-driven **optimization of tactical and strategic decisions** hardly takes place yet.

Farmers and contractors experience a lack of control and sovereignty to work with data generated on their farms and machines. In phase 1 of PPP PA4.0, we carried out a study on data use by famers and contractors, the bottlenecks they face with applying data-driven agriculture, and solutions to overcome these bottlenecks. We took a technical and social approach, identifying ICT, ethical and legal issues. We summarize the results in a summary document in Dutch and English (the full report is in Dutch only so far).

Technical & organisational aspects

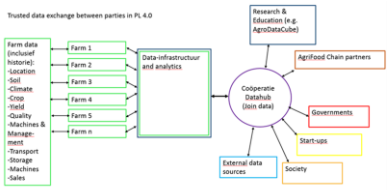
The technical and organizational preconditions for a data infrastructure on farms can be incorporated into architectural principles. There are choices on the principles to be made at 3 levels: **users/ ecosystem, data and technology**. For example, the users/ecosystem level is about data sovereignty (who owns and / or has distribution or user rights and is this organized safely), degree of (de) centralization and possibilities for user interaction. At the data level, it is about governance (= about what agreements are made) and design rules (= what is agreed). And at the technical level, it is about simplicity of exchange (interoperability) and local processing capacity.

For the bottleneck analysis, we used the Stacks (layers) of Bratton model, which distinguishes layers with components that can be assessed for enabling mature data-driven agriculture and AgriFood chains in the Netherlands. The

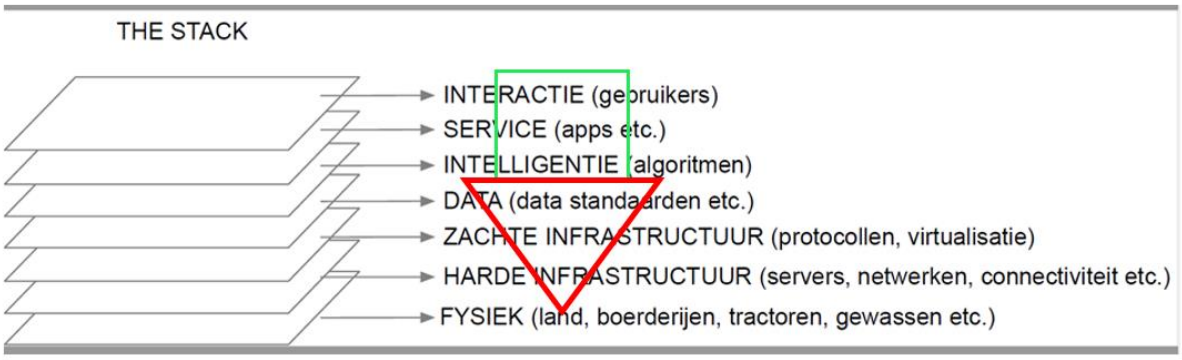
PPP PA4.0

In phase 1 of the Dutch topsector AgriFood Public Privat Project (PPP) PA4.0, an analysis was done into the reasons why data-driven agriculture on open cultivation farms as an integrated concept is so poorly taken off. This is in contrast to, for example, the dairy chain in the Netherlands, where chain optimization takes off thanks to data sharing between partners via the JoinData authorization platform. In PA4.0 with a focuss on data driven open field crops farming, bottlenecks are identified and recommendations are made on how to improve the situation. In addition, use cases are proposed to demonstrate the added value of smart data use in open field crops farms and AgriFood chains.

PA4.0 phase 1 partners: AEF, Agrimaco, AgroConnect, Branch organization Arable Farming, Cumela, Green Education via Aeres and Van Hall Larenstein, LTO Noord, KPN, Kubota/ Kverneland, Ministry LNV, NOM, Rovecom, The Potato Valley, WUR and ZLTO. JoinData has an advisory role. ICTU provides process guidance and ICT know how. In phase 1 of PA4.0, we take a farmer's perspective (looking from left to right in the figure below) because their data position is the weakest in AgriFood chains. In phase 2 of PA4.0, chain parties will be asked to join the PPP.



seven layers in the model from base to top are: physical world, hard infrastructure, soft infrastructure, data, intelligence, service and user interaction (see stacks in the figure below).



The seven Stacks of Bratton: physical world, hard and soft ICT, data, intelligence, services and user interaction. The red triangle shows where we identified the largest bottlenecks.

The first major bottleneck is at layer 4 (Data layer). We even call it a blockade. It has its origins in smaller bottlenecks in the hard and soft ICT infrastructures (layers 2 and 3). As we spreak, it is now virtually impossible for farmers and contractors to work with all data generated on their farms/machines. To do so, they have to have an all-in-one, easy-to-use and cost-effective data platform from which they can do all business with data that has added value (monitoring, benchmarking, accountability, and optimization of farm decisions) without. Now, there are so many, not-all-in-one, poorly connected data-platforms that the use of them does not take off in open field crops farms.

Farmers and contractors are now often forced to work with a patchwork of ICT tools and platforms that data providers supply, with a lock inn/business model to purchase the data. What misses is sector-wide supported architectural principles for the infrastructure of the data space of farmers and contractor. In PA4.0 phase 2 we will further define the principles. The interoperability of data from different providers is on average poor. Data does not meet format standards and is insufficiently structured and/or described in clear definitions. The latter mainly applies to data that is recorded via sensors on tractors and machines. This leads to all kinds of data

quality problems. It simply takes a farmer too much time and energy to be able to use 'his' data in a way that provides added value, with a few exceptions. The majority of farmers therefore does not (yet) start with PA4.0.

Current situation data-platforms

The use of crop management recording software and advisory systems started relatively early in the Netherlands (from about 1990) thanks to the providers (FMIS suppliers) of required software packages. From 2010 we see a lot and rapid development in the tools for digitization of farming and the agrifood chains. IoT, platforms and connectivity have become key concepts. Investments have been made in platforms in many places. It is no longer just traditional FMIS suppliers who provide software tools to farms. Data use platforms were developed and offered from sensor suppliers, agricultural cooperatives, suppliers of fertilizers and plant protection products, machine manufacturers, processing companies, start-ups and knowledge institutions. Despite good intentions, these systems have often been developed out of the developer's own interest and less of the farmer's interest. Vendor lock ins are the result and this limits the development of the ecosystem. It is easy to count more than 25 agricultural data-platforms in the Netherlands. A platform is a place where data is exchanged between parties, with functionalities such as authentication, storage, visualization, structuring, connectivity, advice, etc.. Most are not suitable

On the higher layers of the Stacks of Bratton model, we see cautious developments in the field of data platforms, apps and user interaction. There are some platforms available in the Netherlands that strengthen the farmer's data position and probably comply with the sector architecture principles, but all are still under development and/or lack financial resources for rapid development. As a result of the weak data sovereignty of farmers and contractors and poor interoperability, little intelligence and advanced user interaction arises. For example, artificial intelligence will not take off in open field crops farming as long as the data generated on the farms is not interoperable and structured.

Ethical and legal aspects

Current initiatives to properly organize the use of data (such as the GDPR and the data use codes of BO-Akkerbouw and Copa Cogeca, and the digital elaborations thereof in, among others, Joindata and dJustConnect) show the importance of values such as 'control over data'. However, the current initiatives do not yet lead to much more confidence in the data use and sense of sovereignty over the data among farmers and contractors. We see the following ethical and legal bottlenecks:

- Rules of conduct for dealing with data are too non-committal, as these are mainly codes-of-conduct;
- There is a lack of clarity about who the data source is. Roles and responsibilities of parties to the contract are unclear and sometimes shifting (ie the data source can also become a data user and vice versa);
- Contracts give the data source control, but if you form contracts with many parties, this is time-consuming and expensive; digitization of that contract makes contracting more efficient and cheaper, but risks compromising the control of the data source over the data;
- Vulnerabilities that arise when contracts provide insufficient protection are not sufficiently covered;
- The code of conduct assumes that it is always possible to form a well-considered and informed contract, but this is often difficult (time-consuming, expensive).

Solutions

In general, the bottleneck analysis shows that there is a need to now opt for an improved decentralized concept (each farm with its own data space with good interoperability). Such a decentralized concept is accompanied by cost-effective and safe connections between farmers and their partners. An open approach and compliance with the relevant industry standards (AgroConnect, CEMA, AEF, OGC, etc.) are preconditions. Crucial in this decentralized concept is an effective way of decision-making, often in the form of a set of agreements (or governance through architectural principles & ethical considerations).

The target group of the PA4.0 concept is the more than 30,000 open field crops farms in the Netherlands. Some of these are also contracts. Representatives of these sectors plus business organizations, umbrella organizations and governments must be involved in making these agreements. These umbrella organizations are representatives of agro-ICT, value chain partners and supply companies active at national and international level.

Business parties cannot reach agreements for competitive reasons (see lack of progress in the past 10 years and similar developments in other sectors). That is why help and cooperation with governments is important. In pre-competitive collaborations (e.g. PA4.0 phase 2), within the set of principles it is already possible to start setting up the farmer's desired data space and making connections. By cleverly combining components in the market and project-based cooperation of the parties, it is possible to realize the desired image. Secondly, agreements must be made on how to deal with the new options. Governments should be involved in such cooperation. And links should be there to international developments.

Recommendations

We drafted the following recommendations:

1. Elaborate the architecture principles for smart data use/data driven agriculture in open field crops farming and associated value chain;
2. From there, organize step by step the data space for the farmer and contractor in which all chain partners can have confidence. This is a step that does not go without agreements. A public-private approach with a pre-competitive phase seems to be in order as the companies alone cannot organize it and there is also a great social interest. This can take shape in phase 2 of PA4.0;
3. The components for the data infrastructure are there, they must be brought together on a technical and organizational level. Validate the available technology against the architecture principles and demonstrate in experimental spaces. See also the recommendations for this in the recently published report Digital Europe, Draft Orientations for the preparation of the work program (s) 2021-2022 on page 40 for the agricultural sector. This fits seamlessly with PA4.0 phase 2;
4. An important component is an own data repository (silo or safe) per farm and contractor with platform software with which the farmer / contract worker is ‘in control’ of data generated on his farm;
5. An open approach is important. Ensure that software developers can develop services against the farmer data platforms (layers 5 to 7 of Bratton’s model) and offer them to farmers and contractors at reasonable prices;
6. Build trust by the sector through governance and extension of the 'code for data use'. Take into account that data can become a possible new revenue model for the farmer and his partners;
7. Show the added value of data sharing in use cases. This is provided for in PA4.0 project phase 2;

8. Develop the awareness and knowledge and skills of the farmer (in training) to apply data-driven agriculture, to be able to use the available services and to use digital resources in a modern interactive way. This includes games and the application of Virtual Reality and Augmented Reality.

Implications PA4.0 and next steps:
1. We propose that the farmers' organizations, with support from the Ministry of Agriculture, Nature and Food and Food and Agriculture and partners in the PA4.0 context, work on establishing architectural principles and implementing the sovereign data position of the farmer and contractor;
2. PPP PA4.0 phase 2, with the entry of chain partners, can help shape the aforementioned recommendations and remove the inhibition of fragmentation in the development of data-driven agriculture in open crops. If successful, sectors other than arable farming and roughage production will link up;
3. In addition to PA4.0, more projects are working on digitization of agriculture. Connecting to this remains important. At provincial, national and European level, there are initiatives and projects that (can) provide useful insights or materials, see, for example, the aforementioned EU report and the Ministry of LNV's Vision on data-driven work. PL4.0 is heading for a cost effective data infrastructure that can be used by all types of open-cultivation companies in the Netherlands;
4. Work with data platforms in the Netherlands that can (with minimal adjustments) comply with the architecture principles, and facilitate them to put the architecture principles properly. Make sure that these are suitable for the intended function in PL4.0 and that they are used in use case sop pilot companies;
5. Work on use cases in which some of the interests lie directly with the farmer or the chain and with others the interests lie primarily with society. The latter is another reason to involve the government.

Options for use cases in PA4.0 phase 2 are:
1. Creating an overview of the data available on the farm, including implementation of improvements to archiving machine data and as-applied maps;
2. Translation of fuel measurement and other data in soil map with added value;
3. Estimate yield potential of plots based on data and models with advice on optimal crop rotation;
4. Improving the digital manure chain (in consultation with LTO and Cumela);
5. Better irrigation advice based on farmers and water boards share data;
6. Grassland usage calendar as part of nitrogen cycle;
7. Data passport for agricultural products from open crops;
8. Monitoring the build-up of nitrogen, carbon and biodiversity in the soil;
9. Digital recording of strip crops and data exchange;
10. Data exchange between arable farmer / livestock farmer and contracter.

The final report of PPS PL4.0 phase 1 will be available end of 2020. We will discuss it with Dutch parties that can help shape the desired data space of farmers and contractors. This concerns parties representing farmers, value chains and governments. The outcome of the consultation round is input for work plan and agreements in PPS PA4.0 phase 2 2021 - 2023. International interaction will take place with AgGateway, AEF, CEMA, ETSI, IDS, OpenDei, FIWARE, Copa Cogeca, CEETTAR and AIOTI.