POLICY RECOMMENDATIONS FROM IOF2020

DOCUMENT IDENTIFICATION

Project Acronym	**IoF2020**
Project Full Title	Internet of Food and Farm 2020
Project Number	731884
Starting Date	January 1st, 2017
Duration	4 years
H2020 Call ID & Topic	IOT-01-2016 (Large Scale Pilots)
Date of the DoA	2017
Website	www.iof2020.eu
File Name	Policy Recommendations
Date	30/03/2021
Version	1.0
Status	Final
Dissemination level	CO
Author of the document	Mark Ryan, Allard Jellema, Luis Perez-Freire, Krijn Poppe, Milica Trajkovic, Ovidiu Vermesen, and George Beers
Contact details of the coordinator	George Beers (george.beers@wur.nl)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

PROJECT SUMMARY

The Internet of Things (IoT) has revolutionary potential. An intelligent web of sensors, actuators, cameras, robots, drones, and other connected devices allows for an unprecedented level of control and automated decision-making. The project Internet of Food & Farm 2020 (IoF2020) explores the potential of IoT-technologies for the European food and farming industry.

The goal is ambitious: to make precision farming a reality and take a vital step towards a more sustainable food value chain. With the help of IoT technologies, higher yields and better-quality produce are within reach. Pesticide and fertiliser use will drop, and the overall efficiency is optimized. IoT technologies also enable better traceability of food, leading to increased food safety.

Nineteen use-cases organised around five trials (arable, dairy, fruits, meat and vegetables) develop, test, and demonstrate IoT technologies in an operational farm environment all over Europe, with the first results produced in the first quarter of 2018.

IoF2020 uses a lean multi-actor approach focusing on user acceptability, stakeholder engagement, and sustainable business models. IoF2020 aims to increase the economic viability and market share of developed technologies, while bringing end-users' and farmers' adoption of these technological solutions to the next level. IoF2020 aims to build a lasting innovation ecosystem that fosters the uptake of IoT technologies. Therefore, key stakeholders along the food value chain are involved in IoF2020, and technology service providers, software companies and academic research institutions.

Led by the Wageningen University and Research (WUR), the 70+ members consortium includes partners from agriculture and ICT sectors and uses open-source technology provided by other initiatives (e.g., FIWARE). IoF2020 is part of Horizon2020 Industrial Leadership and is supported by the European Commission with a budget of €30 million.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

CONTENTS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

Executive Summary

The large European research and innovation project IoF2020 has tested IoT (Internet of Things) technologies in 33 use cases. In the final stage of the project, the beneficiaries offer the policy recommendations based on the project results to support agriculture and food's future digitalisation.

Current agricultural policies as the CAP and the Farm-to-Fork strategy, try to make farming more sustainable by reducing inputs and emissions. The potentially lower production that results from this reduction of information as well as from climate change, has to be offset by more innovation, knowledge (AKIS-agricultural knowledge and innovation system) and digitalisation as enabling factors.

Our tests have promising results that underpin this strategy of substituting inputs for knowledge. Although the number of farms involved is low, they can often reduce inputs with double digit percentages and more. However, farmers do not reap all benefits from their (potential) investment that reduces farming's negative externalities. To reach the current objective of substituting inputs for knowledge with digitalisation as an enabler, we recommend that:

1. Policymakers need to provide incentives to implement technologies with clear sustainability benefits. Subsidising the investments or paying for the reduced pollution are options.

For the moment, investment subsidies (in Pillar 2 of the CAP) are perhaps easier in execution than result-oriented eco-scheme payments that pay for reduced or low emissions. In the longer run, a policy based on output performance is more attractive than subsidising technology as this gives more freedom to the farmer to choose locally relevant measures. In the short run that seems not attainable as farmers do not have good digital dashboards that give them insight into their emissions, share data and handle the administrative burden of government and chain documents very well. This goes together with a lack of trust in data sharing. We therefore recommend that:

2. To support eco-schemes and agri environmental schemes, farmers should be provided with a digital dashboard that integrates their data from satellites, sensors and accounting, reduces their administrative burden and empowers them in the platform economy. A strong open data policy and obligations for chain partners to use computer readable (UBL-type) documents supports this and the proposed Farm Sustainability Data Network could provide an excellent test bed and help to build trust in the farm community in data sharing.

3. The existing framework in pillar 2 of the CAP on the European Innovation Partnership (EIP-AGRI) and its multi-actor Operational Groups should be used to help farmers to establish data-cooperatives / data-trusts in which farmers become "owners" and have control of their data, improve contracts for data sharing with food chain actors, develop tools to share and track data for specific purposes using authorisations and gain positive experiences in pooling data for benchmarking and further analysis with data science. A preferential program on this topic can help to overcome the trust issue.

Digital farming is still quite a new thing with multiple different facets, so it requires a highly collaborative, ecosystemic approach to reap the promised benefits, particularly in a European landscape with the predominance of small and mid-sized farms.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

4. Hence, to facilitate the transition to digital farming, organisational models should evolve to make the most from cooperation and sharing, in a wide sense, with a specific focus on three key dimensions.

- Knowledge sharing: to provide guidance, education, good practices, and demonstration on new technologies and solutions.
- Infrastructure sharing: connectivity infrastructure, IoT platforms, data storage, computing infrastructures are all essential components to enable digital farming, but come at a non-negligible cost which often renders a negative ROI.
- Data sharing: to optimize productivity, integrate actors/processes across the whole food chain, and enable new business models capable of generating value for all actors in the chain.

The transition towards this "sharing model" must be supported by existing or yet to-be-created structures. For instance, local AKIS should be strengthened. Agri-food cooperatives and rural communities should be empowered as key "guiding" actors.

The digital farming market is not yet mature, neither in terms of demand nor technology offer. Concerning the latter, one of the most significant requests recurrently identified from the demand side is simplicity, from two different perspectives:

1. Simplicity of usage. The current fragmentation of the technology offer and its poor interoperability is currently a bottleneck for the wide adoption of digital farming products and services, aiming to become plug and play components, which in turn calls for higher standardisation. This also applies also to data sharing, where FAIR principles must be promoted.
2. Simplification of procedures: digital farming solutions can be used to reduce bureaucracy for farmers, automate procedures for regulatory compliance (e.g. health, food traceability), gathering data for the public sector to optimise farming policies, etc. This is a strong value proposition for digital farming technologies, which generates a much-desired competitive advantage.

5. Hence, a strong recommendation is to focus efforts on developing "easy-to-use technology that can make life simpler". A closer cooperation between technology providers and the agri-food industry would help to identify the quick wins that will facilitate the adoption of digital farming technologies. Operational Groups could be excellent instruments to drive this kind of cooperation.

The other significant bottleneck to be addressed is trust. This is a complex issue that must be considered from several dimensions, all of them requiring attention.

1. Confidence in new technologies' performance: inexistence of baselines for a fair comparison, reliable tests, etc.
2. Reliability of the new digital tools. The reliability standard in the farming sector is set very high: ICT tools must be "as reliable and robust as a tractor".
3. Lack of trust in data sharing: motivated, among other factors, by the lack of clear business cases and the possibility of losing control of one's data.

Obviously, no single recommendation can fully address the trust issue, but a number of them are provided in this document.

6. Experimental test farms should be promoted as they can play an important role to perform fair/independent benchmarking and certification of digital farming products, potentially contributing to increased trust. In this regard, the Testing and Experimentation Facilities instrument envisaged

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

by the EC can be an excellent support vehicle, if properly networked with local structures throughout Europe, as well as with the local AKIS.

7. Regarding the specific data sharing trust issue, the existing contractual framework and the technical tools must keep on evolving in order to provide more guarantees to data owners, but in the short term i is advisable to focus on developing the data sharing business cases that prove to bring value for the agrifood sector, building on incipient successful experiences in Europe.

IoT and digital technologies in agriculture depend on enabling technologies, connectivity infrastructure, computing processing, data collection and analysis services, and the regulatory environment (interoperability rules, standards, norms, and regulations). This document's recommendations consider the evolution of emerging digital technologies and emphasise the opportunities of new IoT technologies for better policy design, data sharing, interoperability. The proposals support adopting the latest technologies such as IoT combined with AI, digital twins, edge computing, intelligent connectivity, distributed ledger technologies and data platforms considering the distinct requirements of the agri-food and using the synergies with other sectors. A few selected recommendations are listed below:

8. Policy should accelerate the adoption of connectivity in rural communities, through empowering community-led solutions to implement cost-effective connectivity and internet access to enable the efficient use of IoT and digital technologies in the agri-food sector.

9. There should be clear incentives for farmers to share their data, such as economic incentives or ways to help them improve the standards on their farm or improve their yields. Policy should help strengthen the position and rights of the farmer against big corporations.

10. Ensuring that sufficient data and an effective label-train-validation process is very important to keep the AI systems updated and ready to use by farmers. AI requires data, but also labelling the data to properly train the AI systems. Sharing data as is, without labelling, will not be sufficient to allow the creation of new AI-based smart farming systems. Labelling is highly time-consuming, and needs skilled human resources to do it, bringing an extra complexity to the picture.

11. Policymakers need to ensure data storage infrastructure addresses both the farm-level and beyond the farm level data issues. This infrastructure must consider data ownership and sharing rules to enable farmers share data with service providers to improve services and facilitate interoperability between the public and private domain.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

1. INTRODUCTION

The IoF2020 project was established to support the development, implementation, and use of IoT ecosystems within the agri-food domain to ensure Europe's lead in Smart Farming. Over the past four years, we have contributed towards these goals through the course of our successful and insightful work packages (WPs) and use cases (UCs). As a culmination and substantiation of these efforts, this task will gather the most important insights found from the project and disseminate them as recommendations to policymakers. This policy document has been specifically requested by reviewers following our annual IoF2020 review, to provide our recommendations to influence agricultural policy in Europe. Our recommendations will be based on the facts and experiences directly found within the IoF2020 project and will propose ways to materialise the goals found in Europe's Green Deal.

Environmental and agricultural regulation in Europe is currently very active and directed towards change and innovation. The Green Deal offers clear and focused objectives within the sector, and IoF2020 will use this to support our policy recommendations. It offers us an opportunity to substantiate the claims and contributions found in IoF2020, aligning them with the objectives found within the Green Deal. Our policy recommendations will provide a response to the Green Deal, demonstrating some steps about how some of its goals can be realised.

A key component of Green Deal is the effective realisation of environmental goals through developments in digital infrastructure, innovation, and technologization. Digital technologies will prove to be a 'critical enabler' for attaining the goals of the Green Deal and the IoF2020 project aims to show some ways this can be achieved. Our recommendations are most relevant for focus area six (*From 'Farm to Fork': designing a fair, healthy and environmentally-friendly food system*). Our policy recommendations will show ways that this focus area can be realised.

While there have been various recommendations throughout the course of IoF2020, this policy recommendations document aims to distil the findings of the entire project, incorporating the insights from the 33 use cases (UCs) and seven work packages (WPs). Some of our earlier recommendations in the project will benefit from updates and refinements after their initial publication (e.g., D3.4 from February 2019). This report aims to be complementary to the many policy documents already available in the area but will explicitly demonstrate the findings and insights that were uniquely captured in IoF2020. This document will work as the culmination of our findings, clearly articulating policy issues and gaps that we have identified and our recommendations for resolving them.

The recommendations should preferably (but not exclusively) be relevant for the Green Deal, Farm-to-Fork (including Food Safety) and Digital Europe. Based on IoF2020 results and experiences the recommendations will give suggestions where and how IoT can contribute to the realization of policy objectives and the various claims of IoT benefits (e.g., on environmental performance, resource efficiency, added value data sharing etc.) to support decision making on where to focus policy support and investment. There are three main stages to establish IoF2020's policy recommendations:

Step 1 (October – January 2021): a questionnaire to identify policy concerns among the 33 UCs. Qualitative interviews with 33 UCs on data sharing and focus groups with 226 stakeholders (farmers, tech businesses and researchers) in WP7 on ethics, which will assist in our recommendations

Step 2 (January – February 2021): Two workshops on the themes of 'sustainability' and 'technology'. While the third important theme, trust and data-sharing, has already undergone several focus groups and interviews throughout the project, which were used instead

Step 3 (February – March 2021): Iterations of our recommendations, retrieving feedback from the IoF2020 consortium

We will integrate the Key Performance Indicators that were established in D4.1 to evaluate the 33 use cases. The reason for doing so will indicate the potential, and realised, impact of IoF solutions in each case. These KPIs are classified into the dimensions: economic, environmental, ethical and social.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

1. HIGH-LEVEL POLICY RECOMMENDATIONS

The agri-food sector has seen several technological transformations in the last decades, becoming more industrialised and technology-driven. By using IoT and digital technologies, farmers have obtained better control over the process of raising livestock and growing crops, and improving efficiency. The agriculture IoT market is expected to grow from USD 12.7 billion in 2019 to USD 20.9 billion by 2024, at a CAGR of 10.4% from 2019 to 2024. The key factors driving the growth of this market are rising demand for agricultural production owing to increasing population, increasing adoption of IoT and AI technology by farmers and growers, and focus on livestock monitoring and disease detection to improve farming efficiency.[1]

Smart agriculture is used to denote the application of IoT solutions in agriculture by using IoT sensors to collect environmental and machine metrics, so that farmers can make informed decisions, and improve just about every aspect of their work, from livestock to crop farming. IoT together with GPS, GIS combine the real-time data collection with accurate position information, enabling efficient manipulation and analysis of geospatial data. IoT and GPS are used to achieve precision farming and enable farm planning, field mapping, soil sampling, crop scouting, yield mapping and allow farmers to perform their activities during low visibility field conditions (e.g., rain, snow, dust, fog, darkness, etc.).

Smart agriculture gathers data from the field frequently and accurately, combined with external sources (e.g., weather information, environment conditions, etc.) and administrative documents from the food chain (invoices, laboratory results etc). The combined collected data is analysed and interpreted, and insights are generated to support the farmers to make better decisions. These decisions can then be applied by using robotics and advanced machinery, and farmers can monitor in real-time the processes and get feedback. Technologies used include sensors, communication networks, edge computing, platforms, unmanned aerial systems, artificial intelligence (AI), distributed ledger technologies (DLTs) and IoT as the pivotal technology for the future. Each of the technologies provide valuable insights to farming activities from data collection to management and processing, as well as decision support and analytics. The benefits of IoT in the sector are diverse (see Table 1).

Benefits of IoT and digital technologies in the agri-food sector
1. Collect data using sensors and IoT devices (e.g., weather conditions, soil quality, crop's growth progress, animals' health, pollution levels, water quality, energy consumption) to track agri-food processes, equipment efficiency, fertilisers needed, and ensure uniform quality of the food.
2. Sustainable cost management and waste optimisation using efficient control over production by identifying anomalies in crop growth or livestock health, to mitigate risks.
3. Improving the functioning of the food chain by making farm data available to other actors and trigger consumers to buy more sustainable food.
4. Process automation by using IoT, digital technologies and platforms that automate multiple processes across the production cycle (e.g., fertilising, irrigation, pest control).
5. Efficient control across production processes to maintain high crop quality and growth capacity through automation by increasing product quality and volumes.

[1] MarketsandMarkets Research Private Ltd, "Agriculture IoT Market by Offering (Hardware, Software, & Services), Application (Precision Farming, Precision Forestry, Livestock Monitoring, Fish Farm Monitoring and Smart Greenhouse), Application, and Geography – Global Forecast to 2024".
https://www.marketsandmarkets.com/Market-Reports/iot-in-agriculture-market-199564903.htm I

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

6. Accelerate the transition to sustainable fair food systems with a neutral or positive environmental impact, and ensure food security, nutrition, public health, preserve affordability of food while generating fairer economic returns, and promoting fair trade. Including, the mitigation of climate change impacts and the reverse biodiversity loss.

Table 1: Benefits of IoT in the agri-food sector

The benefits of ensuring the successful development, deployment, and use of IoT solutions in the agricultural sector are quite apparent. It makes sense from an economic point-of-view (greater growth within the industry, increased productivity, reducing long-term costs, and costly waste). It is also very clear from an environmental perspective (reduce climate emissions, less food waste, less herbicide, and pesticide use [through greater optimisation], and improved yields, and a reduction of plant and animal disease through early detection). IoT solutions should be promoted and ensured through effective policy, supportive regulation, and incentives.

Based on the feedback from the UCs, this section provides recommendations to the European Commission in different policy areas, followed up by closer recommendations, broken down by specific policy domains (agriculture, IoT and data, health, environment, and research) in Section 2. There were 3 significant overarching issues found within our evaluation of the UCs: sustainability; trust and data sharing; and technological limitations and connectivity.

1.1. SUSTAINABILITY RECOMMENDATIONS

The Farm2Fork strategy sets objectives for farming in the use of chemicals and reduction of emissions. Without further change this can have a negative effect on food production and farmer's income as agricultural output will be lower. This effect can be offset by improving production efficiency as farmers learn how to farm with less inputs and emissions. The Agricultural Knowledge and Innovation System and IT are essential tools in that innovation and makes public spending on these items defendable. Therefore, it was an important aspect of IoF2020 to investigate if UCs show beneficial outcomes in terms of sustainability performance.

We summarize the findings from WP4 of IoF2020 that looked into the question of establishing KPIs for the sustainability of technologies used within the UCs. Work Package 4 'Business Support' looked at the innovations and market-readiness of the UCs, while outlining different business models and also the UCs' KPIs, of which sustainability took a significant role. Within Task 4.1, we evaluated the operational, strategic, and visionary KPIs of the UCs, such as the quantity of sensors being used, yield increase, CO2 level decrease, and other sustainability factors. Interviews were performed with the UCs, grounded on the KPI settings created by the WP4 team.

Finding clear cut examples of sustainability KPIs, and findings from the Farm to Fork readiness Bootcamp that WP 4 facilitated, showed the merits of an approach that can be termed as "Sustainability By Design", which allows the incorporation of sustainability objectives from the start of the project or the use case. Built with the UN's Sustainable Development Goals (SDGs) as a guiding framework, this approach was designed to guide UCs to: understand which SDGs they directly contribute to; understand the SDGs as a system and therefore the SDGs they indirectly contribute to; how they contribute to the SDGs in question; and how to measure that contribution. The project analysed KPIs from the Green Deal, contrasting them with the successes of the project (see Table 2).

Sustainability Results from our UCs
1. Reduction in the use of fertilizer (4 farms with reductions: 20-30%, 30-40%, 40-50%, and 90-100%).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

2. Reduction in the use of pesticides and herbicides (3 farms with clear reductions: 20-30%, 30-40%, and 90-100%).
3. Reduction in the use of antimicrobials (fungicides) (1 farm with reductions: 20-30%).
4. Reduction in CO2 impact (1 farm with reductions: 0-10%).
5. Increase of product shelf life (1 farm with reductions: 60-70%).
6. Reduction in waste on harvested products (1 farm with reductions: 50-60%).
7. Reduction in number of days treated with antibiotics (1 farm with reductions: 40-50%).

Table 2: Sustainability Results from our UCs

These results show the potential of IoT technologies in farming for achieving the objectives of the Green Deal. The UCs had a clear understanding about their impact, backed by an official list of indicators from the UN (in the case of agriculture, indicators for which the FAO is the custodian agency). However, some UCs needed to look for indicators that better describe their actual or intended impact. As a result, UCs were better positioned to use the 2030 Agenda as a proxy to understand their contribution to, and the work needed, to align to the EU Farm to Fork strategy. Such an approach could be helpful to start the discussion on sustainability related KPIs in similar projects, using the 2030 Agenda, translating it into local EU strategy. Our sustainability recommendations are:

Sustainability Recommendations
1. Policymakers need to provide incentives to implement technologies with sustainability benefits. Subsidising the investments or paying for the reduced pollution are options.
2. There needs to be support to achieve both scale and innovation. Alternative business models based on “digital infrastructure sharing” should be explored and incentivised.
3. To assess the sustainability improvement with IoT adoption, all relevant sustainability variables have to be analysed. This improves the business case and reduces the risk of trade-offs in which farm systems are only optimised on a few goals.
4. There is often an over-concentration on the sustainability of the *on-farm production*, but the entire life cycle of products and strategies should be taken into account to see if these actions are sustainable or not. IoT goes together with higher energy use and using a lot of sensors in the field raises issues on electricity and battery use.

Table 3: Sustainability Recommendations

1.2. TRUST AND DATA-SHARING RECOMMENDATIONS

Trust was widely discussed in the UCs and had a fundamental effect on whether agricultural IoT solutions were accepted and successful. The trials reported reluctance to share data with the application under development or with trade partners using the application to share data. As the project trials brought actors together that had not collaborated before, and the proposed application was innovative, some of the lack of willingness to cooperate or share data is perhaps due to the trial approach. As project members had to learn about issues of business models and governance, this

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 731 884

aspect of setting up collaboration and building trust was often slow and required explicit attention. There are several reasons why farmers and others are not willing to share data:

Reasons Farmers are Apprehensive about Sharing Data (data from IoF2020)
1. An unclear business case. An actor is asked to share data, but the return is unclear.
2. Risk of negative influence of business relations. For instance, if a trader has more insight in the performance of the farm, he could 'punish' the farmer by not offering insurance or not offering a contract. Or the advisors of the company could use the business secrets / intellectual property rights of the farm to advise competing farms.
3. Risk of using data for other purposes by the app or the business partner. For example, providing digital data on contracts from cooperatives and investor-owned firms to farmers and their advisors could make it easy to publish information that is not in their interest.
4. Risk of data ending up elsewhere. For example, government's obtain this data and implement harsher regulations on environmental performance.
5. Data sharing may change the position of the farm. Making processes controllable will redefine contracts and organisational forms, and freedom of operating at the farm will be lost to automated decision-making.
6. A resistance to the 'platform economy'. Platforms combine data to create services that users find useful, with a business model that maintains and innovates the platform. ● a farmer becomes quickly dependent on a certain platform (vendor lock-in) as data cannot be easily transferred at a later stage to a better service provider. ● it is often not clear how he/she benefits from providing data, but it is often clear that other actors in the food chain benefit from a big data strategy. ● there is the feeling that it is provided for free, but they will have to pay for later through the product or service benefitting from this data.
7. The difference between personal and non-personal data is unclear. In at least one member state (NL), IACS data on crops are published as open data, but animal data is not published per farm location as farmers are afraid of visits by animal welfare groups.

Table 4: Reasons Why Farmers are Apprehensive about Sharing Data

In response to these trust issues, there are several ways this can be amended through policy. This section will list a few of these overarching requirements, which will be further elaborated in Sections 2, where they will be allocated to each of the four policy branches that we identify need to develop policy for effective agricultural IoT solutions. Building and ensuring trust is one of the biggest challenges faced by the industry and there is no simple solution, but if there is a joint effort among policy stakeholders, then there is a much greater likelihood of success.

Issues around data sharing regulation is certainly not a new thing, and there have been many steps towards protecting individuals from unfair and harmful data sharing practices (such as the General Data Protection Regulation, GDPR, 2018). However, the GDPR does not protect 'non-personal' data, such as that which is captured on the farm. Non-personal data sharing in the EU is normally done ad hoc and greater concern towards farm data is a relatively new phenomenon. There is a strong link between trust-building and adequate data-sharing regulation. However, data sharing regulation alone will not lead to solidifying trust, but it can certainly be seen as a contributor to it.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

Trust and Data Sharing Recommendations
1. There should be an active promotion of systems in which farmers can manage their data by their consent with authorisations and a data locker system, e.g., JoinData.
2. There should be an improvement of the EU Code of Conduct for Agricultural Data Sharing by Contractual Agreement (short: EUCC): it should be clear that it is a text that guides (legal) contract formation, it should be understandable (shorter, more practical), and include 'example contracts' and 'checklists' for agribusinesses and farmers. (D7.6)
3. A new code of ethics. There should not be an overreliance on contracts for ethical conduct (Van der Burg et al. 2020; D7.6). A new code of ethics should be developed for tech developers and tech service providers, to help realise trusted data sharing practices across the EU, and which includes a richer set of values then the EUCC as well as clear guidance on how to implement and administer it in concrete companies, in order to make it part of the EU data sharing culture (see IoF2020 D7.6)
4. The creation of a kind of digital data libraries may help to (a) it foster standardisation, (b) foster the re-use of data for public purposes such as monitoring it to track impacts on environment or food safety etc, (c) allow to develop common (shared) policy regarding the way data stored in ' libraries' should be used, which allows for more democratic governance by stakeholders.(see D7.3, D7.4, D7.6, Report Data Sharing Activity)
5. Research objective: While IOF2020 has made great progress towards understanding the sources of distrust in data sharing, as demonstrated in WP7, further research needs to be conducted to understand the reasons for distrust in data sharing across the EU. ● *More research* should be done to understand trust and how to respond to improve it. ● Discuss trust and willingness to share data openly and give more room in this discussion to *explore the variety of farmers' concerns* ● Foster *experimentation with data sharing* through funding new projects, which includes farmers as participants who contribute to the realisation of the innovation (see D7.6). ● Make *trust an explicit point of attention* in project design and project evaluation (e.g., in Horizon Europe, DG Research).
6. There should be standardisation for farm data sharing to protect those sharing their data and also those using it. It is aimed to reduce conflict, false expectations, and to avoid legal issues from data misuse. It should be clear, implementable, and enforceable.
7. Assess effectiveness of present regulation and (a) change regulation where it imposes unnecessary limitations to data sharing, and (b) create new regulation to clarify the rights of data sharing partners, such as for example data ownership rights which point out who is entitled to decide about and benefit from what data (finding from IoF2020 D7.4).
8. Policymakers need to protect those sharing data and their intellectual property by putting in regulation against unwanted distribution of data, prevent monopolies or a market dominated by a few big players, and in breach of European competition law.
9. Extend the "right to data portability" beyond personal data to farm/business data. Some work has been made in the context of cloud services by an ad-hoc stakeholder group created by the EC, proposing a "code of conduct on data portability": https://ec.europa.eu/digital-single-market/en/dsm-cloud-stakeholder-working-groups-cloud-switching-and-cloud-security-certification

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

10. Accessible platforms and dashboards: Often, agricultural technology platforms are used only by the larger and more innovative farmers, but all farmers struggle with administrative burdens. Creating a dashboard that handles their administration and provides them with relevant open data could be an option to build trust. This may allow farmers to manage their data with a dashboard and KPIs that are governed by farmers themselves (e.g., a data cooperative). However, our research in WP7 indicated that participants thought this should only be one part of the solution. See Appendix 3.

Table 5: Trust and Data-sharing Recommendations

Trust requires a deepened relationship-building initiative that cannot simply be resolved by more investments or greater regulation. It is something that needs to be ingrained by best practices, proving one's trustworthiness, ensuring adequate follow-up procedures, appropriate protective regulation, while also, considering the myriad of cultural, religious, political and idiosyncratic divergences among stakeholders within the EU. The provision of adequate data sharing regulation can also benefit from providing clarity, advice, and assistance to farmers. The currently available EU Code of Conduct for Agricultural Data Sharing by Contractual Agreement is a great starting point, but there is a need to implement follow-up procedures to the data contracts, improving information dissemination about data sharing (Ryan and van der Burg 2021 publication pending and D7.6).

1.3. TECHNOLOGY RECOMMENDATIONS

Technological limitations were a major inhibitor for adopting and implementing IoT solutions within many of the use cases. These limitations were wide-ranging, and require a concerted effort between policymakers and technology providers to overcome these difficulties. The UCs identified many technological and regulatory differences between countries, such as bandwidth, internet accessibility, and IoT solutions. The lack of rural connectivity, poor or costly internet access, or interference with connectivity, proved to be one of the greatest challenges identified for policymakers by our UCs. Rural areas, where most of the agriculture activity is concentrated, have been traditionally underserved in terms of connectivity services. This represents a serious bottleneck for the development of digital agriculture and the uptake of its benefits, as reflected in the number of UCs of IoF2020.

Technological Limitations and Connectivity Recommendations
1. Transnational and national policymakers need to find greater convergence on regulation to ensure easy, effective, and mutually beneficial transitions between borders, allowing easier adoption of new agricultural IoT technologies.
2. There needs to be clear policy to support technological innovation and adoption through economic incentives, advice, integration, and education.
3. Implement sufficient internet connections in rural areas, ensuring fast, widespread, and reasonably priced availability. Ensure that rural areas have sufficient mains/electricity for IoT connectivity, promote an awareness of this availability, and education of how the sector can benefit from cloud-based services and online business channels.
4. Make specific policy efforts for fair access to, and education of, technology to avoid the "digital divide" and information asymmetries. The digital divide is caused when there are those who benefit from, have access to, and can use digital technologies, while others cannot. The EU needs to ensure there is a *level playing field* and nobody gets left behind.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

5. Technology standards and the use of performance standards need to be set, along with policy decisions including holistic consideration of benefits, costs, effects of digital technologies, climate, re-use, and recycling. The technology itself must be robust and reliable, achieved through *independent testing facilities* to ensure they are effective.

Table 6: Technological Limitations and Connectivity Recommendation

Technological change and connectivity requires a great deal of investment, platforming, and digital architecture development. This not only requires a clear and implementable R&D plan, but also requires agreement, cohesion, and execution, by EU member states. One of the issues discussed in the UCs was the divergence in technological development between member states, making it difficult to implement technologies cross-border. This is an issue that requires attention, but also, issues of poor rural connectivity need to be tackled.

2. AREA-SPECIFIC POLICY RECOMMENDATIONS

2.1. AGRICULTURAL POLICY

To ensure the successful development and use of IoT solutions, the agricultural sector needs to be prepared for adopting new techniques. In many instances, IoT promises great potential to meet the demands being placed on farmers, but in other instances, they may be difficult to implement on the farm because of restrictions, policy, affordability, accessibility, and usability. Therefore, policymakers must be aware of the benefits that IoT solutions can bring, but also, be proactive to bring about changes that will support farmers in the transition towards greater technologization. Technology has the potential to help to realize the objectives of the Green Deal and the Farm-to-Fork Strategy to reduce impacts on the environment without jeopardizing food production. The analysis of trials in IoF2020 suggests that in some applications the impact on the environment was strongly reduced (see the results from Section 2.1). Thus, we provide recommendations derived from IoF2020 about how we can move towards an improved technologized EU agricultural sector.

2.1.1. CAP Eco-schemes and conditionality

The Common Agriculture Policy is currently renewed for the years up to 2027. In pillar 1 the direct payments per ha, that are linked with environmental obligations via the so-called ‘conditionality’, will be supplemented by Eco-schemes. The schemes are voluntary for farmers (but obliged for Member States) and reward farmers for environmental performance with a payment per ha. This will ask for additional monitoring and evaluation. Currently the monitoring and auditing of individual farms and their subsidy application in the IACS is very much carried out with satellite data.

CAP Eco-schemes and Conditionality Recommendations
1. The availability of comprehensive datasets should be stimulated, along with showing the benefits of using these datasets. It should be made clear how to use these datasets. Satellite data should be supplemented with other types of data, e.g., from farm information systems, farm accounting, or sensor networks, to perform on issues like antibiotics, soil management or pesticides, that cannot be monitored from the outside of the farm by satellites or other devices.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 731 884

2. Policymakers should encourage agricultural data sharing, as it would allow for better comparison between technologies, and better baselines for sustainability. There is a huge opportunity in gathering insights from farming practices through data so policymakers can design sustainable policy (e.g., carbon credits, sustainable vehicles, sustainable meat).
3. Digitized data should be encouraged to streamline the process for farmers and policymakers. Eco-schemes hold the potential to lead to a bigger administrative burden if farmers must prove that they have fulfilled the clauses of their eco-scheme contract.
4. Policymakers should enable greater open data platforms and technology accessibility. Digital accessible or open data (animal registers, cadastre, pesticide register etc.) are important to help farmers easily show they abide by the clauses in their eco-schemes.
5. Policymakers should oblige actors in the food chain to provide farmers with invoice data in digital (UBL) format, robotic accounting apps could combine it with payment data from the banks (digital available under the PSD2 obligation), which would reduce administrative burdens considerably (Poppe, Vrolijk and Van Dijk, 2021). In commercial certification, apps and digital certification may safeguard on-farm production management and could replace part of the manual audits (and self-audits). However, there must be a *careful, tactical, and informative, rollout* to provide farmers with relevant information.
6. Policymakers can make use of the policy of the PMEF[2] (formerly: CMEF) and the Farm Accountancy Data Network (FADN)[3]. They provide an excellent opportunity to test out IoT solutions, such as providing farmers with a digital dashboard and key performance indicators. This could go hand in hand with the promotion and development of agriculture data spaces (see the Digital Europe programme) by scaling the data space concept down from EU level to MS and regional level (organize best-practices training).

Table 7: CAP Eco-schemes and Conditionality Recommendations

2.1.2. CAP AKIS

One of the important horizontal aspects of the new CAP is the Agricultural Knowledge and Innovation System, with support for Farm Advisory Services as one of the instruments in Pillar 2. The European Commission is also keen on a clear view of the Member States on how digitization will support the AKIS. The European Innovation Partnership and support for Operational Groups (OGs) in which farmers try to tackle an innovation challenge is another aspect of the CAP

CAP AKIS Recommendations
1. Data sharing should be embedded in topics where some trust is available or in topics where farmers have direct benefits from the innovation (e.g., sharing data on soil and water use could help farmers to investigate strategies to cope with climate change).
2. OGs should also work on standardization, standard contracts and testing apps (testing network / testbed). Policymakers should support standardization activities under the FAS instrument.

[2] See https://enrd.ec.europa.eu/evaluation/back-basics/performance-monitoring-and-evaluation-framework_e
[3] See https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/farms-farming-and-innovation/structures-and-economics/economics/fadn_en

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

3. A R&D ecosystem with a well-established network of farms as testing infrastructure could be established under the EIP or a multi-actor project. The number, location and variety should reflect the diversity and fragmentation of the agrifood sector in Europe.
- Different models should be explored based on *public research infrastructures*, privately-run "*demo farms*", or *public-private models*.
- Agtech providers could *showcase/pilot their technologies and solutions in realistic settings and get back targeted feedback* that will enable them to adapt their value propositions beyond a purely local scale.
- *Experimental farms* could implement open, standard APIs to test new technologies.

4. Education should be provided to farmers on the benefits of data sharing. This would allow farmers to increase their awareness of digital farming technologies and acquire hands-on experience through training.
- This should be provided *freely* to farmers, it should be accessible and understandable, and an outlet for farmers to discuss issues or uncertainties about these technologies.
- Policymakers should encourage SMEs to develop technologies that are beneficial to the farmer, but also, very easy to use, and encourage these SMEs to provide training.

5. There needs to be outreach and information sessions with farmers to encourage the acceptance and development of IoT solutions. The farming community needs to get behind and support technological developments, because it is *new* and *different* from traditional farming practice.

6. There is the opportunity to provide independent certification agencies or evaluators for "*seals of excellence*". This could allow neutral benchmarking, evaluation, interoperability testing, of the technologies and solutions to be carried out.

7. There is thus a need to bring new technologies closer to their potential users, in settings where they can see them in action and understand their benefits without the need of big spending (e.g., *"test before invest"*).

8. Gathering all agri-ICT experts, projects, and collaborations, within a portal may benefit collaborative efforts, both within the EU and internationally. This portal would make it easier for businesses, researchers, and farmers, to identify partners and ways of collaborating. Professional societies like EFITA could support this.

9. *Data* from nationally funded projects and initiatives related to infrastructure like weather stations, soil sampling data, should be collected on a common website and accessible by new projects.This would lead to alignment between the EU and MS policies for the promotion and support of Digital Innovation Hubs for agriculture, and with the Testing and Experimentation Facilities instrument in the Digital Europe Programme.

10. There should be clear guidance to farmers about what type of data they need to report and how to do so. This needs to be made easy for the farmer, so it is not an additional thing that they have to worry about. The EU needs to make greater efforts to harmonise these mechanisms, and provide appropriate information to farmers about cross-border variations.

11. Governments should have a strong open data policy, explained in their National Strategic Plan with clear initiatives to share their data, such as *animal health passports and logs of pesticide use*. There are many beneficial data sources that are not being utilized because there are insufficient incentives to share them.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

12. Agricultural format specifications should be made publicly available to speed up the creation of data tools that support the farmer in his data needs and to report to get EU grants. These should unite data-sharing initiatives to get to an EU standard.
13. There should be a clear unified data-sharing security standard applied within the agricultural sector to ensure the protection of data, while ensuring greater trust.
14. IoT can help aggregate data, but technologies need to be scaled to different needs. In UC1.6, sustainability was not the primary reason for implementation, but was a secondary benefit of the IoT. These '*dual benefits*' should be identified and encouraged.

Table 8: CAP AKIS Recommendations

2.1.3. CAP Pillar 2 Rural Development

Pillar 2 of the CAP, that supports rural development, has several instruments that could relate to digitalization and IoT. One deals with longer term contracts for agri-environmental measures that farmers take. Such contracts have to be monitored and here the same issues arise as under the eco-schemes. Another important instrument is the support for investments. Different technologies could receive subsidies over other ones, e.g., electric forklifts, to promote them as alternatives to fuel forklifts for environmental reasons. Such lists of devices that are eligible are nationally determined. This facility can support a further uptake of IoT in the food chain. Our recommendations are:

CAP Pillar 2 Rural Development
1. Agricultural OEMs should apply the FAIR principle to their proprietary data formats, enabling interoperability of machines that are eligible and those that do not should be delisted.
2. Agricultural subsidies should not only consider one-time investments as eligible, but also *monthly/yearly fees*, like licenses for e.g., *software use*, *service contracts* for maintenance of IoT equipment.
3. CAP could help provide incentives for training that leads to *qualifications* in using high tech in the right way and to its full capacity. Demonstration, training, and education activities therefore must go hand in hand with the introduction of new technologies.
4. Fast track technologies that have a good sustainability performance. Stimulate the industry that can support and develop standardisation to ensure interoperability.
5. Policymakers need to identify the different actors in the value-chain, their needs, and encourage SMEs to provide infrastructures at different levels. They should *create 'champions' in different agricultural technology solutions,* and encourage them to develop these technologies.
6. Those who have been abiding by sustainable practices should be rewarded for their efforts, rather than *only* those who need further improvement. Policy should not penalise those already acting sustainably, by only providing grants to less sustainable farms.
7. Policymakers should help small farms across Europe to find technologies that work at different economic levels for farmers, while making these easily known and accessible.

Table 9: CAP Pillar 2 Rural Development

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

2.2. IoT, DIGITAL TECHNOLOGIES AND PLATFORMS INFRASTRUCTURE

IoT applications embed many technological elements to collectively shape the creation of effective digitalisation systems in agriculture, and provide an enabling intelligent IoT data infrastructure. Making efficient use of IoT and digital technologies in agriculture depends on enabling technologies, connectivity infrastructure (broadband, connectivity, services, etc.), edge computing processing and data collection and analysis services and on the regulatory environment (which encompasses interoperability rules, data quality standards, norms or regulations on data ownership and data privacy, skills, shared modelling frameworks, IoT digital platforms, cloud-based storage and processing, etc.). In this context, our recommendations emphasise the opportunities of new IoT technologies for better decision-making, policy design and monitoring.

2.2.1. Edge Computing

Edge computing offers solutions that facilitate data processing at or near the data generation source and serves as the decentralised extension of the cellular networks, the cloud, and data centre networks. Edge computing offers near real-time insights, facilitates localised actions and access to these insights by the ones that generate the data. In remote agriculture facilities, edge servers can form clusters or micro data centres where more computing power is localised. The edge computing model is well suited to IoT applications in agriculture due to following reasons: near real-time data analysis, lower costs related to operations and data management, reduced data transfer via communication networks, and the assurance that the needed assets remain operational at the local level.

Edge Computing Recommendations
1. Edge computing capabilities should be encouraged to deal with the inefficiency of streaming the information/data to the cloud or data centre for processing. Edge computing infrastructure deployment can reduce the need for transferring large amounts of data.
2. Edge computing must be straightforward to use for the farmer, ideally being '*plug-and-play*', whereby the farmer has easy access and the ability to use these technologies.
3. Edge computing must undergo cost-benefit analysis with cloud computing to determine the *most economically sound model in different contexts* and which one is *more sustainably better*. Local private networks could also reduce electricity demands, and encourage sustainability, and give greater control to the farmer.

Table 10: Edge Computing Recommendations

2.2.2. Connectivity

Connectivity is critical to enable IoT and digital technologies in the agri-food sector. The transition to smart agriculture requiresIoT networks that are easy and inexpensive to set up, support many devices and provide the performance for real-time data transfer, which is essential to unlock the value of more advanced and complex IoT use cases.

Connectivity Recommendations
1. Policy should increase advanced connectivity infrastructure in rural areas and the development of more effective digital tools for the industry to foster widespread adoption of the connectivity across different sectors applications.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

2. There needs to be a careful cost-benefit analysis of the bandwidth requirements in different areas, and *ensure that some places do not get left behind*. While different member states will require different levels of investment and networks, these infrastructures must be reliable and accommodate the agricultural sector's needs. High bandwidth for some applications is required, while lower-bandwidth for others.
3. Connectivity capabilities in agriculture need to enable massive IoT deployments with low-power networks and low-cost sensors that can scale up.
4. The connectivity infrastructure must support mission-critical services in agriculture by providing improved stability of connections to run applications that demand high reliability and responsiveness (e.g., autonomous machinery and drones).
5. Policymakers need to identify the best connectivity infrastructure options to adopt in given locations and contexts, based on their low cost, wide coverage range, and low energy consumption requirements. The connectivity covers wireless and cellular technologies including 3G/4G/5G, Wi-Fi, ZigBee, 6LoWPAN, Bluetooth, LPWAN such as LoRA, Sigfox.
6. There should be an exploration about how low-power wide-area networks, possibly using unlicensed spectrum, can be used in combination with licensed options for connection. Even if connectivity is a must, not every service demands broadband or ultra-broadband connection. The typical requirements for crop monitoring applications are not high in terms of bandwidth or latency. The *edge computing paradigm* can also reduce the dependence on remote cloud servers, and expensive backhaul connections.
7. Governments can subsidise (partially) the cost of connectivity infrastructure and/or services, or other options can be explored, e.g., providing subsidies directly to telco operators or farmers (via CAP). There is also the possibility to examine the setup of public-private consortia, including community-led solutions (e.g., cooperatives), manages shared connectivity infrastructures and services for rural areas and agriculture sectors. These actions are needed because standard *business models* for connectivity *do not scale well in sparsely-populated areas*, where the net benefit does not compensate for the high investment and maintenance costs. New models for addressing this "*market failure*" should be sought, with different public intervention.

Table 11: Connectivity Recommendations

2.2.3. Artificial Intelligence (AI)

IoT and AI are working hand in hand for improving the efficiency of different applications in smart agriculture. The deployment of edge computing accelerates the use of AI techniques and methods close to where other agri-food solutions generate data. A recent report[4] estimated that "the AI in the agriculture market is projected to grow at a CAGR of 25.5% from 2020 to 2026. The AI in agriculture market growth is propelled by the increasing implementation of data generation through sensors and aerial images for crops, increasing crop productivity through deep-learning technology, and government support for the adoption of modern agricultural techniques".

Machine learning-enabled solutions are being significantly adopted by agricultural organisations combined with IoT and AI-based services, advanced infrastructure at affordable cost, scalability, and the IoT and AI-as-a-Service solutions. AI techniques can improve productivity and efficiency by

[4] MarketsandMarkets Research Private Ltd, " Artificial Intelligence in Agriculture Market by Technology (Machine Learning, Computer Vision, and Predictive Analytics), Offering (Software, Hardware, AI-as-a-Service, and Services), Application, and Geography - Global Forecast to 2026, https://www.researchandmarkets.com/reports/5022322/artificial-intelligence-in-agriculture-market-by#pos-1

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

analysing data and support the automation of farming systems (e.g., AI-controlled machinery to pick crops, automate irrigation systems, automate IoT monitoring systems, etc.). New developments in AI and the refinement of existing solutions can be supported by ensuring that agriculture data (both public and private) is accessible, which calls for policies supporting data sharing.

AI Recommendations
1. AI techniques like machine learning should be developed, funded, and incorporated within EU projects and farms to better monitor the crops' status and advise users to reduce pollution, and pesticide use and make farms more productive, profitable, and sustainable.
2. AI standardisation in the agricultural sector should be improved to facilitate growth in the industry and overcome blockages, while ensuring best practices. This standardisation can be adapted from other industrial sectors or applied to the agricultural sector, rather than investing in timely, costly, standardisation procedures.
3. Policymakers should invest in AI development in the agricultural sector, through R&D and encouraging SMEs, to ensure Europe is a pioneer in this field in the coming years.
4. Ensure that sufficient data and an effective label-train-validation process are critical to keeping the AI systems updated and ready to use by farmers. AI requires data, but also labelling the data to train the AI systems properly.[5]

Table 12: AI Recommendations

2.2.4. DLTs for smart contracts

Distributed ledger technologies (DLTs) and smart contracts provide support for the implementation of IoT and digital technologies to bring greater efficiency, transparency, and traceability to the exchange of value and information in the agriculture sector. Still, they often require digital records, cryptography, transaction processing, and data storage. DLTs can improve agricultural supply chains by enhancing how to trace a product's origin, conduct detailed product attributes in each transaction and guarantee its authenticity. This brings vast improvements in traceability, which will have a positive impact on food safety, quality, and sustainability; such as through Blockchain.[6]

A report from the Food and Agriculture Organization of the United Nations and International Centre for Trade and Sustainable Development (ICTSD) (Tripoli and Schmidhuber 2020), states that "through enhanced transparency and higher-quality transaction details, DLTs deliver improvements to food safety and quality (such as product sustainability) and consumer awareness". Through digital and physical assets registered on DLTs, agricultural supply chain actors can build a reputation and track records in the marketplace to increase access to financial services and new market opportunities. DLTs can be a secure, fast, and immutable method to register land titles, providing greater legal clarity to land tenure systems.

DLTs for Smart Contracts Recommendations

[5] Sharing data as is, without labelling, will not be sufficient to allow the creation of new AI-based smart farming systems. Labelling is time-consuming, and needs skilled human resources to do it, bringing an extra complexity to the picture.
[6] Blockchain technology represents a specific distributed ledger technology that may be used for mitigating significant challenges in precision agriculture. The use of blockchain technology could be developed to allow peer-to-peer transactions to be implemented in the agriculture sector transparently, securely, without an intermediary. Blockchain eliminates the need for a central authority and ensures that trust is granted by placing trust in cryptography and peer-to-peer architecture to ensure trust between producers and consumers and reduce the transaction costs in the agri-food sector.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

1. Policymakers should identify the benefits of DLTs such as blockchain, and ways to make it feasible for SMEs to work on this and not leave it exclusively for the big companies. There needs to be further *research and testing* to see how smaller farmers can also use it affordably and securely.[7]
2. It should be further explored how DLTs can be used to provide smart contracts to enable payments for agricultural financial services can reduce transaction costs, decrease the risk for buyers and sellers and increase cash flow and working capital for farmers and sellers.
3. Policy needs to create flexible, digitally-enabled compliance approaches based on "smart contracts" using DLTs and IoT technologies.

Table 13: DLTs for Smart Contracts Recommendations

2.2.5. Real-time data spaces storage infrastructure

There is a need to advance the ability to store, aggregate, analyse, and distil value-creating decision support tools from agriculture data. There are questions related to who owns the data; who is entitled to the data's value; how that data will be used or potentially shared. The answers to these questions affect the business models and how the real-time data spaces and storage infrastructure are designed and deployed.

Creating public-private spaces for data sharing, and developing technologies distributed across all scales of food, energy, and water systems can generate data-based assets that can be used to optimise agricultural productivity and the food pipeline to consumer behaviour, waste management, circular economy, and sustainability. Farm data can be aggregated with data from other farms to develop new products, services, or management analytics. Data can be stored in edge-based decentralised storage systems that provide a data security model and data privacy.

Real-time data spaces storage infrastructure Recommendations
1. Policymakers need to ensure data storage infrastructure addresses both the farm-level and beyond the farm level data issues. This infrastructure must consider *data ownership* and sharing rules to enable farmers to share data with service providers.
2. Policymakers should ensure that real-time data spaces use digitally-enabled traceability schemes (perhaps, based on blockchain-based traceability systems) for collecting data to be stored in digital databases, and using online platforms.
3. Regulations need to be implemented to store data (location of data storage) and the management and analysis of IoT data (edge/cloud data, models, algorithms, blockchain, etc.)

Table 14: Real-time data spaces storage infrastructure Recommendations

[7] UC3.6 concluded that blockchain in the industry (wine) was challenging because of the investment and operational costs. The UC did not implement a 'regular' blockchain but made a shortcut to assure the specific tracing functionalities for the wine value chain they worked with.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

2.2.6. Data Marketplaces

Data marketplaces in agriculture are represented by platforms where entities and stakeholders involved in smart agriculture applications buy and sell data. Data marketplaces (e.g., personal, business, sensor/IoT data marketplaces) sell different data types from various sources. Digital data marketplaces enable new forms of communication and transactions between actors within agriculture's business process (consumers, suppliers, farmers, investors, distributors, etc.). Digital data marketplaces use business models based on their data type and distribution model and apply different monetisation strategies for data marketplaces (e.g., subscription, commission, paid features, give-and-take model, pay-per-hour, etc.).

Data marketplaces can revolutionise the agricultural sector by having platforms-based ecosystems with the proper tools and software to integrate various IoT and data sources. These tools need to consolidate data on climate, agronomy, water, farm equipment, supply chain, weeds, nutrients, and so much more to aid the farmer make decisions. The creation of a single digital market for IoT in agriculture requires federated marketplaces across current IoT platforms. By enabling the re-use of assets across different IoT ecosystem boundaries, secondary revenue streams can be generated for IoT investments, boosting the agriculture market.

Data Marketplace Recommendations
1. Data marketplaces and data-sharing initiatives need to be encouraged and supported by policy (such as https://djustconnect.be/nl/ & https://join-data.nl/).
2. Policy should facilitate interoperability between the public and private domain. For example, share *a common "template"* for data sharing or storage, instead of having many different DB structures.
3. Open source and open data should be encouraged to push towards *greater interoperability*. Data marketplaces are not just about selling data, but also, *sharing data*. Stakeholders can benefit from data solutions, but not necessarily, economically.

Table 15: Data Marketplace Recommendations

2.2.7. Intelligent Infrastructure and Platforms

An intelligent agriculture infrastructure leverages private development and public research. It should address the challenges of digital transformation for the agriculture sector and address climate change, circular economy, and sustainable growth. The new agriculture infrastructure must improve broadband access in rural areas, wireless technologies, edge computing and interoperable IoT and intelligent data platforms. Emerging agricultural IoT applications, using autonomous/robotic systems solutions will require much faster reactivity. Analytics algorithms will have to operate in a distributed context between edges and cloud with heterogeneous capabilities. IoT platforms need to act as a complete ecosystem converging the agri-food applications by collecting and sharing data broadly within agriculture and IoT applications. This needs to be converted into an IoT agriculture platform strategy, based on interoperability principle, security, and standardisation.

Intelligent Infrastructure and Platforms Recommendations
1. Greater investments into different intelligent infrastructures and platforms.
2. Policy should encourage improvements in many layers of the IoT architecture. Platform adoption was shown to be beneficial in the IOF2020 UCs to standardize the context and organise the information of the production environment with which they operate.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

3. Open-source solutions should allow IoT projects to develop the customizations for intelligent infrastructure and platforms.

Table 16: Intelligent Infrastructure and Platforms Recommendations

2.2.8. Standardisation and interoperability for information exchange and data-sharing

The EUCC in 2016 was a significant step forward for providing clear recommendations for establishing legal and ethical contracts between data originators and data users. However, some of the UCs pointed out that these guidelines are not legally binding and many organisations barely, if at all, reflect upon them because of their lack of enforcement. There is a gap in the industry to adopt this code of conduct and enforceable or implement separate binding regulation to protect farm data-sharing. Digital agriculture is making the farm data interoperable and accessible and federating it with public data sources. The usage of public data, open standards and interoperability is needed, and the development of interoperable formats and metadata becomes a stringent necessity. Interoperable standards that bring together public and private data for decision support can enhance the value proposition and push for lower barriers to the sharing and re-using data.

Information Exchange and Data-sharing Recommendations
1. There should be clear incentives for farmers to share their data. Policy should help strengthen the position and rights of the farmer against big corporations.
2. A shared data commons would reduce much of the needed time and resources dedicated to data allocation, complying with a range of different policies, and ease of access.
3. Policymakers need to enforce data sharing regulation. Many organisations are supposed to share data with farmers, but when requested, they do not. For example, the SDa in the Netherlands' data is assumed to share data on animal medication sale, but our UCs said they do not. Policy needs to make organisations abide by data-sharing regulation.
4. Regulatory push in the public-private domain (B2G), create obligations to comply with norms, and regulations, in a way that government agencies lead the *standardisation*.This can be done by providing access to new/improved public services, e.g., based on open government data; simplifying bureaucratic processes, and enforce compliance monitoring (e.g., new CAP).
5. There needs to be clear guideines on how individuals, organisations, and the industry as a whole, can anonymously share data, to benefit technological development (e.g., AI training).

Table 17: Information Exchange and Data-sharing Recommendations

2.2.9. Simulation (e.g., Digital Twins)

There have been great developments in agricultural simulation technology in recent years, such as 'digital twins' of certain crops, harvests, and even entire farm ecosystems. These digital twins are generated digital representations of real-life objects, things, or places. They are used to emulate how those objects would behave in real-life, correlating how a plant, crop, or farm system would act due to specific actions. It allows farmers insights into what would happen when changes are made on their farm. This offers a lot of potential for the agricultural sector. Digital twins enable the farmers to simulate, plan, analyse, and improve crop growth and help them maximising yields and making farming more sustainable. The IoT digital twins allow the agri-food supply chain stakeholders to deal

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

with unexpected deviations. They can assist identify issues beforehand, schedule predictive maintenance at the right time, and provide instant solutions for complex problems.

Simulation Recommendations
1. Policymakers should encourage projects and SMEs to develop and implement simulation tools to evaluate agricultural objects. This would allow for improved validation of actions and more significant insights into outcomes, before implementing them in real-life.
2. Policymakers could introduce digital twins and simulation databases, that are both flexible and huge, reducing validation and development times.

Table 18: Simulation Recommendations

2.2.10. Hardware

While much of our recommendations are data-driven solutions, these would not be possible without effective, reliable, and accessible hardware. Particularly, policymakers need to ensure that the robots, drones, sensors, and computers that carry out much of the earlier recommendations, are built and fit for purpose. This is valid for the agricultural sector, where the farm's hardware used on the farm needs special attention due to changing weather conditions, interaction with animals, and farm changeability.

Hardware Recommendations
1. Ensuring appropriate standardisation is implemented for all hardware implemented on the farm. Hardware needs to be sturdy, durable, and built for purpose, or else, damaged, and unreliable products would lead to frustration and lack of use.
2. Provide funding for research and development within the EU, to develop, test, and implement these hardware technologies on the farm. Collaboration between researchers and farmers is essential for promoting these technologies in an appealing way.

Table 19: Hardware Recommendations

2.3. HEALTH POLICY

Health policy will also have to be adopted to ensure the fair, effective, and smooth transition to a beneficial and prosperous future for agricultural technologisation. There are a number of areas of health policy that can be adopted to benefit the introduction of digital technologies and IoT solutions into the agricultural sector. Some aspects of animal and human health could greatly benefit from increased digitalisation, such as streamlining, automation, more accurate results, and pioneering research. Below are our suggestions derived from the IoF2020 project.

Health Policy Recommendations
1. Greater digitalization, recording, and adequate processing should be promoted to ensure greater transparency and traceability of the food system.
2. Policies on *veterinary care often strongly differentiate between EU countries*, so there is a need for providing clearer and succinct requirements for those in the agricultural sector when implementing cross-border IoT solutions. It may be useful to build a database on these variations, so that they can be incorporated within data at the source.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

3. Responsibility allocation, biosecurity regulation, and best practices, should be clearly defined within policy and education strategies should be implemented. Within the EU, there are *divergences on biosecurity policies and who is responsible*.
4. Policymakers can make the most out of early indicators from data derived from IoT solutions, to prevent early transmission of zoonotic diseases. Agricultural IoT technologies should be used to monitor *animal health*, and this data can be used to improve health problems and issues, and reduce harmful human diseases, which are transferred by animals in the past (e.g., Swine Flu, Bird Flu, Coronavirus, etc.).
5. There should be uniformity among EU countries to ensure that farm animal data is registered and easily available to ensure safe quality food production, through a *passport and number* that follows the animal throughout their life.

Table 20: Health Policy Recommendations

2.4. ENVIRONMENTAL POLICY

Environmental and climate policy (including biodiversity issues) are very important for farming. For farms this is mostly integrated in agricultural policy via conditionality, CAP Pillar 2 agri-environmental measures and (in the future) eco-schemes. Environmental legislation affects the farmers directly, often via national implementation laws, like the Nitrate directive and national laws on the application of manure. Most farms in the EU are obliged to keep books for fiscal accounting. With digitalisation these can be broadened to environmental accounts and -where relevant- linked to IoT sensor data. Such data can be used for improving the management but also for economic instruments (emission trading, emission quota, taxes) to provide incentives for good environmental management.

Environmental Policy Recommendations
1. There needs to be dedicated policy and financial support programs to facilitate wider-scale implementation of IoT solutions in combination with sustainable agricultural promotion and environmental protection policy. For example, cohesion amongst varying actors could ensure evaluation of the effects of data-driven fertilization planning, arable crop growth, through field mapping, zoning, and nutritional need of plants.
2. Certification of organisations that implement ecologically sustainable practices and who fight food waste could be *given by analysing their contribution from their data*. Furthermore, *certification* could be streamlined through digitalization to ensure more sustainable supply chain visibility, while doing so in a *less-resource-consuming way*.
3. Promote digital technologies and services for measuring environmental performance.
4. Move towards new digital labels for sustainability. Research and development between different partnerships, technologies, and see how you can orchestrate all these together.
5. Provide incentives for businesses and researchers to work together.

Table 21: Environmental Policy Recommendations

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

2.5. RESEARCH POLICY RECOMMENDATIONS

In addition to agricultural, technological, environmental, and health policy recommendations, there are also clear overlaps and requirements for further research in the area of agricultural digital technologies to ensure that the EU is a pioneer in the development, deployment, and use of emerging technology.

Research Policy Recommendations
1. Further research should be conducted around farmers' attitudes to sharing data, why there is often a trust issue, and ways to overcome this in the future.
2. Policymakers should try to encourage transparent data sharing with research institutes, through standards and regulation.
3. There should be a process whereby data models can be shared and used, but adapted to the individual needs of the farmer. There have been initiatives where this has already been attempted, such as *the development of smart data sharing initiatives in IoF2020*.
4. Research agendas need to help establish more concrete business models for agricultural innovation processes.The more concrete the business model in the UCs, the more successful the innovation process was.
5. Identify ways that synergies of different research projects work together. Exchange between projects to bring the same topic and work groups closer together.
6. Enable identification and synergy between businesses and researchers. Identify where other projects are doing the same, and link with businesses, for better knowledge use.

Table 22: Research Policy Recommendations

3. APPENDIX 1: USE CASES AND QUESTIONS

Use Case	Title	Country
1.1	Within-Field Management Zoning (Potato)	Belgium, Germany, the Netherlands
1.3	Soya Protein Management	Austria, Italy
1.4	Farm Machine Interoperability	Belgium, Denmark, Germany, the Netherlands
1.7	Traceability for Food and Feed Logistics (IoTrailer)	Belgium, France, the Netherlands, Poland
1.9	Within-field Management Zoning Baltics	Latvia, Lithuania, the Netherlands
2.2	Happy Cow	Belgium, Germany, Ireland, the Netherlands
2.3	Herdsman+	United Kingdom
2.4	Remote Dairy Control	Belgium, Netherlands, Germany
2.5	Early Lameness Detection Through Machine Learning	Ireland, Israel, Portugal, South Africa, United Kingdom

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

2.7	Multi Sensor Cow Monitoring	Czech Republic, Hungary Poland, Slovakia
3.2	Big Wine Optimization	France, Italy
3.3	Automated Olive Chain	Greece, Spain
3.4	Intelligent Fruit Logistics	Belgium, Germany, the Netherlands
3.5	Smart Orchard Spray Application (Smartomizer)	Hungary, Poland, Portugal, Spain
3.6	Beverage Integrity Tracking	Italy, Portugal, Romania
4.1	City Farming Leafy Vegetables	Germany, the Netherlands
4.2	Chain-integrated greenhouse production	Italy, Spain
4.3	Added Value Weeding Data	Austria, the Netherlands
4.4	Enhanced Quality Certification Systems	Italy, Spain
4.5	Digital Ecosystem Utilisation	Cyprus, Greece, Slovakia
5.1	Pig Farm Management	Belgium, Italy, the Netherlands
5.2	Poultry Chain Management	Belgium, Spain
5.3	Meat Transparency and Traceability	Germany, the Netherlands
5.4	Decision-Making Optimisation in Beef Supply Chain (Sharebeef)	France, Italy, Spain
5.5	Feed Supply Chain Management (IOFeed)	Germany, Spain, United Kingdom
5.6	Farm Internet Tracking of Pigs	Spain, Sweden, Switzerland
Total 26		

Table 23 List of Participants

We sent a questionnaire of six questions to our 33 UCs, and 26 replied (see Table above). These questions asked individuals to identify the most relevant policy-related issues and solutions that they encountered throughout their relative projects. The six questions that were asked were:

Six Questions asked in the Questionnaire to the Use Cases
1. What kind of policy issues did you encounter during the use case? (Please provide examples)
2. Which type of policy are you referring to?
3. Was there a clash / inconsistency between different types of policies in the UC? (e.g., cross-border? Please provide examples)
4. Are there any policymakers in agriculture, environment, health, IT/Data, or research, that would solve problems in your use case or upscale results? Please describe.
5. Can you imagine that farmers or others in the food chain make use of the app that you develop in your use case in reporting their operation to a government agency? Please describe.
6. Is there any data set in the government that is currently not open (in a usable format) and that would have improved the application in your use case if the data would have been open?

Table 24 Questions asked in the Questionnaire to the Use Cases

These questions elicited a wide diversity of responses, spanning approximately 100 pages of text. We have arranged the most important themes and issues that arose during our analysis, documenting an overview in Table below. This table gives a broad overview of the main concerns and recommendations derived from the 26 UCs, which responded from the IoF 2020 policy questionnaire. It is important to consider, though, that per theme often many different “sub themes” were mentioned. This is especially the case for subjects like data sharing and lack of uniformity between countries. The aspects discussed below also have a strong degree of overlap with the answers that were received during the focus groups and interviews in D7.3 and D7.4 of this project and in the Data Sharing Activity

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 731 884

that reports about interviews with the 33 UC coordinators on added value of data sharing, obstacles encountered and the solutions suggested to overcome these obstacles.

Question	General themes
1	- Trust - Data sharing - Internet coverage rural areas - Variation rules and regulations - Lack of confidence in IoT solutions
2	See Table 4
3	- Authorities requesting different data - Lack of uniformity - Technical variations between countries - Different rules and regulations

4	- Facilitation of data sharing
	  - Provide incentives for data sharing
	  - Provide incentives for standardisation
	- Provide better internet coverage in rural areas
	- Technical harmonisation of tools

5	- The respondents listed several possibilities for sharing information with governments:
	  - Traceability
	  - Quality control
	  - Food safety
	  - Evaluation of environmental impact
	  - Health care (diseases spreading)
	  - Decision making
	- Some do not see the need of sharing information with governments

6	- Access to data from other EU member states
	- Access to cadastral information
	- Access to animal data
	  - Medication
	  - Registration of animals

Table 25 General Themes and Issues within the Use Case Analysis

The following subsections will outline each of the six questions that we asked the UCs, outlining their responses. Our methodology is both qualitative and quantitative. Quantitative in the sense that we attempt to derive what were the most discussed, important, and challenging issues for the spectrum of UCs deploying IoT solutions in agri-food settings, but also, qualitative in the sense that we evaluate the lived experiences and values that found within each UC questionnaire. These UCs provided up with a blueprint for our workshops, but more significantly, they gave us clear insights about the key findings of the IoF2020 project and our recommendations for policy.

1. What Policy Issues did you Encounter?

From our analysis, it became clear that the predominant issues that were holding the agricultural sector back from benefiting from IoT solutions are trust, connectivity, and data sharing regulation. These same results were also evident within the data-sharing focus groups and interviews in D7.3 and D7.4 and the interviews with the 33 UC coordinators that were part of the Data Sharing Activity.

- Connectivity issues (both coverage and cost) is a big, well-known problem --> however, there is only one request to policy makers in this regard
- Trust --> fear from data sharing (new thing, difficult to grasp technically for farmers), and lack of confidence (performance, profitability, etc.) in new technologies
- Some issues in "data sharing regulation" or "trust" --> overlapping with "market issues and competition law"; e.g., barriers for accessing data in proprietary formats; or avoid knowledge of sensitive data to distort competition (see Figure 1).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

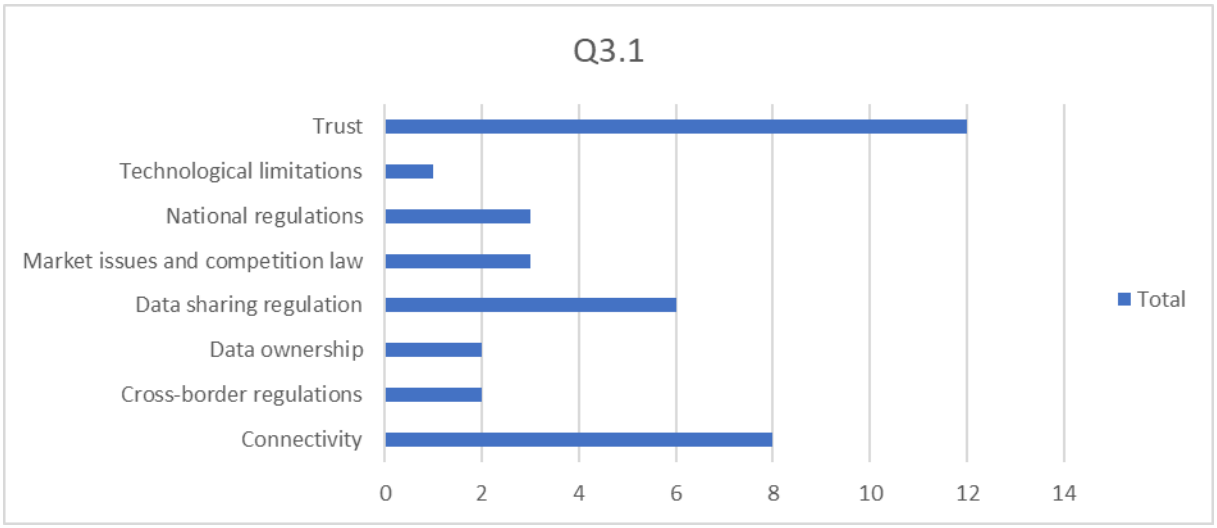

Figure 1 Main Concerns from the Use Cases

One of the main problems the respondents encountered during the use case trial period concerns data exchange, sharing and ownership. Particularly the issue of data sharing was mentioned often by the respondents. However, the types of issues encountered on data sharing vary between the Use Cases:

- Due to market competition and the protection of company secrets, data sharing is in many instances not a viable option for companies. Some companies, like Original Equipment Manufacturers (OEM's), are unwilling to share data, as their data might be beneficial for competitors. The same reasoning applies to intellectual property,
- Some companies are unwilling to share data on what might be considered sensitive issues. For example, use-case 1.7 (Traceability for Food and Feed Logistics) mentioned that feed producers and/or transport companies are unwilling to share the frequency of wrong deliveries of feed into the wrong silo,
- Also, farmers are in some instances reluctant to share data. Use Case 4.3 (Added Value Weeding Data) stresses that other than with their crop advisors, farmers are unwilling to share their data as they are afraid that it will lead to additional policy and/or certificates which increase production costs while the price for their products remains on the same level. Furthermore, Use Case 4.4 (Enhanced Quality Certification Systems) points out that, even though there is written agreement, farmers are still reluctant to put data on a cloud.

Several respondents suggested actions policy makers can undertake, like providing incentives for data sharing, providing incentives for standardisation, assess present regulation and take away hurdles it provides for the sharing of data, clarify the rights of data sharing partners and strengthening the rights of farmers, create projects that allow to experiment more with data sharing, or develop databases (data ' libraries') which are accessible to all actors and governed by them and which allow for experimentation and learning (see D7.3 and D7.4).

Internet Coverage in Rural Areas

Another problem often mentioned by the respondents concerns insufficient internet coverage in rural areas. Several respondents mentioned the problems of insufficient internet coverage:

- The broad deployment of Sigfox weather sensors is obstructed (UC 1.3),
- The exchange of data through the cloud is obstructed due to slow internet access (UC2.2),
- Due to a lack of infrastructure, internet coverage is limited to certain part of a farm, for example buildings (UC3.2),
- Difficulties to distinguish between connectivity problems and internal errors in de sensors installed which can result in a loss of sensor collected data (UC5.2)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

Technological Issues
During the trial period many Use Cases came across technical issues. The nature of these issues, though, vary considerably per Use Case. This is demonstrated in the following examples:

- Difficulties for software developers to gather and use data present on farms due to different formats being used in sensors (UC5.1),
- Farm sensors not offering the possibility to download data for other than its original purpose (UC5.1),
- A lack of common interfaces for data sharing (UC2.5),
- Lack of knowhow and maintenance resources for IoT systems (UC3.2 and 5.2).
- Lack of interoperability between public body databases (UC4.4).

Lack of Uniformity Between Countries
Quite a lot of respondents indicated that in many policy areas there is a lack of uniformity between countries. Here are a few examples:

- Technical differences (e.g., bandwidth)
- Different rules and regulations (e.g., different law on the use of ear tags for pigs, drone use),
- Different documentation standards,
- Different commercial and market configurations,
- Different veterinary policies (e.g., strict vs. liberal policies).

Confidence in IoT Solutions
Farmers' lack of confidence in IoT-solutions was mentioned three times in the questionnaires. In some cases, farmers are reluctant to use IoT-solutions that are not well established. This is expressed in one of the comments made by UC 2.2 (Happy Cow): "There is however reluctance amongst farmers on these ideas. To farmers it comes across as a future under "Big Brother" and clear examples of a business case for them as farmers are extremely rare". In addition, Use Case 3.5 (Smart Orchard Spray Application, Smartomizer) points out that "some farmers are not willing to use less pesticides, because they prefer to "play it safe" and do not prescribe reductions to the full extent possible".

2. Which Policy are you Referring to?

	Regional	National	EU	Agricultural policy	Environmental Policy	IT or Data policy	Research Policy	Health Policy	Other*[8]
UC 1.1		X	X	X	X	X			
UC 1.3		X	X			X	X		
UC 1.4	X	X	X	X	X	X			
UC 1.7								X	
UC 1.9			X					X	X (1)
UC 2.2		X	X	X		X			X (2)
UC 2.3	X	X	X	X	X	X	X		
UC 2.4						X			X (3)
UC 2.5						X			
UC 2.7				X		X			
UC 3.2									X (4)
UC 3.3		X		X		X			
UC 3.4	X	X	X						X (5)
UC 3.5	X	X	X	X	X				
UC 3.6						X			
UC 4.1	X	X	X	X	X			X	
UC 4.2	X								
UC 4.3		X							
UC 4.4	X	X				X			
UC 4.5		X		X					

[8] **UC 1.6** Rules and regulations regarding UAV operations**; UC 2.2** Market and Competition regulations**; UC 2.4** Competition / market protection policy; **UC 3.2** The policy is more related to technical (HW and SW) issues and to such related to the availability to have a local support (in the rural area close to the farms/wine domains) to ensure the system maintenance; **UC 3.4** Competition law**; UC 5.5** Biosecurity; **UC 5.6** UN: 17 Goals for sustainable development, e.g., industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

UC 5.1	X	X	X	X		X			
UC 5.2						X			
UC 5.3		X	X			X			
UC 5.4	X	X	X			X			
UC 5.5			X			X			X (6)
UC 5.6			X			X	X	X	X (7)
Total	**9**	**15**	**14**	**10**	**5**	**17**	**3**	**4**	**7**

Table 26 Use Cases' Relevant Policy Concerns

Our UCs highlighted what they believed to be the most significant types of policy that were restrictive, clashed, or were inconsistent. It became clear that agricultural policy and IT / data policy were the two most significant. Some also specified health and environmental policy as concerns (see Figure 2).

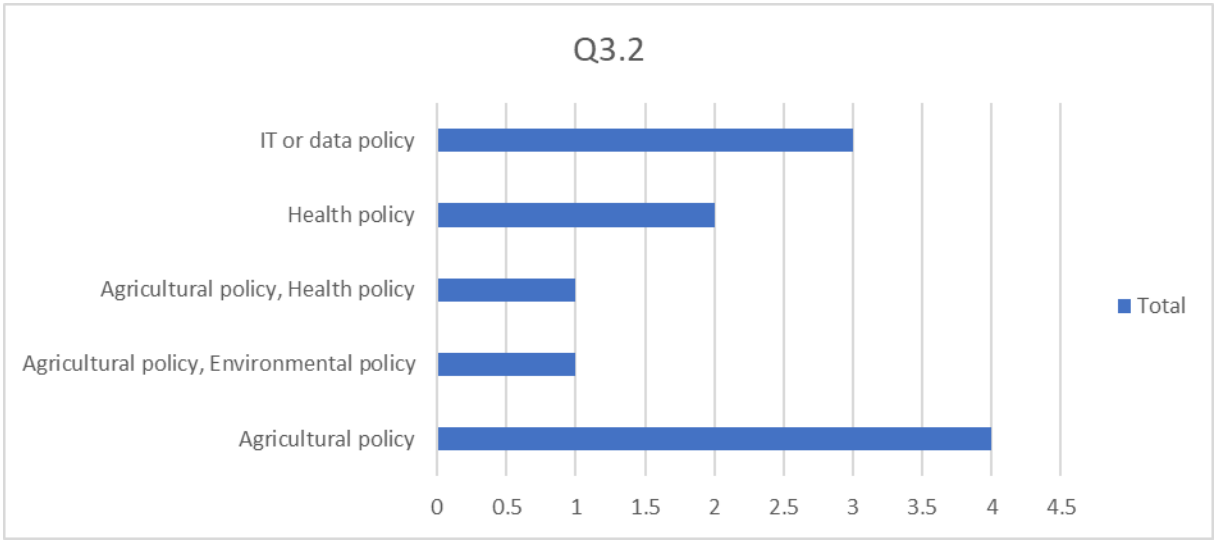

Figure 2 Types of Policy where Problems Arose

3. Was there a Clash Between Different Policies?

18 of the Use Cases replied no to this answer or that they have not witnessed any. A very interesting insight from question 3 in the questionnaire was that the respondents viewed cross-border regulation and recommendations to be clearly the most challenging issue within their use cases. This would point to the issues they face would best be dealt at an EU-wide level. There is a specific call for greater unity, consistency, and clarity, in relation to agricultural and data sharing policy within the EU. Cross-border issues require scale solutions at a transnational level (see Figure 3).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

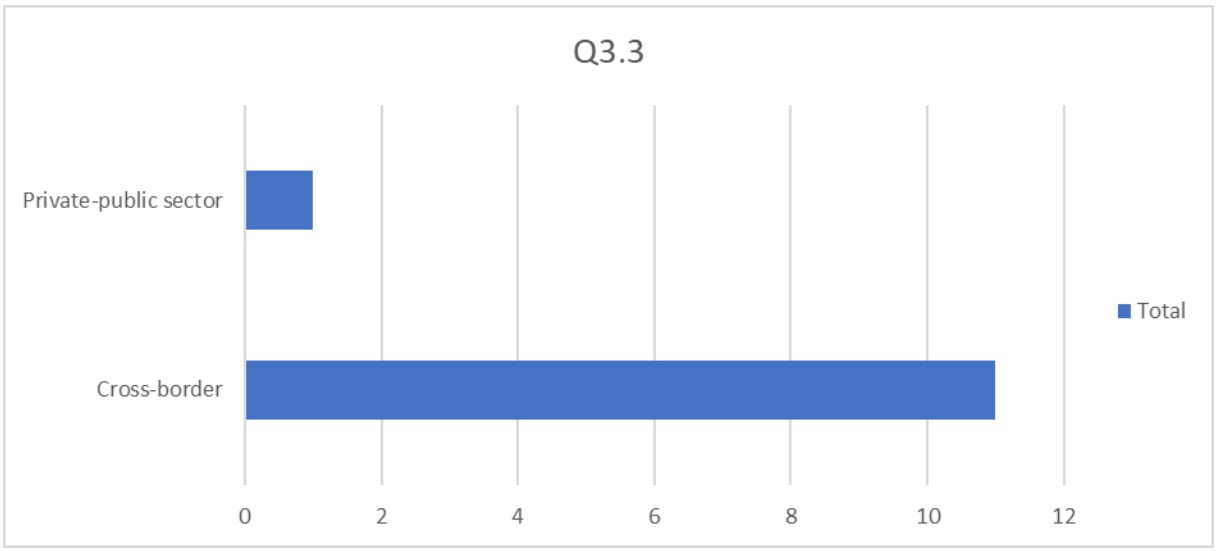

Figure 3 Policy Inconsistencies

4. Is there Anything Policymakers could do to Solve Problems in your UCs?

Seven UCs did not have anything additional to add here. Those who did, we analysed which Directorate-General in the EU would be most responsible for providing the changes required to meet the needs of the European agri-food IoT sector and arrived at some helpful insights. The leading Directorate-General was DG Agri, closely followed by DG Connect. This was not a huge surprise to the policy recommendations team, as these were suspected to be the two key Directorate-Generals for the area (see Figure 4).

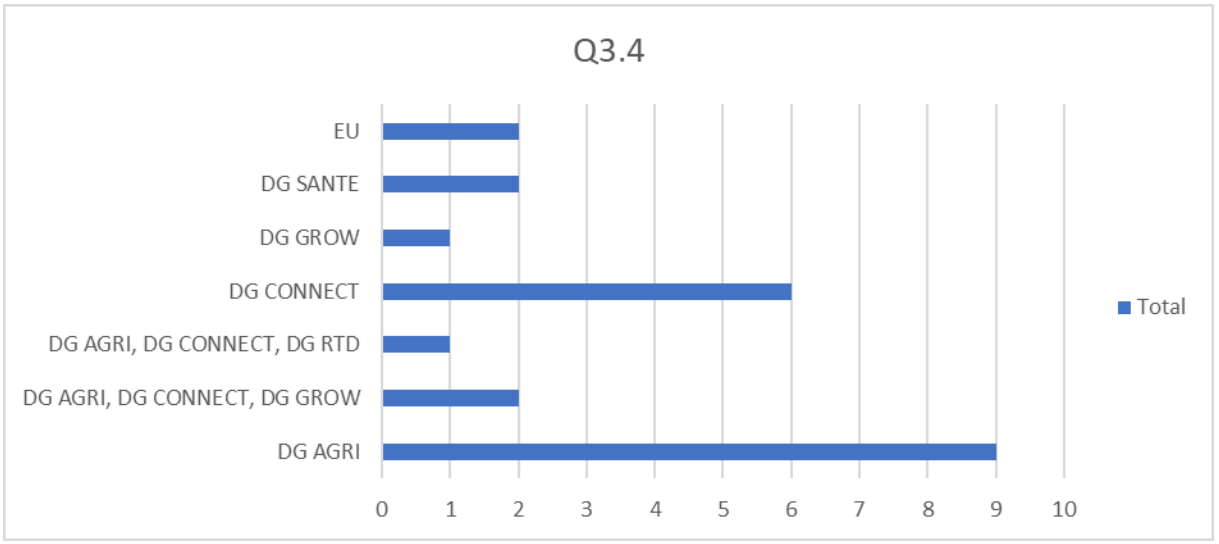

Figure 4 Directorate-Generals Responsible for Providing Agri-food IoT Policy Solutions

One thing that was insightful in our analysis is that many of the issues identified in question 1 were a lot higher than the number of requests by the respondents in question 4. This probably indicates that they were aware of many of the issues that they faced, but it was a lot more difficult to understand how these issues could be solved by policymakers.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884

5. Can Farmers use your App to Report to Governmental Agencies?

The respondents listed several possibilities for sharing information with governments: Traceability; Quality control; Food safety; Evaluation of environmental impact; Health care (diseases spreading); Decision making; Some respondents do not see the need of sharing information with governments.

6. Is there Data in the Government that is Currently not Open that would have Improved the Application in your UC?

16 UCs said they have not encountered such an issue or were unaware of such issues, while the other 10 UCs provided input about more open governmental datasets. The responses made it clear that there are a few significant instances where open governmental data would be hugely beneficial to the industry. Examples are higher resolution satellite images (Use Case 1.3), soil texture and fertility classes database (Use Case 3.3 and 5.4) and cadastral information for OEM's and FMIS's (Use Case 1.4 and 4.5). Like what was mentioned before on the issue of rules- and regulations, this is not surprising considering that, depending on the sector, the "data needs" for each use case differ considerably. Another thing that caught attention in question six was that many of the respondents wrote something along the lines of "not that we know of" or "not that we are aware of". In addition, almost all Use Cases in the Dairy Trial that participated in the questionnaire (except Use Case 2.7, Multi Sensor Cow Monitoring) answered question 6 in this manner. In contrast, almost all Use Cases in the Arable Trial (except Use Case 1.7, Traceability for Food and Feed Logistics) did give some sort of alternative.

4. APPENDIX 2: TECHNOLOGY PLATFORM

Agricultural Technology Platform	Data Sharing Platform for Sustainability Management
Operated by one provider (John Deere, Claas, Lely Dairy Robot, Cosun Beet Company))	**Operated** by a farmers data cooperative for farm management information / certification / accounting
Users: large farmers, contractors Data linked to business secrets, IPR	**Users:** relevant for all farmers to deal with "red tape" and run sustainability programs / eco-schemes Data in family farms linked to privacy
Risks that farmers face: • Industrialisation, increase scale • Farmer becomes franchiser • Vendor lock in • Lack of competition	**Imperfect market**: Farm oriented dashboard does not exist. Why do FMIS / Accounting software not scale up or ERPs not scale down: • A business model problem? • How to mix public and private data?
Potential government reaction: • Promote startups • Support frontier research like AI • Regulate algorithms (sustainability) • Regulate competition (e.g. data portability / number of vendors)	**Potential government reaction**: • Create a dashboard with data locker for farmers as infrastructure (utility) governed as a data trust/cooperative • Also as countervailing power • Oblige the use of UBL in paper work

Table 26 Types of platform

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731 884