Precision agriculture and the future of farming in Europe

Annex 2: Exploratory Scenarios
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Abstract

Precision agriculture (PA), or precision farming, is a modern farming management concept using digital techniques to monitor and optimise agricultural production processes. PA methods promise to increase the quantity and quality of agricultural output while using less input (water, energy, fertilisers, pesticides, etc.). The aim is to reduce costs and negative environmental impact and produce more and better food. The methods of PA rely mainly upon a combination of new sensor technologies, satellite navigation and positioning technology, and the Internet of Things. It has been making its way into farms across Europe and is increasingly assisting farmers in their work.

This annex presents four imagined future scenarios. Each scenario is a fictional account of a future in which the role of agriculture in our society has evolved in a particular way. The development of these scenarios serves a dual purpose:

- they can help us to guide the discussion about what kind of world we want to live in tomorrow; and
- they can help us to identify and explore policy actions that will allow us to steer our future path in a desirable way.

We publish them together with the study ‘Precision Agriculture and the future of farming in Europe’ to further support parliamentary committees and individual MEPs in exploring, anticipating and responding to potential PA development paths and their associated impacts, and to aid reflection upon anticipatory policy and agenda setting in the European Parliament.
The Scientific Foresight project ‘Precision agriculture and the future of farming in Europe’ has been requested by the Science and Technology Options Assessment Panel (STOA). These exploratory scenarios of the study were developed by a team of foresight experts in close collaboration with scientists from Wageningen University and VetEffecT. The Scenario development and foresight phase were coordinated by Cornelia Daheim (Future Impacts).

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Introduction

In this section, we present four scenarios for the future of precision agriculture that have been developed in the context of the present Foresight study. Each scenario is an imagined account of a future in which the role of agriculture in our society has evolved in a particular way.

These speculative scenarios do not aim to predict the future. Instead, they are each meant to illustrate one particular direction in which our society – and within it, the role of agriculture – might evolve.

The development of these scenarios serves a dual purpose: The scenarios can help us guide discussions about what kind of world we might want to live in tomorrow, and they can help identify and explore policy actions that will allow us to steer our future path in a desirable way.

We hope that these scenarios provide an accessible means for the reader to understand the social, ethical and legal dimensions of the options lying ahead. They were designed to facilitate the Foresight process, and they are presented here to further support committees and individual MEPs in exploring, anticipating and responding to potential precision agriculture development paths and their associated impacts, and to aid reflection upon anticipatory policy and agenda setting in the European Parliament.
Scenario 1: Economic optimism
Market dynamics play a central role, trade is free and ever more global, and the economy is booming. People rely heavily on technology and witness rapid technological developments. They place trust in technological development and the mechanisms of the market to solve problems, now and in the future. New technologies see fast breakthroughs, meeting little resistance, and technological innovation mainly takes place in the private sector. The market mechanisms govern developments, and bring about increasing risks and phenomena of economic and social inequality. Although there is free trade, the resulting differences in income determine the global access to technology. But: People have faith that technology will in the end – in combination with the market mechanisms – be able to solve issues in the environment as well as social and economic inequality. For example, global food security has improved. And as long as they show return on investment technological applications will continue to break through and be rolled out.

A lot of agriculture has moved outside Europe and new ‘free’ locations are being used. Agriculture left in Europe is fully automated, up to the point of autonomous robots and controlling farms – and PA and other technologies are implemented for the sole goal of higher efficiency.
Main characteristics:
- Main objective: economic growth
- Very rapid economic growth
- Rapid technological development
- Rather slow population growth
- Increasing worldwide trade globalisation/free trade
- PA and other technologies are implemented for the sole goal of higher efficiency
- PA develops fully, up to the point of autonomous robots and controlling farms (loss of jobs)
- Policy and legislation create open markets

International
In 2050, society in Europe can best be described as cosmopolitan. Increased international competition has increased global trade, and also improved food production efficiency, and kept prices low. Privatization and deregulation also increased efficiency and allowed for tax relief in numerous areas. Market liberalization has been continued, so that market forces led to overall cost reductions and productivity improvement.

Socio-cultural Beliefs – In the Words of a Citizen

As long as we have economic growth, we will prosper and so will our children. We must ensure that we continue to grow and perform, faster and better. Competition between countries, people and businesses is a good thing: it improves the quality and efficiency and keeps prices competitive. It also offers more opportunity for self-development. Independence, freedom and personal development are very important. Performance and/or making money makes that possible. We want to lead a luxurious, comfortable and above all stimulating life, both professional and private! Well, life is a rat-race. Those who don’t make it get left behind. And yes, there is a strong divide between groups, the haves and have-nots. There is low solidarity. But that’s just how it is, everyone has to fight for himself.

Technology
Technology development is strong, but clearly focused on cost effects and not on environmental or overall sustainability issues (unless they imply cost savings or increased profits). However, many technological applications that have been diffused widely recently, now turn out to solve problems only partially, as in the case of the heavily increased use of chemical fertilizers or genetic modification, but it turns out they bring other problems with them. Stronger interventions are starting to become called for by a small, but growing part of the population, to avert even greater problems. However, the main idea still counts that what we cannot solve now, will probably be solved by future generations.

Government
There is a strong belief in market forces, and government focuses on basic tasks in the field of national security and justice, and less and less in e.g. protection of nature and landscape or social equality. The influence of the private sector is strong, and (financial short-term) cost-benefit analyses are relied on when making important choices. The downsizing of the government has been drastic, but areas of concern of remain that market forces so far seem not to have solved, such as gaps in health and education or the high (youth) unemployment.

Ecology
In this liberal, individualizing and efficiency-oriented world, economic growth is high, but also the ecological risks (particularly climate change and control thereof) are large, and they are increasing. However, the majority of people don’t worry about these risks; they believe that technology will solve everything “in the end”. Nature is seen as a source of material wealth, and there is little regard for animal welfare and biodiversity, unless it is put in a ‘hip’ or ‘recreational’ context. Sustainability is only a fashion for young “hip” people, which is a very small minority of citizens, and overall environmental awareness is low. Nature is seen primarily as a place for adventure, fun and entertainment. Only in areas where it is economically profitable (e.g. catering, tourism or adventure sports), there is investment in conservation. Economically unattractive areas are left to their own devices.

Labour
To remain competitive with emerging economies in South-America and Asia, people have to work longer and wage increases are rare. Still, labour is comparatively expensive. High-skilled people and high-educated people compete on an international level, and often work together in international teams, in virtual environments.
**Agriculture**
Because of upscaling (due to internationalisation and high tech production) farmers have to either grow big or be integrated with multinationals. Emphasis is placed on optimizing processes. Large multinational companies own data and also patents on organisms in genetics.

Technological breakthroughs have been witnessed especially in biotechnology and genetic modification – which helped prevent food shortages and, so it is argued, made everyone healthier, also through the wide-spread use of “pharma-food”. Data about what you eat and what you want to pay for your food is also directly passed on to the big players, provided you give permission - but most people do, as they prefer convenience over privacy. Also, sensor technology, tracking and tracing has been taken to a new level. The internet of things has developed into the internet of living things: Plants, animals and even people are now constantly connected online. Now, we are also witnessing the rise of artificially regulated ecosystems (outdoors).

This new form of “super-highly-intensive” also needs less land. Food is often grown vertically, and increasingly under ground or in the water - because this is efficient. Land that is no longer used for agriculture is now “given back to nature” (mostly to be used for recreation and other forms of economic gain). In local ‘test, innovation and research’-areas, smaller (science) farmers develop new, super healthy products.

**Food**
In order to meet the growing demand for food worldwide, we see many investments in new technologies, such as food printing, aquaponics, vertical farming (urban agriculture) and the cultivation of algae and insects as novel sources of proteins.

The rapid rise of the food printer has ensured that the food chain has changed radically: it is faster and shorter. Almost everyone has a food home printer to print food tailored to his or her specific needs, adding flavour and a personalized set of nutrients. HAPPs (a new form of health apps, used by nearly all citizens) measure body signals and synchronize e.g. with the food printer’s nutrient mix. Next to this, home appliances (TV, refrigerator, toilet) are equipped with smart sensor technology and share real-time information. The development towards widespread use of food-printing had timesaving reasons, but also financial motivations: dairy and meat are very expensive, and the alternatives just become cheaper in the 2030s. There is also a strong increase in luxury “natural” food, because ‘real’ food provides you with status nowadays.
Farming

Farming in this scenario:
General farming as we knew it in 2015 is no longer 'needed', and there are few (some rare low-skilled ones, but mainly high-skilled) jobs left in farming. Only 'test, innovation and research' institutes of the big players have a special status. These institutes are still mainly populated and run by humans – but they are very few. Most farmers have either evolved to big corporations or have been bought by large corporations. A few 'traditional natural' farmers still exist, but are there mainly for tourist and conservation purposes. And some people take up 'traditional farming' after their pension (of course with the help of some robots), which is known as quite an expensive hobby.

What characterizes this scenario, in the words of the experts:
- "Less people in agriculture"
- "Integration-farm medicine food"
- "Dependency on tech providers"
- "Less diversity of farming"
- "Business makes the rules"

SKILLS

Skills in this scenario:
'The farmer' doesn't exist anymore. Most job growth was for specialized ICT-high tech- or nutrition experts. The remaining jobs on a farm, these are very few low-skilled jobs for tasks that can't be automated, but mainly it is about legal responsibility and management in fields where automation cannot yet take over. Those who work on a farm now are specialized in technology, deal with data and are surrounded by robots. And when a problem occurs, they e.g. call in the advice of 'genome experts' for checking the crops' values and possible modification, or of 'special location advisors' that know about and can modify the composition of the new surroundings where crops are currently grown. In farming, legal know-how, data science and ICT-skills are critical.

What skills farmers need in this scenario, in the words of the experts:
- "Highly technological background"
- "ICT skills"
- "Data skills"
- "Business management for farmers"
- "Market skills"
- "Manager-trader"
CONCERNS/ OPPORTUNITIES

Experts highlighted the following possible concerns in this scenario:

- Risk of monopolies
- Increasing inequalities and risk of social unrest, high risk of strong social exclusion
- High environmental impacts & risks
- Risk of land grabbing
- Privacy and security issues
- Possible health issues: because of a lack of food diversity and possible long-term high food prices

Experts highlighted the following possible opportunities in this scenario:

- Regulate monopolies (relates to ‘hacking’ in previous section)
- Conserve back up technology and create seed banks as a back-up
- Data availability
- Socio-economic restructuring to stimulate taxes

A note on the special concern of land grabbing, in this scenario:

The views on the implications of this scenario on land grabbing differ. One view is that land grabbing is “ignored”, selling land, even nature, to companies from foreign nations is alright, as long as it’s for a good price. It is expected that in this scenario people/businesses can buy what they want. Therefore, a lot of land grabbing occurs, also from outside of EU, accelerating the speed of decline of small farms. Small farmers cannot keep up with technological breakthroughs because of lack of investment: big multinational corporations buy up land for under market value, misleading farmers. The land is not necessarily bought for agriculture purposes. The other view is that land becomes less important because less land is needed. The European highly productive agriculture will be able to produce more with less input and thus continue its growth (and export) without extra land grabbing.
Scenario 2: Global sustainable development
The protection of the environment and the combat of inequality are of highest importance. These targets are achieved through global cooperation, clear political frameworks, efficient technology and sometimes even behavioural change aimed at sustainability. Sustainability, equality and justice are at the core. Technology contributing to these targets will be adopted. People will therefore be mainly looking for and investing in technologies contributing to “a better world” according to these criteria. There is global governance by strong international institutions and legislation, but applied as frameworks and targets that are then realized by the actors “on the ground”.

PA is pushed forward and developing rapidly where it clearly drives sustainability of agriculture forward, and is strongly regulated. It can be found in the city, in the shape of vertical farms, and in the countryside, where every plot of land is attributed to a specific use, be it food production or conservation of nature and biodiversity.
Main characteristics:
- Main objective: global sustainability
- Strong economic growth
- (Relatively) Slow (global) population growth
- Medium rapid technological development
- Worldwide trade/globalisation/free trade
- Strong global governance, government sets sustainability frameworks & targets
- Increasing regulation intensity
- Governments push for behavioural change
- PA breakthroughs relate to sustainability and equality issues
- PA develops fast, semi-autonomous technologies on most farms (can not take jobs – farmers in role of sustainability shepherds)

Circular Economy
The circular economy is nearly realised, because of governmental cooperation across national borders and a strong legislative push. Also, a "totally green" energy system is coming into place, based on renewables. We see the introduction of very high CO2-prices and a global scheme for climate change mitigation and adaption. Companies have to report on their sustainability achievements with eco- and water-footprints and required triple-bottom-line reporting.

It has become clear that market forces alone provide no solution for international issues of poverty and the environment, but that effective institutions like the EU and UN can. Shared and cooperative solutions are seen as the only option. Freedom and material prosperity are important, but within certain internationally accepted limits. Sustainability is obligatory.

Regulations
Social problems such as safety, care for the elderly and children, hunger in developing countries and environmental issues are expected to be solved by the government and supra-national institutions. In the context of sustainability, the focus is on lining out clear targets and providing strong sustainability frameworks, and also in parts on changing consumption patterns and correcting human behaviour.

The institutional side has thus been strengthened, but not in a "nanny state paradigm", but as those who provide the frameworks and targets. There is a strong confidence that experts, "the right people in the right place," can make decisions for the common good. Local government also plays an important role, given the importance of self-sufficiency, which is achieved mainly at local level.

Nature
Nature is seen as a sign of prosperity and as something that must be protected. However, there is a strong focus on reducing risks: Nature must be controlled and environmental benefit should not "be at the expense" of humans. Technological solutions help to ensure that nature "is governed accordingly". Thanks to data that is collected in real time, the governing institutions have a complete overview of potential risks and disasters. For this, privacy is partially given up. "Prevention is better than cure", and citizens are willing to pay a lot of taxes for projects and investments in technologies that make them feel safe.

It is also a priority that landscape and nature have to contribute to food security. Some rural areas are categorized as 'health areas'. These are heavily regulated areas: they are non-smoking, lighting should be reduced and noise is severely limited, and they are popular for recreation.

Nature now has its own legal rights, and many groups fighting for instating more rights for animals and plants. As a consequence, there is an increasing number of conflicts between groups pleading to keep people safe versus groups pleading for nature's rights to do damage to people.

Safety
Safety is a high priority - the government is expected to protect and prevent disasters; this is done in coordination of international, national and regional institutions. Guidelines and laws are important and respected, as they are also strictly enforced. Citizen action groups make a case to be as safe as possible to the environment. For this cause, it is by now widely accepted that lifestyles also had to change; and some of these changes (such as less meat consumption) were directed by government via e.g. price interventions.
Agriculture
Agriculture is heavily controlled by the government, which holds all the data and therefore all the information, processing and analysing it using supercomputers. International governments prescribe via frameworks and targets, what, where, how much and how farms can produce, all in the name of environmental sustainability, food security, health and safety. But who better to decide for us than the government? Farmers are becoming less and less entrepreneurial and increasingly function like “executors”, whose main task is to realize the targets set.

The biobased economy and circular economy are a priority and the government invests heavily in technological developments that contribute to the realization of these systems. Everyone pays a high price for their waste, so non-circular living and producing has been punished. There is a preference for local production in general, but more importantly so for food. A ‘jungle of labels’ arises on the market, but the government now plans to intervene here, too.

Technology
Technological developments “control” and “manage” nature. International and national governments play a hugely important role in this. Much is invested in large-scale projects e.g. for ensuring food security or realising the circular economy or the bio-based economy. There is also a large emphasis on sustainability of course, and we see breakthroughs in renewable energy and the biobased economy. This also includes non-food products like plastics out of biomass; and algae based food and chemicals. Electric and autonomous transport has become mainstream.

Vertical agriculture
Urbanisation continues. In the cities we see a lot of ‘green’, thanks to the vertical agriculture, aquaponics, and urban agriculture that have found a place in previously vacant buildings. With tracking and tracing devices and apps to scan people and products, consumers get information about freshness, nutrients, origin and production conditions before they make a purchase. The government provides labels to guide consumers. We freely give all our data to the government, “so they can take better care of us” and so we can live as sustainably as possible.

Food
The world economy is globalised, but many people prefer locally, sustainably produced food, and they also want their food to be healthy and safe. People who are ill or have unhealthy behaviors such as smoking and drinking are monitored for what they ingest. People still prefer food to be – or at least appear – natural. Food printing is only used in hospitals and nursing homes for medical reasons. People are allowed to eat 60 grams of meat per week, other than that we now eat much more insects, algae, nuts and fungi as a source for protein. This means that new types of farms have developed, like insect farming and algae farming as viable new economic opportunities for farmers.

Land use
Due to the strong role of government, there is nearly no competition in land use for food production, nature and biodiversity, or production for biomass (energy production). The reason: All these decisions are made by the government with help from their supercomputer. Many regions remain or become relatively self-sufficient, as does Europe.

Governance
We are highly internationalized, and supranational government organizations have more power now. An effective system of global governance is established, so that we now have strong international institutions and laws. Through policy instruments such as pricing and standards, the international government aims for a more efficient economy: A global circular economy. Companies are controlled in terms of the long-term impacts of their products and judged harshly on the respective sustainability reports and footprints. However, many say now that our biggest risks nowadays is bureaucracy, the breach of international commitments and not making timely decisions.
“What PA & Skills Demand Look Like in 2050 - Scenario Details”

**Precision Agriculture**

Precision Agriculture in this scenario:
Producing safe food and enough food, with low environmental impact is key, and PA has to serve that goal, via maximum production within regional soil and climate constraints and low waste. The incentives have thus been strong to employ technology. A focus of PA was and is to contribute the circular economy and to environmental protection, and generally be serving nature, man and animals’ wellbeing rather than economic profit. Therefore, PA breakthroughs related mainly to sustainability, and PA has developed fast, so that there are semi-autonomous technologies on most farms. But due to balancing this with the impacts on social sustainability and thus jobs, farms are not (yet) fully automated. As accountability is critical, PA has also focussed a lot on increasing traceability and transparency in agriculture.

**Farming**

Farming and PA in this scenario, in the words of the experts:
- “3d and 4d printing”
- “Better, cheaper transport”
- “Robots, but also still human labour”
- “ICT process”
- “Farmers do what government tells them. Government has supercomputer”
- “Tracking and tracing”
- “People at the wheel, robots do dangerous and heavy work”
- “Farm becomes control room, farmer controls from behind computer screens”
- “Natural foods, also algae, insects etc. for protein (meat and diary is expensive)”
- “Internet of things, everything is connected”
- “Full traceability thanks to PA”
- “Focus on system metrics (indicators sustainability) > an objective way to measure sustainability”
- “Knowledge-based agriculture”

Far as possible – and this was mostly successful so far e.g. because of the payment schemes for sustainability contributions. Farming has become a more attractive profession with a good income. However, the risks are high, because if not all regulations are followed and not all targets are met, the penalties are also severe. Farmers thus have to protect themselves against claims and document all their actions in detail (administrative skills) – they have to be skilled in avoiding claims and lawsuits.

**Skills**

What skills farmers need in this scenario, in the words of the experts:
- “Dealing with bureaucracy”
- “Education, education, education”
- “Spread general knowledge on sustainability via education push”
- “Digital blacksmith”

What characterizes this scenario, in the words of the experts:
- “Focus on environmental benefits”
- “Positive image of farming”
- “Examples can be found in Munich: compensation for shifting to organic produce”
- “Full traceability thanks to PA”
- “Big brother versus personal freedom”
- “Focus on system metrics (indicators for sustainability) > an objective way to measure sustainability”
- “Knowledge-based agriculture”

Many countries have also introduced special programmes for young people and female farmers to get into food production a long time ago. While automation and robotics are accepted as long as they contribute to sustainability, job loss should be avoided as far as possible.
Scenario 3: Regional competition
Regions (groups of countries, countries or regions within countries) have taken over. They concentrate on their own direct interests and regional identity, which has caused some interregional or intercultural tension – and it has made exploiting advantages of scale impossible. Security is paramount and technologies that have not proved themselves in this respect, or technologies promising fast and large-scale change, are not adopted. Instead, technology for efficiency and security is invested in heavily. The local food supply is e.g. based on the principle of national or local independence, with the environment in second place.

PA is utilised to stimulate regional growth and production. Because of the regional scale being dominant, and because of society's demand for food security, some genetic manipulation of plants, soil and weather is accepted, but only when highly monitored. Farmers are regarded as the main assets to make sure we are self-sufficient as a region.
Main characteristics:
- Main objective: security
- Slow economic growth
- Rapid population growth
- Slow technological development
- Trade barriers
- Strong national governments
- To save time and produce more, technology is pushed and accepted in PA
- We want 'real' products, but when needed, to be self-sufficient, modification is allowed
- Farmers are seen as important members of the community

Regional competition

but wants to see something in return. Those who do have work can live comfortably. But who is sure of his job, an affordable home, a well-deserved retirement? Prices for food, energy, health and education have kept rising. The increasing terrorism, rising crime and open borders threatened our economy and all of us. Politicians are expected remove these threats.

Environment
Environmental pollution and climate change are not really perceived as a problem - the effects are regarded by most to be greatly exaggerated by interest groups, and environmental policy as only leading to more and more complicated rules. The problem is postponed with the assumption that we should deal with it when it is really urgent, and when it clearly affects security in Europe.

A major worry of citizens concerns the growing dependence on foreign energy. Regions desperately want to be self-sufficient to avoid dependency, and while renewable energy helps us to be independent, the positive effects for the environment are rather "incidental". There are still attempts to develop the circular economy, but the high level of mistrust makes it difficult to connect sectors - also, major investments are directed towards security matter more.

Mistrust and protectionism
There is a great mistrust in institutions - and actually distrust in man in general. The tendency towards protectionism is strong. Due to the regional orientation, certain economies of scale cannot be achieved (limited technology transfer, nearly no transnational climate policy support).

Low investment and citizens' attitudes
Citizens do not want to pay taxes without actually seeing something in return: Our own problems are more important than that of Europe and the rest of the world. Therefore, investments towards new technologies remain rather low. People say: "We are not responsible for solving the troubles of another person; moreover, the question is whether we can help others. In this way we keep what we have and most of us can live a good and comfortable life. We do not want to depend on other people for food, energy and water. It's every man for himself, and yes, maybe huge gaps arise between rich-poor, high and low educated and young-old, or between one region and the other, but everyone has to fight for themselves."
Agriculture
Due to the primacy of self-sufficiency in society agriculture gets more space (both physically and in law) to achieve self-sufficiency. In most regions, food supply is regulated as closely as possible. In many regions, farmers also supply energy. Precision agriculture, big data and automation are accepted in agriculture, as they provide more efficiency and thus more food security. In general, “tinkering” with our food is not accepted: Food printing, pharma food and GMO are considered “high risk” technologies, people want ‘real’ stuff. Only in high risk areas, or areas where it is difficult to produce it is accepted. Although meat is becoming more expensive, there is little demand for new sources of protein such as insects or algae. The reason is cultural attitudes: We prefer to stick to what we know.

Farmers’ first duty is produce enough food, and are under a lot of pressure from regulation and monitoring. Locally produced food is popular because people have the idea that they know where it comes from and can trust and rely on it. Automation and robotics - though generally regarded as necessary because in some cases it is safer than using human labour, and for productivity – have come at the expense of jobs - and that has led to criticism and mistrust towards farmers. Accidents that happen with or robots and drones are widely reported in the media. Robots have even been vandalized in some regions, they are seen as more of a threat to employment than migrants at the start of this century.

Nature
Nature is well appreciated, but at the same time, it is guarded as a potential source of threats. Farmers are expected to “take care of nature” and are held responsible when things go wrong, such as flooding or power failure. Recreation takes place under supervision and in rural areas it is no longer allowed to go wherever you want. Animal welfare is important; consumers want their food to be real and safe. Therefore animals are tracked to make sure they have lived a healthy life.

Technology
Technologies that have not proved themselves or technologies promising fast and large-scale change are not adopted, while technologies contributing to the sense of security and autonomy have succeeded. However, due to lack of investment, few major technological breakthroughs are to be expected.

Technologies in the field of security and thus also food security have been spread massively. On the other hand, modification of the weather and modification of organisms is only accepted in areas where there is a high risk of natural disasters or food shortages, but only under severe control-mechanisms. Virtual technologies exist, but are not as important as real life world or meeting in real life, and generally IT-development is hampered by privacy issues and fear of cyber-attacks. Drones and micro robots are used for surveillance and security, but are not allowed to be used for other goals.
**Farming**

Farming in this scenario:
Farmers take the lead and in many regions are the frontrunners when it comes to renewable energy. They are seen as important members of the community because they make sure we can feed and power ourselves. However, people will not accept large subsidies for farms or farmers. They have to produce sufficiently and efficiently, and as all others, their activities are tightly controlled. Government involvement thus focuses on control and regulations, not financial help.

What characterizes this scenario, in the words of the experts:
- "Farming becomes more pragmatic in this scenario."
- "The farmer gets a more important role."
- "Sharing and shared learning is limited as we see more competition between regions."
- "PA will not be taken up so fast because of the regional scale."
- "We will see part-time/urban farming/specialist farmers/different types of farmers."
- "We see small scale technology."
- "More unskilled people in this scenario, who might not be able to work with technology."
- "We might not invest in PA because labour is cheap."
- "There will be many jobs in farming."

**Precision Agriculture**

Precision Agriculture in this scenario:
PA is exploited to stimulate regional growth and production. Regional competitiveness and survival is key, not sustainable development. Full tracking and tracing is in place, and cameras and sensors everywhere are used to control farming activities for ensuring safety. We see automation and digitalisation in production, transport, and food processing. Therefore farms are semi-automated in most regions - but development has not been as fast as many expected. Because of a lack of scale and distrust in new technologies, further advancement in PA seems to have come to a halt. PA technology is mainly focused on monitoring, collecting data, interpreting data, ICT, GIS, GPS etc. And automation in PA has also brought a lot of social unrest (as in other sectors), because of loss of jobs. Robots are used for dangerous or heavy labour, but manual labour is still used. We do not trust robots entirely and in some regions we do not accept loss of jobs because of automation. Because of the regional scale being dominant in this scenario and society's demand for food security, some genetic manipulation of plants, soil and weather is accepted, though highly monitored. The farmers who are allowed to work with these methods and products are strictly monitored and the products are accurately tracked and traced - and consumers often sue farmers if they get sick and can associate it with food products. But now, there are nearly no more food scandals, and in some regions there are even undercover government agents spy on farms and farmers.

There is a strong preference for using 'natural resources' to influence production circumstances, for example we use bees, birds and insects in smart ways to reduce use of insecticides. Also robotic birds are used to protect crops. Data is used to manipulate our environment (determine, place, time and method), but the methods used are preferentially more low tech and do not involve tempering with genetics. Tech development has also been slowed because of the general distrust, which led to data being rarely shared between people, organizations and regions.

**Skills**

Skills in this scenario:
Like in the previous scenario, farmers will have to protect themselves against claims and thus all their actions will have to be documented in detail (administrative skills) and they will have to be skilled in avoiding claims and lawsuits. They still need to understand the ecosystem to know what can go wrong. Apart from this, new technology knowledge is needed and rather hard to acquire due to a lack of knowledge sharing.

What skills farmers need in this scenario, in the words of the experts:
- "More entrepreneurial skills."
- "Self-sufficiency / farmers more important."
- "Labour intensive work."
- "Organic farming."
- "Social interaction (more direct sales, more visitors)."
- "Regional organic farming."
- "Open source, share, reuse."
- "Law (claim culture)."
- "Security, monitoring."
- "Self-sustaining region, so good insight in what is needed locally."
- "Low waste production."
Experts highlighted the following possible concerns in this scenario:

- What will regional fragmentation do to export?
- Regionalisation could impact negatively within a world wide market – more import and less export
- There is little trust in government and institutions
- High inequality, low solidarity in society
- Loss of jobs because of automation is not accepted
- People monitor not only products but also each other
- Keeping knowledge available
- How do you deal with risks like extreme weather events? What contingency plans are there?
- How can we save traditional production

Experts highlighted the following possible opportunities in this scenario:

- Policy agility is needed
- Reducing agricultural footprint
- Regional organic farming

A note on the special concern of land grabbing, in this scenario:

Big firms buy out small farms, possibly below market value, but not multinationals, rather firms from own country or region. Only within regions, land ownership will be a crucial issue and financially interesting, it could even be encouraged by government if production is not safe. Nonetheless, land grabbing is less of an international problem because of the smaller scale; regions will protect their own land and are closing their borders at least partially. Mainly older farmers are easy victims for land grabbers, as they can’t keep up with changing technology and legislation.
Scenario 4: Regional sustainable development
For problems with the environment and social inequality, solutions are sought at the regional level. The key is a drastic change of lifestyle and decentralisation of government. Everywhere, the main focus is on one’s own region - because everyone believes this is where sustainability can be realized. Decisions arise from idealism rather than fear, the communities are strong and tightly knit. Overall, the paradigm is about small scale change, and while this has been successful in many respects, the advantages of large (international) scales could not be realized.

PA is employed to produce more sustainably and to decrease environmental impact. It has made progress, but farms are not fully automated, due to lack of scale and a generally slower technology progress.
Regional Sustainable Development

Main characteristics:
- Main objective: regional sustainability
- Medium to slow economic growth
- Medium population growth
- Slow technological development
- Trade barriers
- Local management, local actors
- PA used for food security and sustainability goals

Regional
Solutions to problems in the areas of environmental and social inequality are realized at a regional level. The key to this is a drastic change of lifestyle on the one hand and a decentralization of administration. Sustainability and the interests of future generations are paramount. Because there is small scale change, certain economies of scale could not be realized. However, this is accepted as economic growth is not seen as an end in itself, nor is income growth. Instead, regional sustainability which is also understood as wellbeing and quality of life, is the main objective.

Well-being
Community spirit, self-determination, leisure, health, a clean environment and cultural identity are most important. More and more people decide to step out of the ‘rat race’ and choose to prioritize their own health and wellbeing and that of their families. The market for organic, local products and products that contribute directly to the income of small farmers is growing rapidly, although people have to pay a higher price for them. In many regions and municipalities, priority is given to the preservation of valuable cultural heritage and landscape, despite pressure from the business community. People are increasingly self-reliant and organize themselves into local collectives. Besides citizen collectives, NGOs and civil society play a major role. This is encouraged by governments, but it was first clearly a primarily bottom-up initiative acting at the regional level. Care for one another and responsibility for your environment is the norm, as community spirit, civic responsibility and socio-cultural diversity are of paramount importance. The call to bring back the ‘human dimension’ in our lives has for example, led to volunteering having become more important in the provision of all kinds of needs in terms of care. As a consequence, there is also a lot of social control.

Nature and self-sufficiency
The countryside and the city have become more connected, as the ‘hinterland’ is crucial for food security and nature. The consideration for nature, the environment and animal welfare is high. While there is limited economic growth, this is not seen (any longer) as a major problem, since it is considered less important. There is also a strong orientation on local products and great confidence in local government (self-sufficiency), and a decrease in consumption of luxury foods. Given the importance of local production, the pressure on the environment rises, mainly due to the increased amount of land needed for farming. Local products are popular; people have an aversion to polluting mass production. Many people grow their own food and on a local level. Communities try to be as self-sufficient as possible in their food supply. Products and goods are preferably not transported over long distances but produced “close to home”.

Nature conservation and sustainability efforts
There are strong agreements in the EU and local governments for protection of nature and landscape and to smoothen the transition to sustainable energy; the support for preserving nature and for ecological restoration and nature is broad. Mobility and congestion decrease, causing air pollution, noise pollution and landscape degradation to remain limited. Citizens do not accept it if these rules are violated. After all, everyone has to take responsibility for a healthy environment now and later.

Animal welfare is very important and many people eat meat only twice a week. Organic production is the norm. Insects, fungi and algae are widely accepted as a new protein source. Work is underway on a universal convention on the rights of nature and animals. Also, local ‘traditional’ knowledge about dealing with the landscape and with nature is regarded as crucial. Regarding economic activities, the focus is on preserving the heritage, traditional landscape and nature (also for the increased regional tourism). If tourists do damage to the landscape, they are put on a blacklist.
Agriculture
Farmers are local heroes and seen as guardians of the region. They provide food, energy and new raw materials. For example, furniture and clothes made from fungi that are specially produced by mushroom growers. Many people buy shares in a local farm and get to reaping, picking or slaughter on the weekends. Children are obliged to help on local farms and in nature areas because they have to understand how the earth and nature works. Health, nature and agriculture are sectors that effortlessly blend into each other and establish a high cross-over in the area of wellness, health, recreation, mindfulness and food.

Older farmers are respected as very valuable as traditional, local knowledge is seen as key to sustainability, and many become coaches for young farmers and urban farmers. Farming is regarded as a craft, handed down from older generations. Only on a small scale, robots are used to do the hard and dangerous work.

Trusted Technologies
Technological advancement differs greatly between regions, but in general, technology doesn’t develop fast, because of the lack of scale and the regional focus. Technology that contributes to sustainable production is used on a small scale. Robotic technologies are accepted in order to facilitate production, but not at the expense of jobs. The technologies that are there are mainly focused on the management of energy, water and food. Sustainability, reuse, recycling and closing production cycles are also subject to technological innovation. The biobased economy and circular economy take a flight. Waste is reduced to a minimum. Many investments are made in local, sustainable energy.

Sharing Economy
The sharing economy and new forms of barter are the order of the day, as it is less important to own stuff and property is less of an attribute to social status. People share vehicles, machinery and equipment such as tools with each other on a neighbourhood and city level, enabled by internet platforms and mobile applications. Middle man are cut out, this is a platform model. Collaboration is highly valued in close-knit communities, but there is little trust in large institutions – people prefer to settle matters “with each other directly”. Crowdfunding has become a popular source of funds for enterprises and innovations, where citizens and local businesses jointly invest in new projects and products.

Regional food is popular. Labelling and certification have partly given way to full transparency as the buyer can trace the history of an individual product with ICT. Consumer demands differ by region, and farmers are not only food producers, but also heritage guardians and energy producers, as there is demand for e.g. bio-based energy including biogas from manure. Tractors and other electric machinery are shared as much as possible, and are used for energy storage at night and in wintertime as they are connected to the grid.

Regions and cities make up their own rules when it comes to spatial planning and the type and size of farms suited and accepted in the region. In some regions the population is shrinking, while others experience great pressure for urbanisation and growth. Nearly everywhere, communal gardens and greenhouses are important food sources for many residents - farms produce for the local market and have close relationships with their customers. Respect for the farmer and his knowledge of the ecosystem and his craft is high.

Food
Meat and dairy products have become more expensive and the protein transition has therefore been given a huge boost. We now eat algae, seaweed, mushrooms and occasionally insects to get our proteins. In addition to animal welfare and the importance of sustainable production, health is also an important factor in our choice of food. At neighbourhood level there is a lot of information offered on the influence of diet on physical and mental health and what choices contribute to healthy living as ong as possible. In case of illness or diseases, diet changes are one of the first resources used.

Pharma Food is not accepted because it is regarded as “too unnatural”, natural food can do the same. Food printing has only been accepted in hospitals and retirement homes, because it is useful, but otherwise food should be as natural as possible.
Precision Agriculture

Farming and Precision Agriculture in this scenario:
Precision agriculture, digitalisation and automation are accepted because they contribute to reducing negative environmental effects of agriculture and thus to a healthier planet. PA serves a highly sustainable production, promoting circular economy, favouring less waste, and the focus on low and local renewable energy use. Therefore, it is not profit that mainly determines the choice of PA technology, but the possibility to reduce environmental impact, but due to the lack of scale make technological advancements have not been as fast as expected in the 2010s. Next to PA, manual work, craftsmanship and tradition are very important – as is preserving general human labour and local jobs.

Therefore, ICT, sensor and location technologies are used to produce more efficiently and more sustainably, but farms are not fully automated or autonomous. Robots are mainly used for dangerous and very hard work. PA technologies and big data thus serve to give insight in what local nature needs. The predictive capacities of technologies are extremely important because providing a sustainable future for future generation is of high priority. Farmers have become local heroes, communities support farmers and rely on them for food and energy.

**Farming**

What characterizes this scenario, in the words of the experts:
- "Farmers are supported"
- "Farmers as community leaders"
- "Community involved in decisions"
- "Trust in farmer – quality – traceability – environment"
- "Short food chain – interaction"
- "Partially self-sustainable – exchange with other regions"
- "Origin of food well known"
- "Very variable incomplete availability of food producers"
- "Farmers made where possible"
- "No PA unless really needed"
- "Non-invasive PA if you can, do yourself, if not, use PA"
- "Diversity across regions"
- "No standardised tech, highly customised"
- "Greening of agriculture and more PA (but selective about what technology)"
- "Linking rural regions to nearby cities"

Skills in this scenario:
In this scenario, farmers will need to have multiple skills. However, the skill farmers need the most in this environment is the ability to cooperate: Being involved cooperatively with the community and as well as with other organisations in the supply chain. Here, "diplomacy skills" are also needed for dealing with these regions, making sure trust is kept and the farmers’ and the community’s understanding of local sustainability are in sync.

The farmer thus becomes a kind of "holistic professional": He controls all different aspects of farming and then brings in technology in a specialist way, only where it is most appropriately used. Farmers also become leaders in their local communities, needing "people skills" and (transformational) leadership skills. Finally, farmers have to be able to understand organic production for ensuring sustainable production, and be able to analyse regional potentials and demand, while utilizing PA as a tool.

What skills farmers need in this scenario, in the words of the experts:
- "Differs per region. But very tight links to community so ‘people skills’"
- "Communication with community"
- "Emphasis on ethical issues"
- "Diverse production skills"
- "Social skills"
- "Hi-Tech skills"
- "Transformational leadership"
- "Better understanding how nature interacts"
- "More generalists / super specialists for local areas"
- "Diplomacy with / towards other regions and cooperative management"
- "Stick-to-it-ive-ness"
- "Sense of solidarity"
- "Traditional knowledge"
- "Master-apprentice relations to teach the youth"
**Concerns/Opportunities**

Experts highlighted the following possible concerns in this scenario:

- To overcome lack of scale
- Large interregional differences in income and access to technology
- Dealing with vulnerability within the region, if you have a natural disaster like floods or drought. Do you have the infrastructure between regions to move food around? And also people – because you might have to move people around as well and skills
- Maintaining quality assurance will be a challenge in this scenario
- The government needs to be more powerful than corporations
- Technology as a tool needs government support
- Farmers need support and skills to manage mistakes
- How to coordinate regions
- Dealing with variability and diversity

A note on the special concern of land grabbing, in this scenario:

In this scenario land grabbing is not accepted. Borders are closed, so international land grabbing seems impossible. Government and civil society will not accept land grabbing if it would occur.

Experts highlighted the following possible opportunities in this scenario:

- Protect local environmental concerns. You need some support in this respect, otherwise people could just do what they want
- Stimulate skills sharing by use of technology because otherwise you may not make the progress you need
- Policies are needed that will encourage that sharing and also getting the interregional cooperation moving as well
- Policies should be able to allow diversification of the regions and also allow the farmer in the region to have a different role – of more of a leader in the community, producing safe food.
- Stimulate innovation and skills and encourage sharing of skills and technology
- Strengthen social cohesion model
- Safety net for disasters between communities
- Look for ‘smart’ human-robot task sharing
The ‘Precision agriculture (PA) and the future of farming in Europe’ study used possible future scenarios to explore opportunities and concerns related to increased uptake of PA in Europe.

In this annex, we present four scenarios for the future of precision agriculture that have been developed in the context of this foresight study. Each scenario is an imagined account of a future in which the role of agriculture in our society has evolved in a particular way.

These speculative scenarios do not aim to predict the future. Instead, they are each meant to illustrate one particular direction in which our society – and, within it, the role of agriculture – might evolve.