

Agribusiness in 2035 – Farmers of the Future



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Maintaining ecosystem services as a challenge for the future

Today and in the future, agriculture and the food industry face a number of challenges, such as climate change or the scarcity of resources that are important for food production. In order to guarantee a high quality of life, especially for generations to come, it will be even more important in the future to preserve natural resources along the whole food value chain. How natural resources are handled is determined not least by the way they are produced and consumed. For this reason, both production and consumption in Germany, taking ecosystem services into account, are becoming the focus of attention for politicians and scientists. Accordingly, these developments are also driven by a changed social perception of agriculture and the increased expectations towards it. Food scandals and media reports on unsustainable factory farming have led consumers to call for more transparency along the food chain in order to better trace the origin of food. At the same time, farmers are struggling with the fact that they do not receive special recognition for their work or for high-quality sustainable food, since a large part of the population still prefers to purchase cheap food.

The goal of the project “Digital Agricultural Knowledge and Information System (DAKIS)” is to develop a new decision support system, which enables the management of the non-commodity products of today, such as ecosystem services and biodiversity, as “products” of agricultural activities with an economic value. DAKIS will introduce a flexible work organisation that will enable resource efficient sustainable production and cooperation among farms. This will be achieved through the use of real-time digital information systems. At the end of the project, a prototype of the DAKIS will be delivered demonstrating the feasibility and beneficial effects of diversified small-scale land use in two test regions in Brandenburg and Bavaria. The research project is funded by the Federal Ministry of Education and Research (BMBF).

A digital support system like DAKIS has the potential to contribute to a more sustainable food production. However, it is still unclear what are the future prospects for such a system. Does it have a high degree of flexibility, so that it can find diverse application possibilities? How could the future look like in which DAKIS will be used?

The Fraunhofer Institute for System and Innovation Research ISI developed scenarios for the future of German agriculture as different framework conditions for the DAKIS application to provide specification for its key elements and functions. This brochure presents four different scenarios and gives us insights in which situations a decision support system could be of great benefit for farmers.

In the scenario process, all partners of the DAKIS project have actively contributed. At this point we would like to thank them all for their efforts!

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Agricultural system in the future – What is the DAKIS vision?

Our vision of the agricultural system in the future is that it will be spatially and functionally diversified to meet different, and potentially conflicting, environmental and socio-economic objectives. The project “Digital Agricultural Knowledge and Information System (DAKIS)” contributes to this vision by developing automated, small-scale, landscape-specific production systems. These systems will be tailored to the needs of society, and effectively integrate requirements for agricultural goods and services into farm planning. This will be achieved through new and innovative digital information and management machines.

For this purpose, the approaches and tools developed within the DAKIS project will be very innovative. For the first time, production and marketing of ecosystem services and biodiversity will be integrated through digitisation of modern planning processes. Resource-efficient new work organisation and cooperation between farmers will be encouraged through the development of a digital platform and interlinked robots. The analysis of site-specific potential changes the agricultural landscape, including island and patch cropping. New concentric utilisation gradients around the urban centre will be provided by the flexibility of the small-scaled management methods. With DAKIS, the effects of agricultural management on the environment become clearly visible and facilitate approaches for the payment of ecosystem services and biodiversity. In this brochure, we describe future framework conditions for using the DAKIS decision support system. Our focus is the farmer as user.

The vision is on its way and has to be developed with feedback from those affected, i.e. from all of us! Take a look at the content and give us your feedback. We hope this brochure gives you inspiration to think and form your own vision for the future!

Prof. Dr. agr. Sonoko Dorothea Bellingrath-Kimura

Coordination of the DAKIS Project
Leibniz Centre for Agricultural Landscape Research (ZALF)

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Scenarios at a glance

Value chain in change	Transparent and global	Transparent and local	Intransparent and global
Biodiversity in agricultural areas	Focus on promotion of nature protection	Nature protection as a side effect	Creation of protection areas
Availability of bio-based resources	Better distribution of resources	Demand cannot be met	
Structure of land owners	Agricultural areas belong to the state	High diversity of land owners	Only a few owner of agricultural land
Addressing the climate change	Climate change proactive addressed	Climate adaptation	
Quality and quantity of labels	Few harmonised labels	No labels any more	High variety of labels
Market for ecosystem services	Remote promotion of ecosystem services	Significant market share	No market for ecosystem services
Growth paradigm	Reduced consumption	Qualitative growth	Continued quantitative growth
Purchasing behaviour	Ecology & health-oriented decisions	"Sense"-based consumer decision	Price-driven consumption
Governance for food security	Regulation on an international level	Regulation by local governments	
Perception of farmers	Farmer as a producer	Farmer as shaper of natural landscapes	
Information along the value chain	Seamless information flow	Retailer as the information hub	Rich analog information
Technologies in primary production	Artificial intelligence farm	Hybrid farm	Machine farm
Diffusion of e-commerce	Highly centralised e-commerce	Decentralised local retailers	Food-shopping as social event
Agri digital and agricultural law	Harmonisation of legal standards	Enabler for technological transformation	Law lags behind technological development

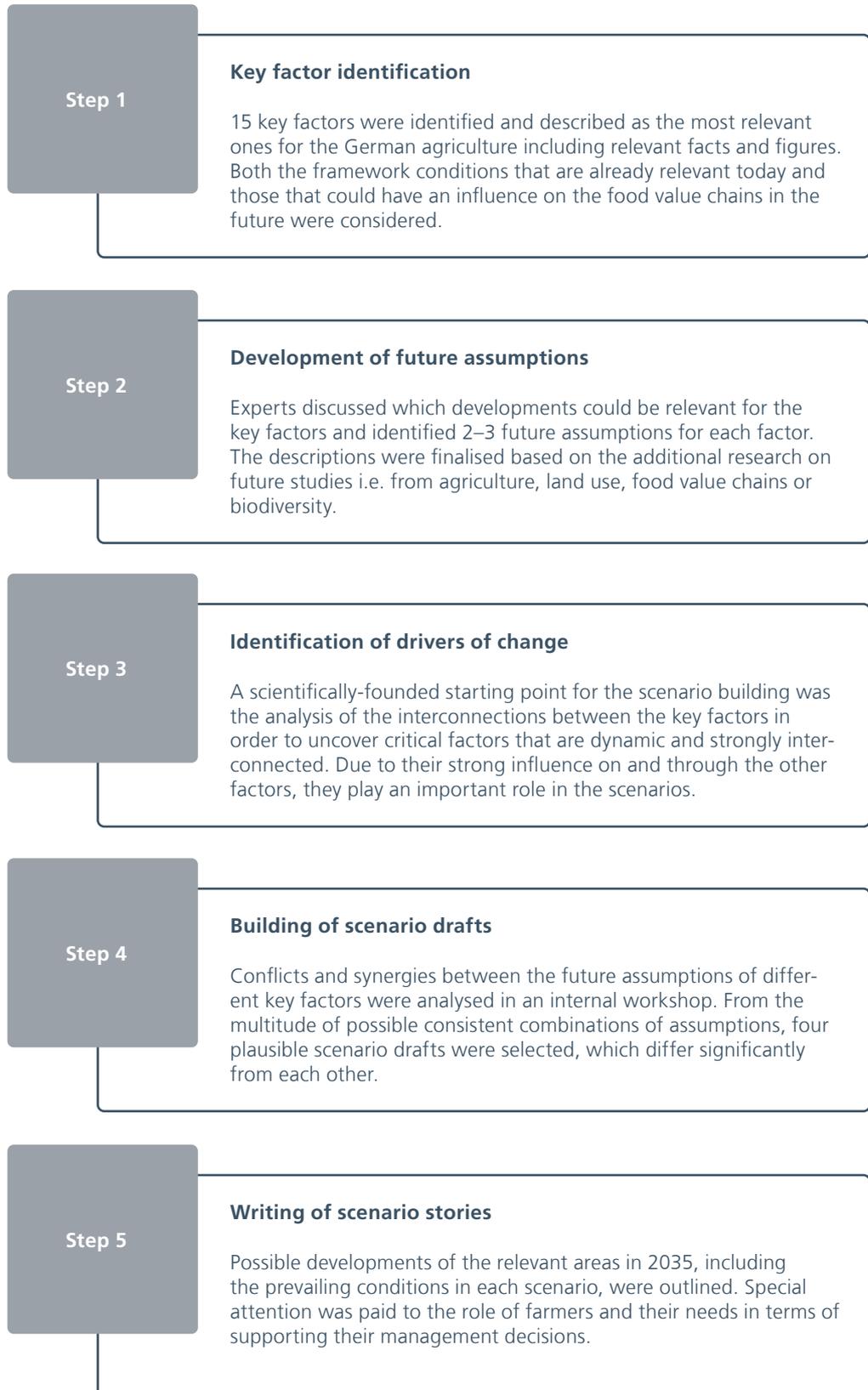
Scenario 1 (see p. 12) Scenario 2 (see p. 16) Scenario 3 (see p. 20) Scenario 4 (see p. 24)

Five steps of scenario process

The framework conditions for German agriculture are subject to constant change, and at the same time as the associated uncertainties with them. Despite these uncertainties, we still know a lot about future developments. There are demographic trends that will shape the future in the long term. Trends that describe political, economic, societal and technological developments can be included in the discussion on possible futures. Nevertheless, we must be conscious of the complexity of these developments and therefore create robust solutions.

Dealing with the high complexity is an important aim of the scenario development. Based on a complex network of relevant factors, scenarios present a description of possible situations in the future. The scenario method is an established and proven instrument within the foresight methods for addressing uncertainties. It enables to combine different future perspectives in order to create plausible and scientifically based future stories.

For the consideration of longer-term developments in the project DAKIS, the time horizon 2035 has been chosen. The scenario process was implemented in several stages: First, the general conditions for future development of agriculture were analysed, by taking into account relevant factors (step 1) and assumptions on their future developments (step 2). Project internal and external knowledge was involved in the course of literature analysis and two interactive workshops with experts from the areas of agriculture, engineering, model building and simulation as well as agriculture law. As part of the influence analysis, the different future possibilities were connected with each other to find out the main drivers for change (step 3). On its basis, the various combinations of future assumptions were examined and interpreted as possible futures (step 4). According to the criteria of consistency, plausibility and distinctiveness, four scenarios have been developed, each describing different framework conditions for the application of a decision support system (step 5).



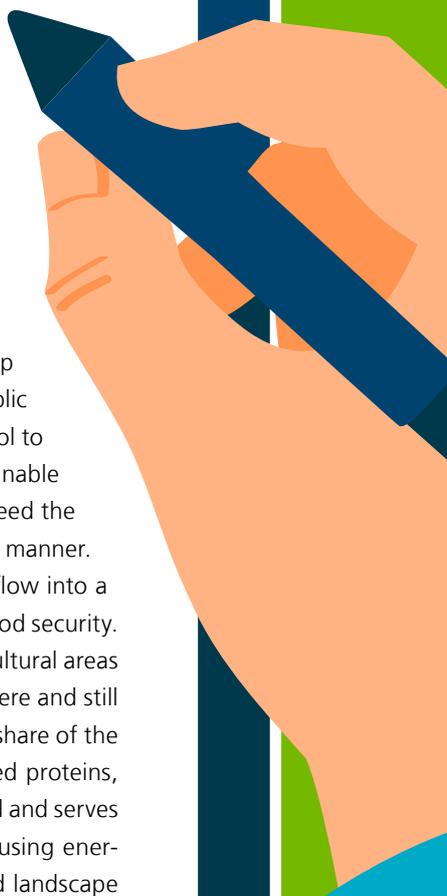
Scenario 1



Environmental protection by global high-tech and regulation

Globalised world, government regulation and harmonisation

This scenario assumes a globalised world in which government regulation and harmonisation play a major role. Through state control and a worldwide coordination of legal standards, global networking works flawlessly, which is expressed in transparent value chains, coordinated food labels and a sustainable and non-profit-oriented food supply to meet basic needs. Climate change is proactively tackled because the international cooperation provides sufficient momentum to address this global issue. Climate change is actually a driver for innovation and change, i.e. ensures a better life through a better air quality, cities without cars or carbon-free industries. However, ecosystem services are not promoted directly, but rather supported through monetary compensation elsewhere. For instance, in order to compensate for the consumption of conventional products, measures are taken to preserve the South American rainforest. Consumers and industry are open for new technologies. The flow of information along the entire value chain enables more people to gain access to knowledge about i.e. agricultural production methods or processing steps of purchased food. Consumers can track their products, which puts pressure on producers to maintain high production standards. Centralised e-commerce prevails, which influences the value chain and where the state is actively involved. The importance of the state in the value chain is also reflected in the fact that the entire agricultural land is in its hands. Land is leased according to the principles of the “Economy for the Common Good”.



Ben (14) attends a school in a small village near Munich. He will complete his mandatory student internship in the next two weeks. The Ministry of Education has developed a standardised programme for this purpose and allocates internships for all students according to their talents and interests. Ben is very good at science and is committed to nature and the environment. Therefore, the programme “Sustainable Farm & Food” was assigned to him. Within the next few days, Ben will finally get some real practical insight. He will be allowed to visit the “Auenthaler Hof”, which is run by the managing director Michael according to the state-funded sustainability concept.

Today is Monday, April 2nd 2035 and it’s the first day of the programme. All students of the programme take part in a virtual introductory session. Ben sits at home in front of his computer and listens to the keynote speech by Maria Arbol, Minister of Agriculture, who talks about the origins of the national farming concept, which has now been in use for more than ten years:

“The year 2024 was a year of change. Natural disasters, caused by climate change caused millions of deaths worldwide. In Germany, there were years of massive crop failures due to extreme droughts throughout spring and summer. The general public knew that something had to change fundamentally. The state had to take control to make all economic sectors more environmentally friendly and CO₂-neutral. Sustainable farming concepts have been developed for agriculture, which are intended to feed the German population independently, which works in many areas, in a crisis-proof manner. Nevertheless, we are in close global exchange. Production surpluses can thus flow into a well-functioning global food supply system, so that we can also ensure global food security. To implement this concept, the state had to take control and buy up many agricultural areas and give it to people who wanted to follow its path. For those farmers, there were and still are government incentives and investment programmes available. A significant share of the protein supply of the entire nation is now built on insect breeding, plant-based proteins, cultivated meat and aquaponics. The saved agricultural land can be renaturalised and serves to promote biodiversity in Germany. Vegetables should mainly be produced using energy-efficient vertical farming technologies. As you may have noticed, diversified landscape with extensive agriculture, pastures and forests are already emerging. A centralised state control system has been introduced to ensure food supply in line with reduced consumption. In addition, recycling of nutrients plays a major role, for example, certain elements are recovered from wastewater. You too, dear children, can run a high-tech farm in the future! The student internship is intended to give you an insight into our concept! I wish you a lot of fun for the next two weeks!”

Farmer's perspective



"I trust international cooperation to curb climate change. Although its effects make my work noticeably more difficult, new technologies and innovations fortunately make it easier to deal with the changing climatic conditions."

"The state creates good framework conditions for the profitable management of my agricultural business. The state takes a lot of decisions off my hands. Even though I cannot get rich from working as a farmer, I am still satisfied because I can certainly make a living from the state support."

"I'm basically very open to new technologies. Digital platforms make my work much easier. They provide me with solutions to various problems in my everyday life as a farmer."

"With my products, I can contribute to food diversity. AI assists me in producing a broad spectrum of food. People from across the country – and even beyond – can enjoy my groceries through e-commerce."



What will be the next mix of crops which my AI system will propose? Which funds can I apply for?

Meteorologists have predicted that Germany will experience its third consecutive summer of drought. It is predicted that the eastern part of Germany will again be particularly critically affected by the drought. As a result, all arable land owned by the state, has not been profitable for the past two years. Karl (44), a vegetable farmer from Brandenburg, has been unable to harvest the last two summers at all. Five years ago, he specialised in growing vegetables which are very sensitive to drought. He has an irrigation system, but water prices are high and the business is threatened with a loss of profitability. This is why the state now pays for the water for food production. The project, which he started with great euphoria, was also threatened by climate change. But Karl is not too worried about his existence, because he knows that the state is there for him even in bad times. The state not only controls the food supply through subsidies and the food demand through taxes, but also compensates for climate-related crop failures with state emergency aid. That calms him down. The DAKIS platform makes it easy to apply for emergency aid.

Nevertheless, he doesn't want to take that risk again next season. State aid scratches at his honor as a farmer. Before he started growing all kinds of vegetables, he had only produced pumpkin. However, there was a Europe-wide oversupply, so the state had offered him attractive subsidies in case he would change his core business. It seemed that these state incentives clouded his view of the reality. He had opposed all advice from DAKIS, which had clearly predicted the high risk of his approach. This time he wants to trust DAKIS. The platform offers him individualised demand-oriented cultivation recommendations. State funding options for each type of cultivation have also recently been linked. He is suggested to grow beetroot because the plant is very robust in periods of drought and can be consumed in almost every stage of growth regardless of the usual harvest time. Due to its good shelf life, it can easily be exported to other countries and continents. On DAKIS he finds a large network of specialised vegetable growers with whom he can exchange ideas on how to successfully grow beetroot.

Fortunately, the summer was not as dry as forecasted by meteorologists. Karl's decision is nevertheless clear. He will focus his business on growing all kinds of vegetables. He can use this year's solid sales revenues very well to invest in modern cultivation technologies. He received helpful tips from his colleagues at the farmers' network in DAKIS. He has also received state funding. Now he can build a sustainable, state-of-the-art business from which his twelve-year-old daughter Linda will hopefully benefit in a few years. He should have listened to DAKIS' recommendations earlier. Then he could have saved himself a lot of effort. Fortunately, the state helped him out of trouble, otherwise his willingness to take risks would probably have destroyed Linda's entire livelihood.

Scenario 2



Environmental protection by local food circles and qualitative growth

Decentralisation, diversity and sustainability

This scenario is characterised by decentralisation, diversity and sustainability. Consumers live health-conscious and therefore attach great importance to high quality food. They buy their food locally and appreciate the great cultural importance of agriculture. The direct connection of society to agriculture is enabled not only by the large number and diversity of agricultural farms, but also by decentralised retailing. The many local retailers act as information hubs, i.e. as a central location where all the information generated along the value chain converges and new paths can be taken. They control the value chains, make them efficient and so transparent that labels are no longer necessary. Agricultural production is therefore highly differentiated, the value chains are regional, short and transparent. Climate change is addressed reactively, as certain developments have to be taken into account in order to be able to produce at all. Climate change measures are implemented directly at local level, even if this means that consumers have to forego comfort. Moreover, measures to conserve biodiversity are an essential part of agricultural land use. Climate change forces the development of innovations and changes towards a better and, above all, healthier life. New technologies are seen as a means to ensure sustainability and are therefore accepted and promoted in the agricultural and food industry. So called “hybrid farms”, i.e. a mixture of manually-operated large machines and small autonomous robots, work hand in hand. The technological change is not slowed down by the legal framework. On the contrary, it provides security for business investment in the development of new agricultural technologies and is the source of farmers’ and consumers’ trust.

An illustration of a hand holding a stylus pointing at text on a tablet screen. The hand is orange and the stylus is grey. The tablet is white with a grey border and a grey home button at the bottom. The background is blue.

Johanna (43) is a cattle farmer and beef producer from Passau. She has a factory for cultivated meat and keeps water buffalos in a species-appropriate way. Today she takes her eight-year-old son Oliver for a walk in the Bavarian Forest to show him the semi-wild herd of bison. They live there on a huge pasture, but also have access to the forest, so it is often not easy to see them. While walking around and searching the herd, Johanna tells her son what has happened the past years until today:

“When I was your age, I was very interested in nature and the environment. My grandpa took me into the forest every weekend to discover wildlife. That was the highlight of the whole week. After graduating from school, I studied engineering. On my many travels around the world during this time, I have seen how beautiful our planet is. My goal was to use the knowledge I had gained during my studies to develop concepts that would counteract some of the ecological undesirable developments of that time. The massive meat consumption of the industrialised countries – which was made possible mainly by factory farming – had enormous negative effects on our environment. Food systems were globally connected and very vulnerable to disruptions within the chain. I never understood all this!

While at first, only a few people recognised these undesirable developments, more and more people became aware of the negative effects of their behaviour. This has been fueled by a public discussion of the links between our food supply and the numerous crises and terrible natural disasters of the 2030s. Today, people love to shop in their local bakeries and at farmers’ markets, which obtain their ingredients from farmers in the immediate vicinity.

People recognised more and more that if one wants to live environmentally friendly, one must be open to new technologies in the food industry as well. Not only the animals and the environment in general have benefited from this rethinking, but also people like me with my cultivated meat factory!”

Oliver was very impressed by the trip with his mum. He often had to think of the bison grazing at the edge of the forest during sunset.

Farmer's perspective

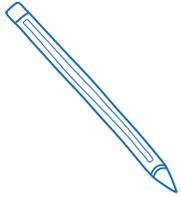


"I personally know the majority of the people who consume my products. I even count many of them among my close circle of friends. So I want to provide them with high quality, healthy food."

"I feel supported by the local society and I am happy about the high social standing of my profession. I am very proud of my agricultural business and I am very happy showing it to interested people on our farm tours."

"I accept new technologies, but I don't necessarily have to implement them if they don't do much good for me and my immediate environment. I'm actually quite happy with the status quo."

"I have a good no strained relationship with the farmers in the neighbourhood. They are my friends and sometimes business partners. We produce various products so that there is no competitive situation at all."



On which areas is it worthwhile to grow food and where should nature conservation areas be established?

It was a Sunday evening and farmer Anna (35) had done all the daily work on her Bavarian farm. With a glass of a local craft beer and a smartphone in her hand she enjoyed the beautiful sunset on her patio. She decided to share a few photos of her working day. She actually always gets a nice response to her postings from her everyday life as a farmer. And for Anna it is important that her neighbourhood has a direct connection to agriculture. After working on social media, she spontaneously took a look at the DAKIS app. She does this occasionally to get new inspiration on how to make her work more environmentally friendly and also more tangible for the local community.

On this Sunday evening, the idea arose to renature an area of about five hectares of her farmland. A local recreation area for the entire community is to be created there. Because of its poor soil conditions, the area is surrounded by a lot of forest and is therefore very shady, and for food production this area is not very profitable anyway. Therefore two farmer colleagues joined the idea without much hesitation and gave up part of their adjacent farmland for the project. They also believe that the land is significantly more valuable for environmental protection and are therefore convinced that the increased biodiversity contributes to a more robust regional ecosystem, which ultimately also has a positive effect on their agricultural yields.

For the project, the involvement of the entire local population is very important for the three farmers. That is why they have created a ceremonial setting for the start of the project. There is a traditional farmers' celebration day with live music on Anna's farm. On this day, Leonard – a landscape gardener from Straubing who is a specialist in such projects and should therefore act as a project manager – announces in detail what the farming community has planned. Anna became aware of him through the DAKIS app and had thus made contact with him.

Leonard informs the cheerful guests that a biotope with a large pond in the middle should be created, in which the local flora and fauna can settle and a symbiosis with the adjacent forest can take place. The design should be particularly informative for children. Finally, a kind of adventure park will be created. The children can experience nature and for example use interactive information boards to learn more about the local plants and animals. The village community was very impressed by the idea. During the evening, many party guests came to Anna and assured her of their voluntary support in implementing the environmental protection project.

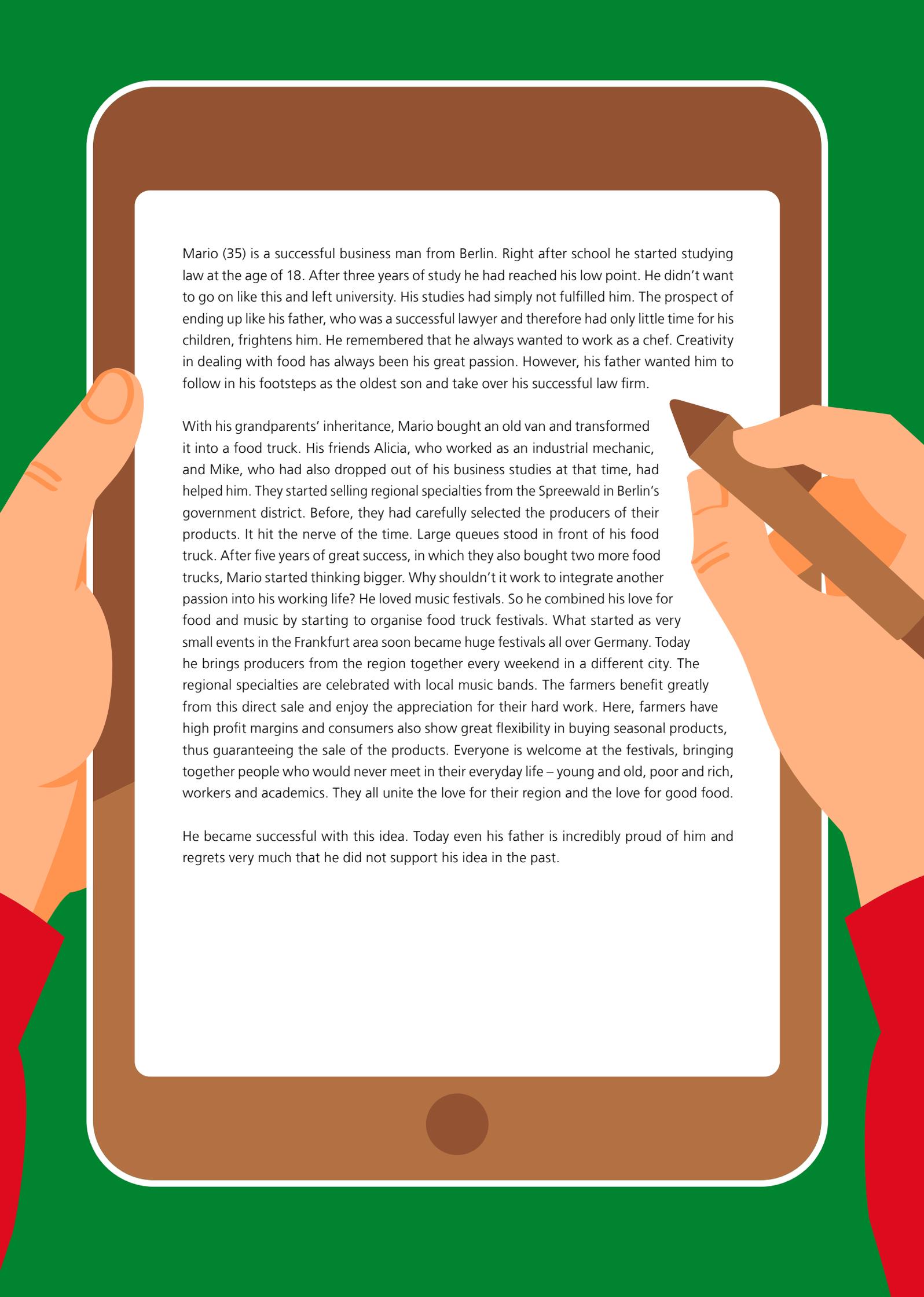
Scenario 3



Event consumption by face-to-face interaction in local food circles

Consumption and direct communication

In this scenario, the majority of people do not want a change because they are satisfied with their way of living. Buying food is not only consumption, but becomes more of a family or social activity. There is a high diversity of food and consumers are more open to variation and experimenting with food. When choosing food, they use their own senses at the point of sale. People buy in shops or at regional or local food markets and look forward to talking to the producer or simply to the neighbour. As a result, e-commerce has not established itself in the predominant food sector. Some markets are experiencing huge increases in both food traffic and profits as a result of a concerted effort to open up local food markets to traditionally underserved populations. Markets are no longer reserved only for privileged middle-class buyers. The negative effects of climate change can be seen and experienced in many areas, but this does not lead to adjustments in citizens' consumption behaviour, for example, not consuming high amounts of environmentally harmful animal products. Consumers still feel good about their consumption decisions, because the preference for regional food gives them the feeling of acting in an environmentally friendly way. There is no enthusiasm for new technologies in society, which is reflected by the resistance to advanced digitalisation in many areas. There is no trust and therefore no acceptance of digital platforms caused by security problems or the growing power of global companies. Farmers do not rely on new technologies either. They primarily use large, manually driven machines; technological development focuses on assistance systems. Only parts of the agricultural processes have been digitalised, and the connection to further steps in the value chain is missing. Some parts in the production chain have a certain level of intelligence, but there is no connection between them.

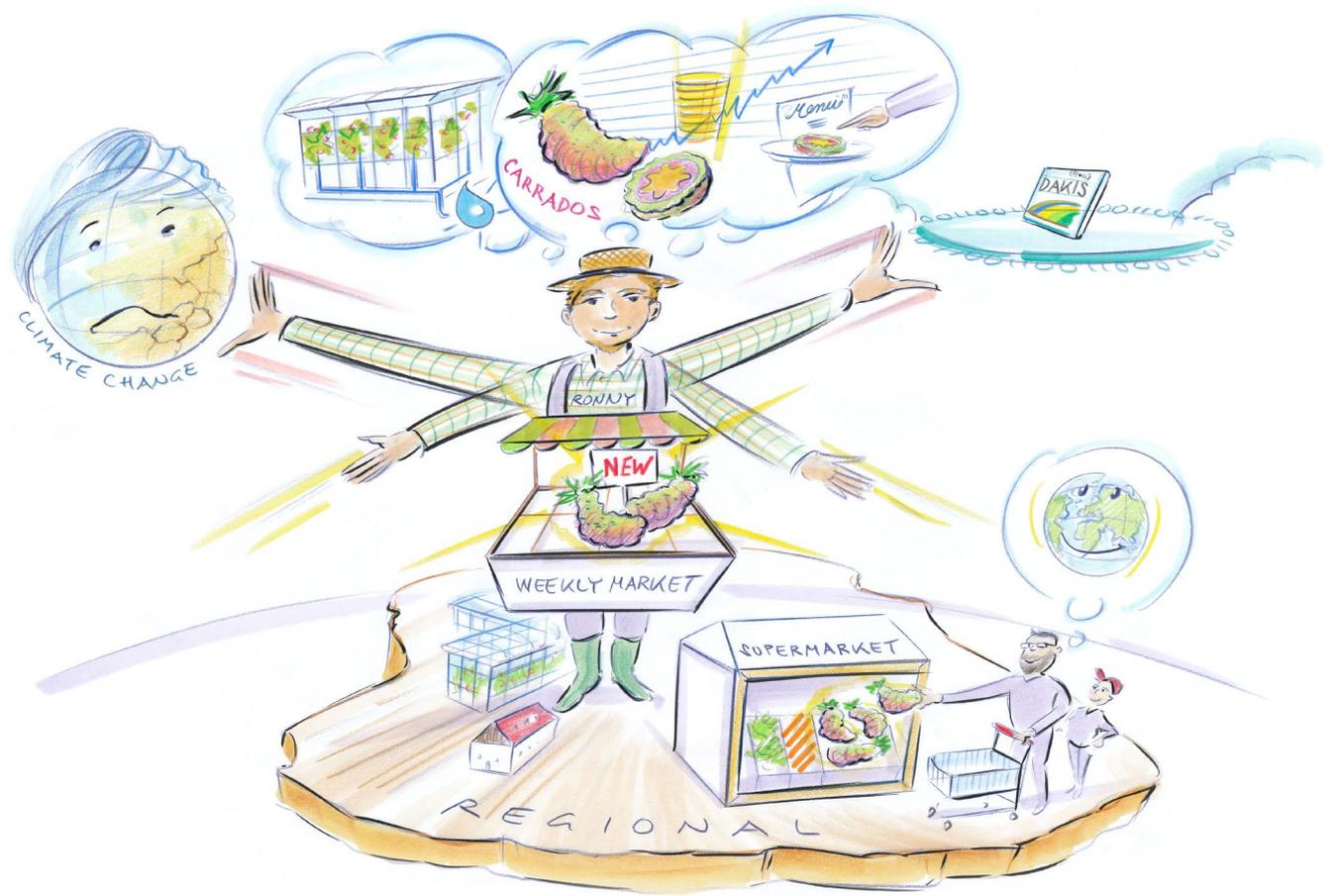
An illustration of a hand holding a pencil, writing on a tablet. The tablet is brown with a white screen. The background is green. The hand is orange and is holding a brown pencil. The text on the screen is in a simple, black, sans-serif font. The text is arranged in three paragraphs. The first paragraph is at the top, the second is in the middle, and the third is at the bottom. The hand is positioned on the right side of the tablet, with the pencil tip pointing towards the text. The hand is holding the pencil in a tripod grip. The tablet is held by another hand on the left side, which is also orange. The background is a solid green color. The overall style is clean and modern, with a focus on the text and the act of writing.

Mario (35) is a successful business man from Berlin. Right after school he started studying law at the age of 18. After three years of study he had reached his low point. He didn't want to go on like this and left university. His studies had simply not fulfilled him. The prospect of ending up like his father, who was a successful lawyer and therefore had only little time for his children, frightens him. He remembered that he always wanted to work as a chef. Creativity in dealing with food has always been his great passion. However, his father wanted him to follow in his footsteps as the oldest son and take over his successful law firm.

With his grandparents' inheritance, Mario bought an old van and transformed it into a food truck. His friends Alicia, who worked as an industrial mechanic, and Mike, who had also dropped out of his business studies at that time, had helped him. They started selling regional specialties from the Spreewald in Berlin's government district. Before, they had carefully selected the producers of their products. It hit the nerve of the time. Large queues stood in front of his food truck. After five years of great success, in which they also bought two more food trucks, Mario started thinking bigger. Why shouldn't it work to integrate another passion into his working life? He loved music festivals. So he combined his love for food and music by starting to organise food truck festivals. What started as very small events in the Frankfurt area soon became huge festivals all over Germany. Today he brings producers from the region together every weekend in a different city. The regional specialties are celebrated with local music bands. The farmers benefit greatly from this direct sale and enjoy the appreciation for their hard work. Here, farmers have high profit margins and consumers also show great flexibility in buying seasonal products, thus guaranteeing the sale of the products. Everyone is welcome at the festivals, bringing together people who would never meet in their everyday life – young and old, poor and rich, workers and academics. They all unite the love for their region and the love for good food.

He became successful with this idea. Today even his father is incredibly proud of him and regrets very much that he did not support his idea in the past.

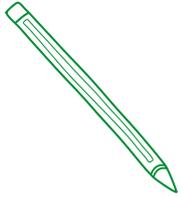
Farmer's perspective



"I think it's good that my products are mainly sold in local supermarkets. Selling my groceries at the weekly market is an attractive second mainstay for me, especially if you always come up with something new to make customers curious."

"Why should I produce in a climate-friendly way if consumers don't care about the environmental impact of their food? Consumers believe that buying regional food is environmentally friendly enough. I can cope with the occasional droughts and floods somehow."

"Growing white lupin (very rich in protein) is currently very profitable. Consumers are literally tearing the lupin-based food out of my hand. I am planning to buy a new, larger and more modern machine so that I can produce lupin-based food even more efficiently."



Which new business models can be profitable?

Ronny (56) is a farmer from Brandenburg whose farm specialises in the cultivation of cucumbers and other cucurbits. Despite drought summers, which occur regularly due to climate change, the conditions for growing cucurbits are still perfectly fine. Nevertheless, Ronny is currently very unhappy and dissatisfied with his business. His vegetables have become shopkeepers at the weekly market. The demand of local supermarkets is not as high as it used to be. He is afraid that his vegetables are simply not “fancy” enough for the curious consumer.

When his son Karl, who works as a chef in a small Berlin restaurant, visits, he talks about the carrados boom (a newly bred variety from the avocado family) in Berlin. Carrado is an integral part of the daily diet of the urban population. The fruit, which comes from South America and was genetically modified in the USA – significantly reduced its water requirements – is considered the superfood par excellence because of its many healthy unsaturated fatty acids, vitamins and minerals. Ronny senses the opportunity for a new, economically lucrative business. Why shouldn't he just grow carrados on his fields instead of cucumbers and other cucurbits? People love regional products and it is only a matter of time before the trend also reaches the weekly market in rural Brandenburg. There he can offer carrados, prepared in all possible variations. His son Karl will help him with his cooking skills and recipes. Ronny is very euphoric. He is convinced that the Brandenburgers will literally tear his carrados out of his hands. Maybe he will even make it to the Berlin market with his regionally grown products.

Ronny knows that there is an app called DAKIS that supports farmers in implementing innovative projects. But he doesn't think much of the virtual world, he rather relies on his many years of professional experience. He therefore travels to Mexico and helped on a carrado avocado farm for a few weeks to prepare himself optimally for his new core business. He believes that the “learning by doing” approach has proven itself in the real world for decades and has always been the most successful way to put new ideas into practice. He also doubts that DAKIS would help him as a platform that mainly promotes ecosystem services. He is well aware that it does not make much ecological sense to grow carrados in Brandenburg.

After his time in Mexico he finds out that he has to build an expensive greenhouse-like dome to guarantee the tropical climate that is ideally for growing carrados. Plant breeding also helped to guarantee yields after the second year of planting. The high investment sum does not deter him. He is more convinced than ever that it will be a great success. After five very successful years, the trend is clearly decreasing. Due to the decline in demand, growing carrados is no longer economically viable. Ronny remains on a large part of his investment if he doesn't have an idea how to use the greenhouse for other purposes. In addition, he has overused his farmland. He had underestimated the high water consumption for this kind of cultivation in growing avocados, because in the past Brandenburg never had a problem with water scarcity. He even hoped to achieve a positive water balance compared to South America, where the water scarcity is higher and more water is evaporated.

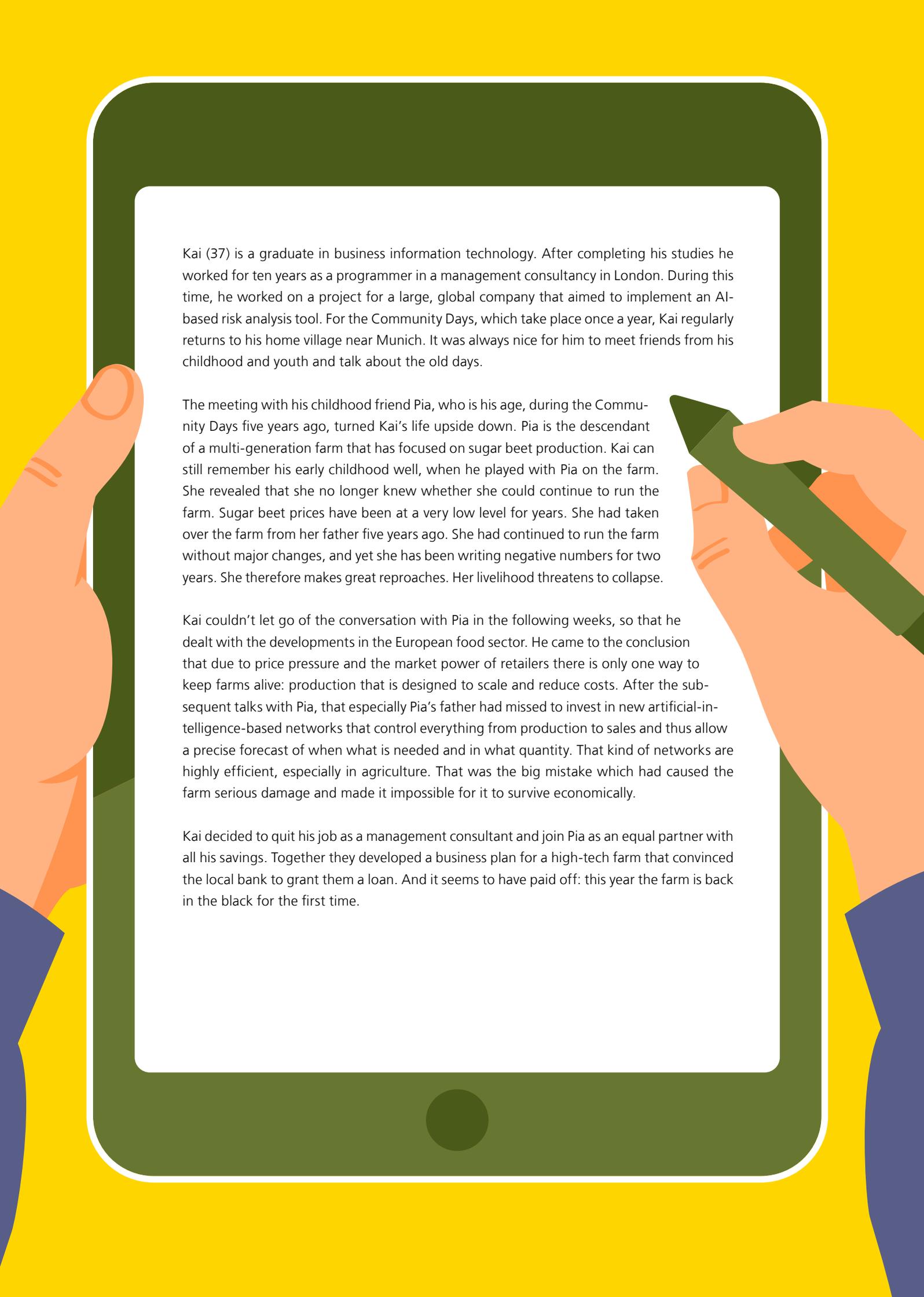
Scenario 4



Reduced consumption and de-growth by necessity

Growing retail business, no transparency and global food system

In this scenario the retail business is the big winner in the global food systems. Consumers do not particularly value the quality and sustainability of food, but rather their purchasing decisions are primarily based on the price, so that consumers' decisions are strongly tied to income. Consumption behaviour has changed not on its own initiative, but out of necessity. As an example, a secondary market has developed which is geared to the longer use of products by upgrading, repairing, reusing or recycling them. Nutrition had to be changed to a plant-based diet and to a reduced meat consumption. The unfavorable conditions for agricultural production caused by climate change and the incapacity of meeting the high demand for resources are the main reasons for this development. Farmers only take on the role of producers of biogenic resources. Only a few large landowners intensively cultivate the whole agricultural area, which is characterised by large, uniformly cultivated territories. The area for agricultural production and the area for promoting biodiversity are strictly separated. These managed and unmanaged areas are very close to each other and their dedicated spatial constellations are controlled via Agriculture 4.0 with sensors, drones and other monitoring systems. All this leads to a highly intensive agricultural specialisation. New technologies based on artificial intelligence (AI) support farmers in achieving the highest possible efficiency, and the main goal is to continuously increase agricultural yields. The data exchange required to optimise AI technologies is not subject to any regulatory restrictions. Retailers are also using AI technologies to design centralised e-commerce that maximises profit. Sustainable food production is therefore not of central importance for retailers, as the ecological footprint is not particularly relevant for consumption decisions. The large number of different product labels confuses the consumer anyway, as they were introduced for marketing purposes only. In addition to the legally required labels and voluntary information, there is a large number of seals and symbols of origin in food packaging that are smartly integrated for all application steps. The global value chain is therefore not transparent to the consumer.

An illustration of a person's hands holding a green tablet. The left hand is on the left side, and the right hand is on the right side, holding a green stylus. The tablet screen is white and contains three paragraphs of text. The background is yellow.

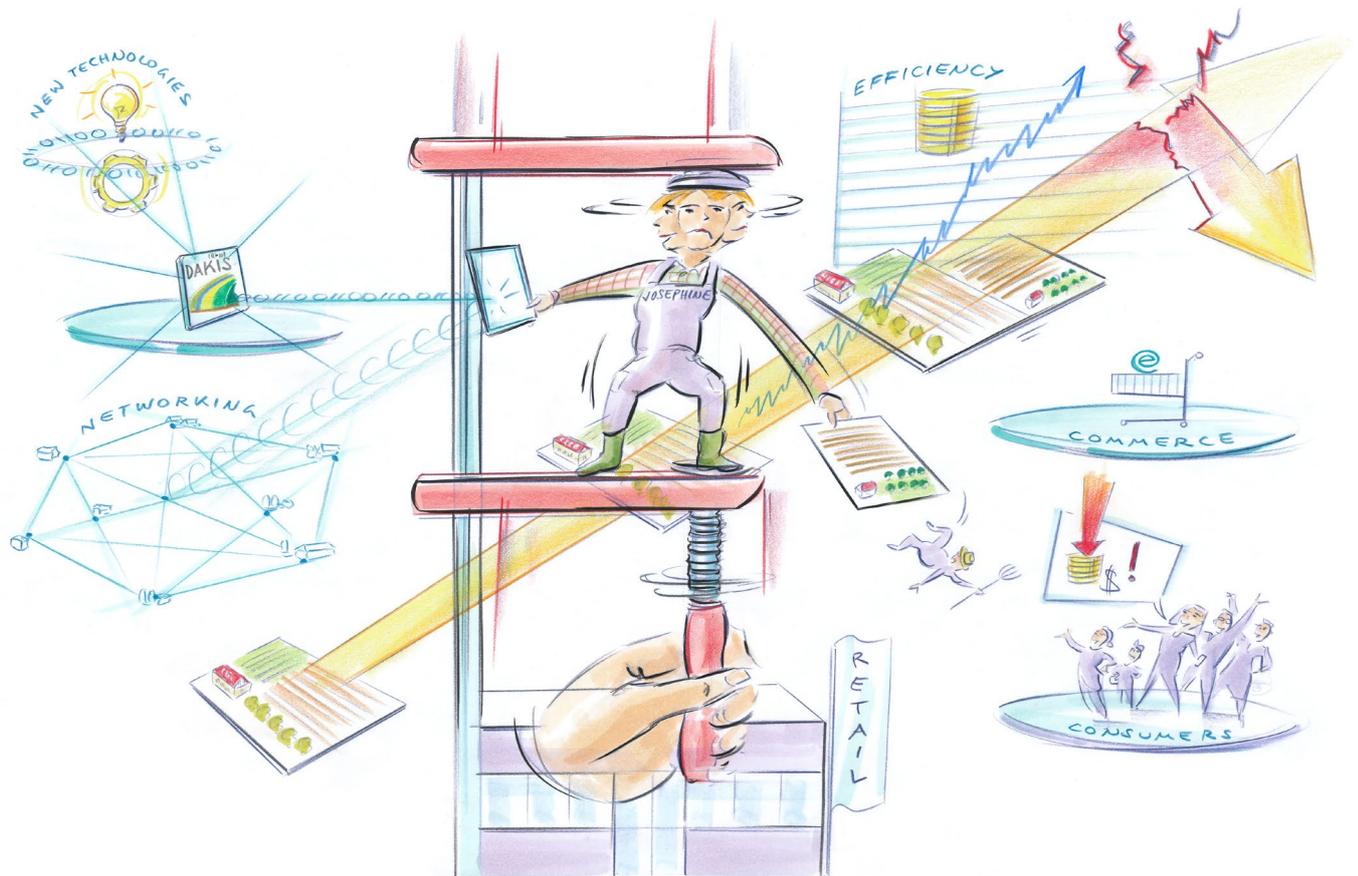
Kai (37) is a graduate in business information technology. After completing his studies he worked for ten years as a programmer in a management consultancy in London. During this time, he worked on a project for a large, global company that aimed to implement an AI-based risk analysis tool. For the Community Days, which take place once a year, Kai regularly returns to his home village near Munich. It was always nice for him to meet friends from his childhood and youth and talk about the old days.

The meeting with his childhood friend Pia, who is his age, during the Community Days five years ago, turned Kai's life upside down. Pia is the descendant of a multi-generation farm that has focused on sugar beet production. Kai can still remember his early childhood well, when he played with Pia on the farm. She revealed that she no longer knew whether she could continue to run the farm. Sugar beet prices have been at a very low level for years. She had taken over the farm from her father five years ago. She had continued to run the farm without major changes, and yet she has been writing negative numbers for two years. She therefore makes great reproaches. Her livelihood threatens to collapse.

Kai couldn't let go of the conversation with Pia in the following weeks, so that he dealt with the developments in the European food sector. He came to the conclusion that due to price pressure and the market power of retailers there is only one way to keep farms alive: production that is designed to scale and reduce costs. After the subsequent talks with Pia, that especially Pia's father had missed to invest in new artificial-intelligence-based networks that control everything from production to sales and thus allow a precise forecast of when what is needed and in what quantity. That kind of networks are highly efficient, especially in agriculture. That was the big mistake which had caused the farm serious damage and made it impossible for it to survive economically.

Kai decided to quit his job as a management consultant and join Pia as an equal partner with all his savings. Together they developed a business plan for a high-tech farm that convinced the local bank to grant them a loan. And it seems to have paid off: this year the farm is back in the black for the first time.

Farmer's perspective



"Retailers put a lot of pressure on me. They always strive for maximum profit and use their information advantage through the centralised and all-determining e-commerce. Accordingly, the profit margin for me is negligible."

"It makes sense to focus on the production of a certain food. High scaling is the only way I can operate as efficiently as necessary. The retail sector is taking measures to compensate for the lost biodiversity. However, I don't know how long I can continue to plant monocultures on my land."

"Climate change has a serious impact on my farm. The water for irrigating my plants is becoming scarce in the now regular drought summers. I am desperately looking for technologies that can help me to remain economically profitable despite the difficult conditions."



How do I make my farm more competitive by networking with other actors?

Josephine (45) is very excited. She is preparing for the annual meeting of the “Bavaria Milk” community. It is a horizontal cooperation of all dairy farmers in the region. Today, the dairy farmers meet in a completely different setting as the community is celebrating its fifth anniversary. So a celebration with live music in the city hall of Passau is planned. Over 300 people are expected to attend. Josephine will give the speech as initiator of the cooperation. Before the event, Josephine meets Sebastian, a journalist of the local newspaper. A large newspaper report on the history of the “Bavaria Milk” is to be published in the Sunday edition of the newspaper. Josephine reveals how everything came about:

“I took over my father’s farm almost 20 years ago. Under his management our farm was for many years Bavaria’s largest producer of fresh organic milk. I can still remember my childhood on the farm, when we took our cows to the lush green pasture together. Unfortunately these times have changed. Even before he retired, he had to struggle with the fact that milk alternatives flooded the market – cheap milk from all over the world dominated the domestic market and caused milk prices to fall even further. Society’s appreciation of agricultural products in general and animal products in particular has declined massively. As digitalisation progresses, an alienation from nature has taken place. When buying groceries in a supermarket or online, price was the major criterion. The form of animal husbandry and the environmental impact were not particularly interesting. This change had a massive impact on our farm. When I took over the farm, we were already very afraid for our existence. Many fellow farmers had to shut down their business. We therefore had to completely change our business if we didn’t want to lose our livelihood as well. Our guiding principle was efficiency and productivity. There was no other way. From then on the pastures were used intensively, leading to a decrease in biodiversity on these areas. We have significantly increased our livestock. Through milking robots we were able to save personnel costs. Thanks to AI technologies, we were able to largely avoid crop failures. This was the only way we could keep our heads above water.

But a little over five years ago, I had enough of it. I wanted to regain some power over my decisions. I never let go of the childhood memories of happy cows grazing on lush green meadows. The DAKIS platform was my salvation at that time. The app suggested that I should completely change my management practice. Horizontal cooperation – in particular by sharing agricultural machinery – can save a lot of money. The idea of “Bavaria Milk” was born! Through DAKIS I was able to network with my colleagues from all over the region. DAKIS makes it easier for us to use our machinery pool more efficiently and always be up to date. As a small side effect, we now have a better position within the value chain compared to the powerful retailers. Today I can take my cows to pasture for at least a few weeks in summer. Even if it doesn’t help me from an economic point of view, it makes me very happy!”

Using scenarios to develop robust solutions

The possibilities for using the results of a scenario process are diverse. External opportunities and risks can be analysed or internal communication processes can be supported. In order to prepare for the different futures, a future-proof approach should be developed. In this project the different futures give us the opportunity to make DAKIS future-proof.

In the concept phase of the DAKIS as a support system, the developments within the agricultural landscape were discussed within the project consortium as well as the core actors and specified in a vision of the agriculture for the long-term future. This vision describes “agrarian systems of the future for 2050, to be operated using automated small-scale production systems. These produce specific to the landscape, spatially differentiated and functionally diversified and are tailored to the demands of society by new and innovative information and management systems”. The vision provides all project partners with a common orientation for the development of models that will be integrated in DAKIS. The scenarios point out the potentials and challenges for its application. This includes on the one hand different requirements for the decision system. On the other hand, DAKIS proposes specific solutions depending on the scenarios, since model variables will take on different values in different scenarios.

In DAKIS different information will be bundled. First, landscape data collected by satellites and sensors will be transferred to the database in real time, supplemented by market data processed by computer models. Farmers can then use these data to make decisions for their farms. In this context, new communication channels will be established for cooperation between farmers, consumers and society in order to achieve increased promotion of ecosystem services and biodiversity throughout the regions.

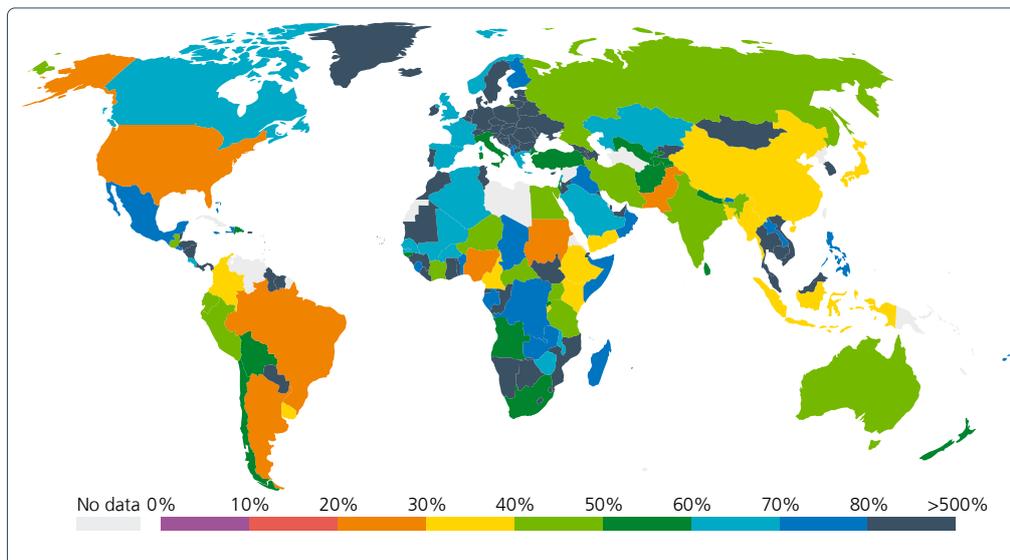
The four scenarios “Environmental protection by global high-tech and regulation”, “Environmental protection by local food circles and qualitative growth”, “Event consumption by Face-to-face interaction in local food circles” and “Reduced consumption and de-growth by necessity” have a different view for example on cooperation but also transparency along the food value chain, the importance of the efficiency in production or the environmentally friendly consumption. Depending on the scenarios, DAKIS will provide different management options for farmers.

Factors and Future Assumptions

Value chain in change

Multinational companies have established global value-added networks in which goods at the pre-production-stages sometimes cross national borders several times. The environmental footprint has to be minimised. Will operational control over the entire value chain and the transparency increase?

Intransparent and global	Transparent and global	Transparent and local
Supply chains have become complex and non-transparent due to increased specialisation and international division of labor.	Regionality plays a subordinate role. Many consumers demand more transparency and monitoring of complex supply chains. Food and feedstuffs are grown where cultivation is best possible.	There is increased re-shoring of value creation to the domestic markets with regional, short, and highly transparent value chains. Diversification of cultivation in Europe takes place and feed is being grown locally.

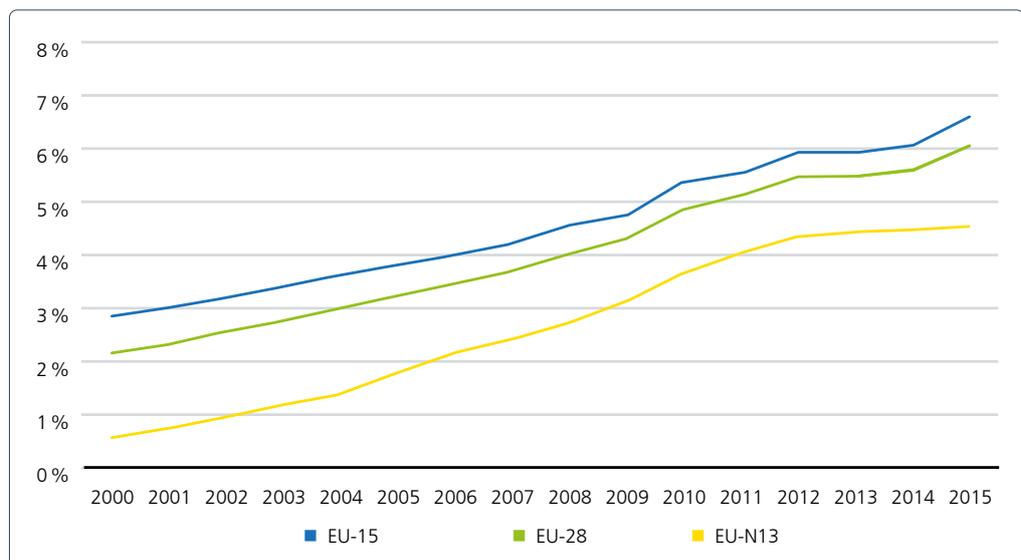


Trade – exports plus imports – as share of GDP, 2017 (Ortiz-Ospina and Beltekian, 2018 based on World Bank)

Biodiversity in agricultural areas

Today there is little appreciation of biodiversity. Only organic food production promotes biodiversity. Some agricultural measures to protect biodiversity are already in place, however, the policy measures are still ineffective. Will biodiversity measures be an integral part of the agricultural land use?

Diversification of agricultural production with promotion of nature protection as a side effect	Multifunctional integrated use of land with focus on promotion of nature protection	Intensified use of agricultural areas and creation of protection areas
<p>Spatial patterns of land-use are diversified, there are more crop rotation and less monocultures. New technologies for monitoring and reduction of resources are in use.</p>	<p>Cooperative farming, integrated agricultural land use, and biodiversity measures are gaining importance. The landscape is more and more recognised for its multi-purpose use.</p>	<p>Areas for agricultural production and those for the promotion of biodiversity are strictly separated which leads to highly intensive agricultural specialisation.</p>

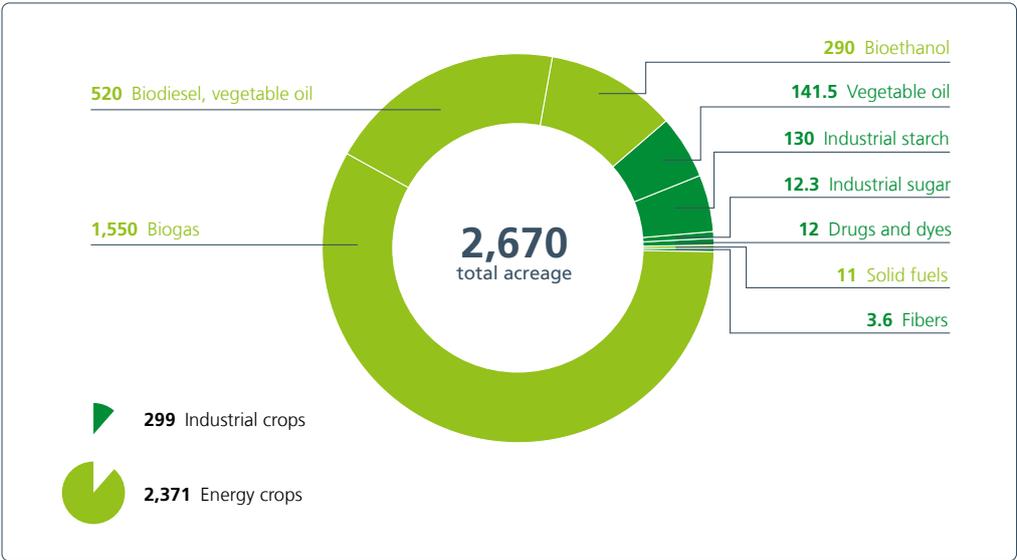


Evolution of the share of the organic area in the utilised agricultural area in the EU
(European Commission, 2016 based on Eurostat data)

Availability of bio-based resources

There is a lot of pressure on bio-based resources. Conflicts about resources, i.e. about land, water, energy or minerals, increased. There is a high dependence on existing sources, but there are first approaches for circular economy. Will the resource use be more efficient and better distributed?

Demand for resources cannot be met	Less as well as efficient use and better distribution of resources
<p>There are a lot of conflicts as demands for bio-based resources rise and wars are fought over land, water, energy, and minerals. Due to climate change, resource problems increase.</p>	<p>Circular economy is widely implemented. Resources are less used and if in an efficient manner. They are better distributed between countries.</p>

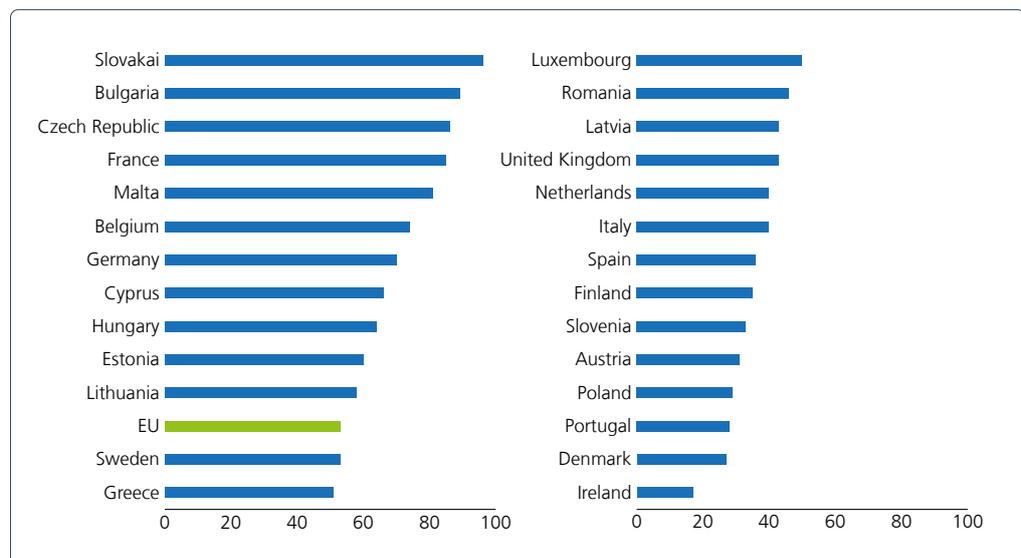


Cultivation of renewable resources in Germany 2019, estimated (FNR, 2020)

Structure of land owners

Increased land grabbing leads to a decoupling of the prices of leased land and from what can actually be produced and gained from that land. Public investments can support private investors in making ecological investments. Who will own the agricultural areas and what will be the role of the state?

Only a few owners of agricultural land	There is a high diversity of land owners	Agricultural areas belong to the state
Management decisions of farmers are profit oriented to be able to pay the high prices for renting agricultural land. "Land grabbing" is spreading.	Diversified investment in agriculture is possible and agricultural areas are in the hands of many.	Agricultural fields are in the hand of the country and the lease of land is conducted according to Economy for the Common Good.

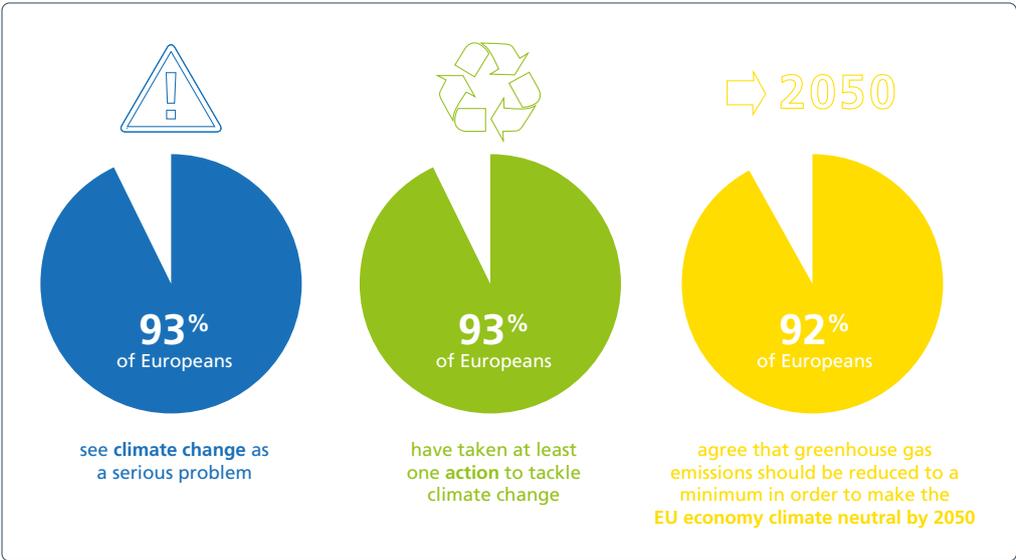


Percentage of leased land of all farmland in EU Member States (Eurostat according to Swinnen and Knops, 2013)

Addressing the climate change

The consequences of climate change are an increase in the intensity and frequency of extreme weather events such as heavy rainfall, heat waves or droughts. This has direct consequences for agriculture. Are we able to address climate change proactively, or will we simply adapt?

Climate adaptation	Climate change proactive addressed
<p>The hope that climate protection will have any effect at all has been lost, so a shift is being made from climate protection to pure climate adaptation. Resources are being invested in flood protection, genetically modified seeds, expansion of water reservoirs, river regulation, relocation of agricultural areas, urban greening and even geoengineering or climate engineering.</p>	<p>The necessary decarbonisation of the economy entails both additional costs and opportunities for the economy, including the need for business and government to invest much more. Climate change is a driver and motor for innovation and change. Climate protection influences the modernisation strategy and brings local advantages.</p>



2019 Survey (European Commission, 2019)

Quality and quantity of labels

In addition to the legally required labeling and voluntary information, there is a wide range of seals, symbols of origin and symbols in food packaging. Labels create quality expectations among numerous consumers and are therefore often used for advertising purposes. Will there be more harmonisation of food labels?

No labels any more	Only few but therefore harmonised labels	High variety of labels
<p>There is no longer a need for labels due to full traceability and all information of product qualities is online. This development was caused by the complex and confusing label structure.</p>	<p>There are EU-wide harmonised labels based on policy decisions. These labels are seen as reliable. Also private companies take part in the certification.</p>	<p>In addition to legally required labeling and voluntary information, there is a multitude of seals, symbols of origin and symbols in food packaging. The requirements for the allocation of such labels and test marks vary widely.</p>

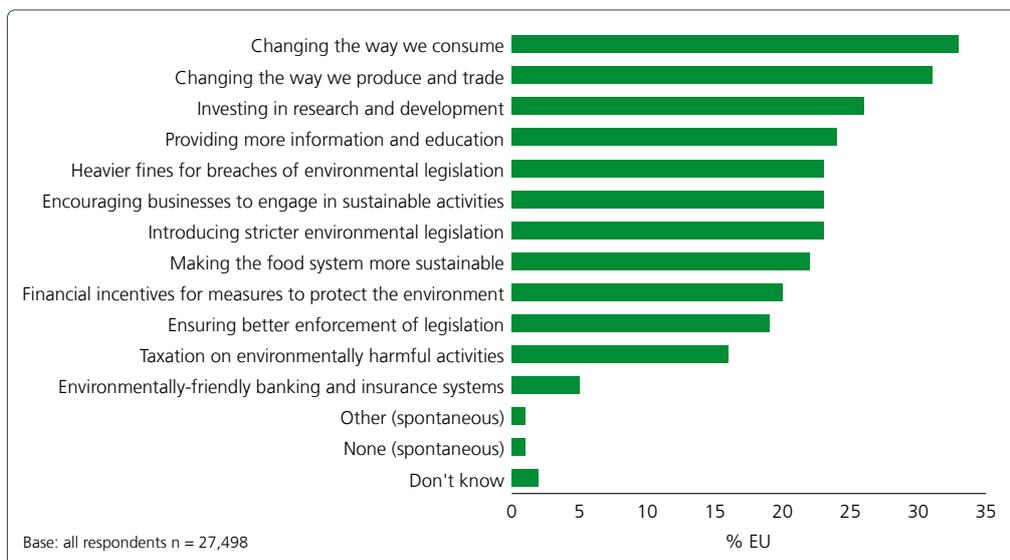


So many people pay attention to the ...? (BMEL, 2020)

Market for ecosystem services

More sustainable management techniques can support biodiversity and the provision of ecosystem services. The additional expenditure for their implementation must be reflected in higher prices for consumers. Will the footprint of ecosystem service be relevant for consumption decisions?

No willingness to pay for products promoting ecosystem services	Significant market share for ecosystem friendly produced products	The protection of ecosystem services follows a remote approach
<p>The ecosystem service footprint is not relevant for the consumption decisions. Consumers have no understanding of the influence of agricultural management on the provision of ecosystem services.</p>	<p>Consumers understand the impact of their buying decisions on the management of agricultural land and further on the promotion of ecosystem services. There is a high traceability within the value chain.</p>	<p>Food production does not have to preserve ecosystem services directly. There is instead the possibility of payments to support the provision of ecosystem services somewhere else.</p>

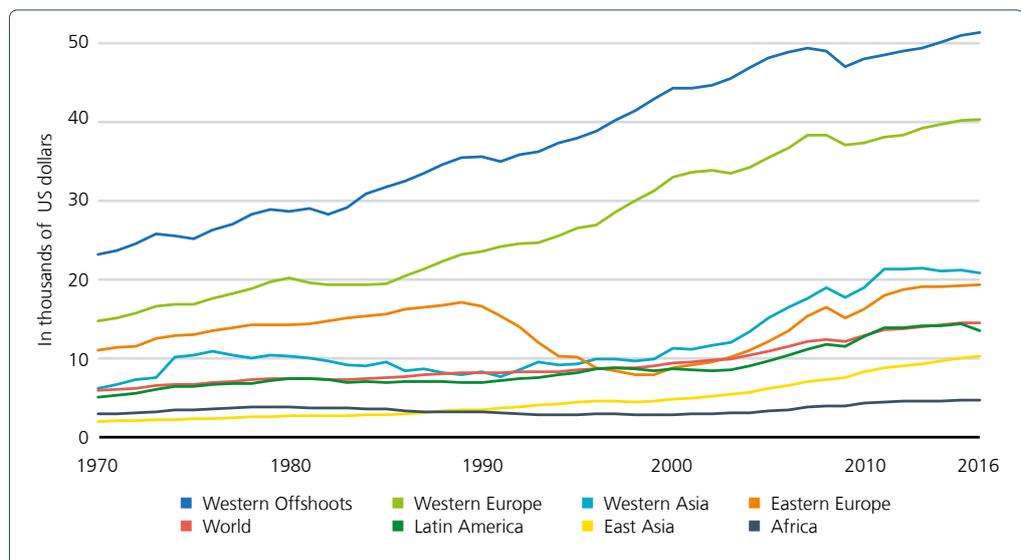


In your opinion, which of the following would be the most effective ways of tackling environmental problems (maximum three answers)? (European Commission, 2020)

Growth paradigm

Growth is one of the main objectives of the current economic model. A growing GDP is still an indicator for a country's success. The next generation demands a new, more sustainable economic model. Will the focus shift to non-material goods and qualitative growth?

Continued quantitative growth without renouncing consumption	Reduced consumption and degrowth	Qualitative growth and change of consumption patterns
<p>Growth-oriented market economy with income inequality within countries and increased consumption of agricultural and livestock products.</p>	<p>The next generation is demanding a new, more sustainable economic model, making personal property less important. Products are used over a longer period of time, and plant-based nutrition is preferred.</p>	<p>GDP is complemented by other indicators, i.e. satisfaction, ecological footprint per person and planetary boundaries. Quality of life is decoupled from consumption and focuses on non-material goods.</p>

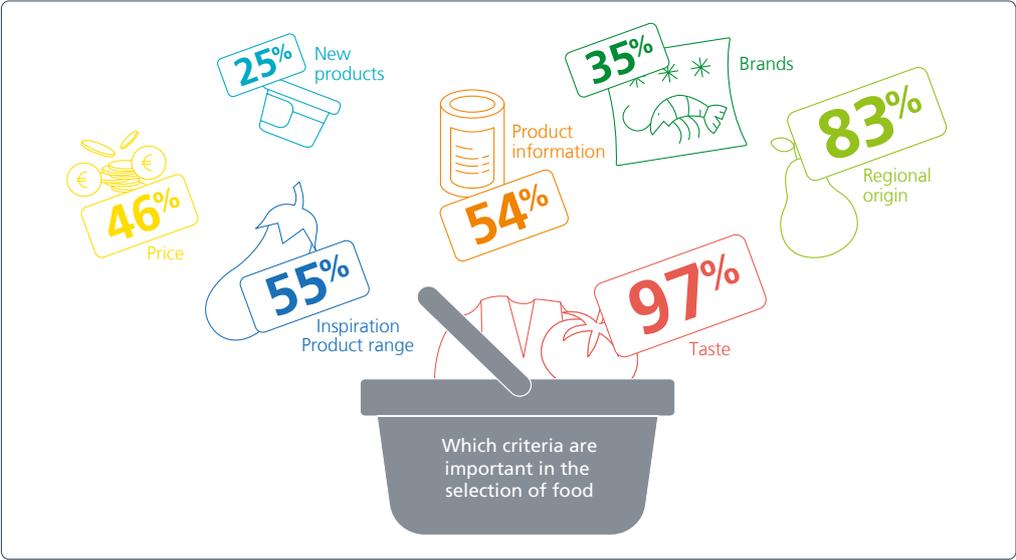


Average real GDP per capita across regions (Maddison Project Database, 2018, based on Roser, Max, 2013)

Purchasing behaviour

More and more people are suffering from food intolerance, while others follow a vegetarian or even vegan diet. Products of regional origin and organic products play a particularly important role. However, price is still an important criterion. What will become the basis for making purchase decision?

Ecology & health oriented decisions	Price-driven consumption	"Sense"-based consumer decision
<p>The consumer makes the purchase decision based on the environmental impact of the product and the categorisation as a healthy food.</p>	<p>The purchase decision of consumers is linked to their income and based on the price only. All information concerning food products is in one place, i.e. an app or at the e-commerce platform.</p>	<p>Consumer use their own senses at the point of sale when choosing products and make decision based on the information that is available in the supermarket.</p>

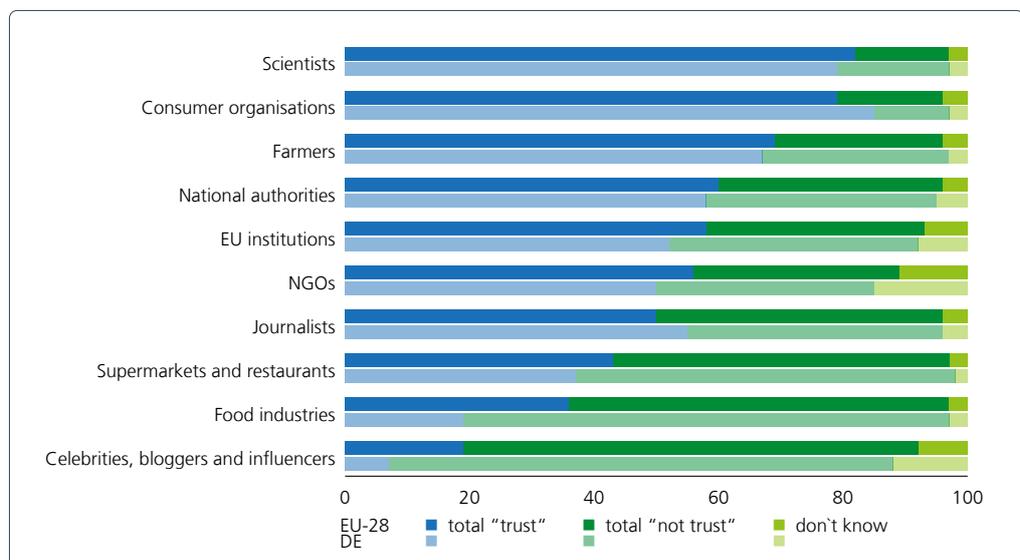


Which criteria is important in the selection of food? (BMEL, 2020)

Governance for food security

Food supply chains today cross multiple national borders. Good collaboration between governments, producers and consumers contributes to food security. International cooperation and governance gaining in importance. Will the regulation be more effective at local or international level?

Regulation mainly by local governments	Regulation on an international level – international institutions and the international expert community are involved
<p>The regulation on a local level is more expensive and labor intensive, but it is easier to ascertain the needs of the local population and the self-responsibility to ensure that nutrition security is higher.</p>	<p>The awareness of the crucial role of responsible and effective governance in achieving key development objectives is enhanced and international cooperation and governance gains in importance.</p>

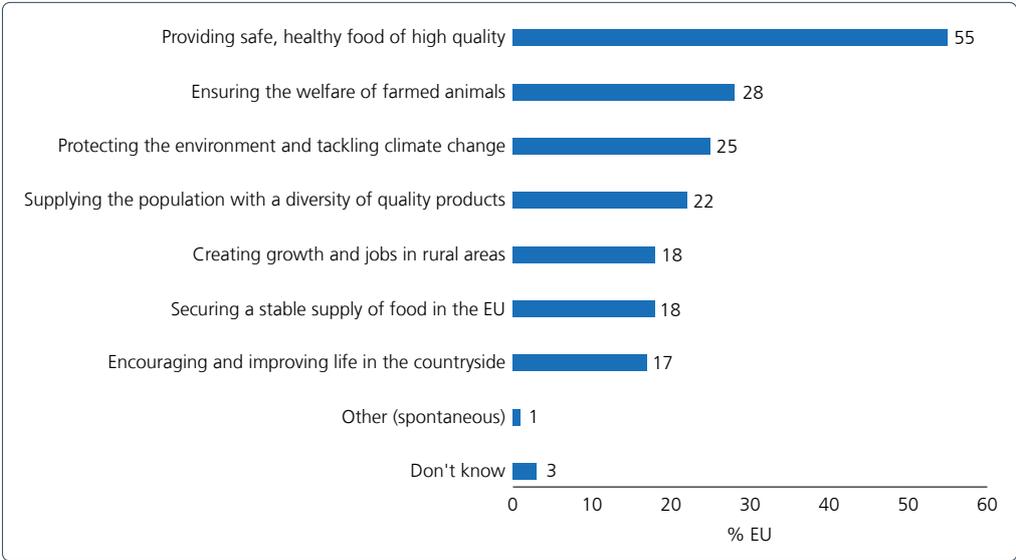


Please tell me to what extent you trust the following sources or not for information on food risks? (EFSA, 2019)

Perception of farmers

There is an irrational and unrealistic societal perception of agriculture. The media contribute to this attitude by showing the ecological side of agriculture in advertising, but also by reporting on food scandals and factory farming. Will the transparency of farmers' work increase and their reputation change?

Farmer as shaper of natural landscapes	Farmer as a producer
<p>Farmers are recognised for their contribution in shaping the space in which people live. They take care of the land as well as the environment and they are appreciated for doing so.</p>	<p>Agriculture is mainly perceived as economic activity and farmers are not visible within society. The agricultural work is not well understood and there is a very low transparency of agricultural production.</p>

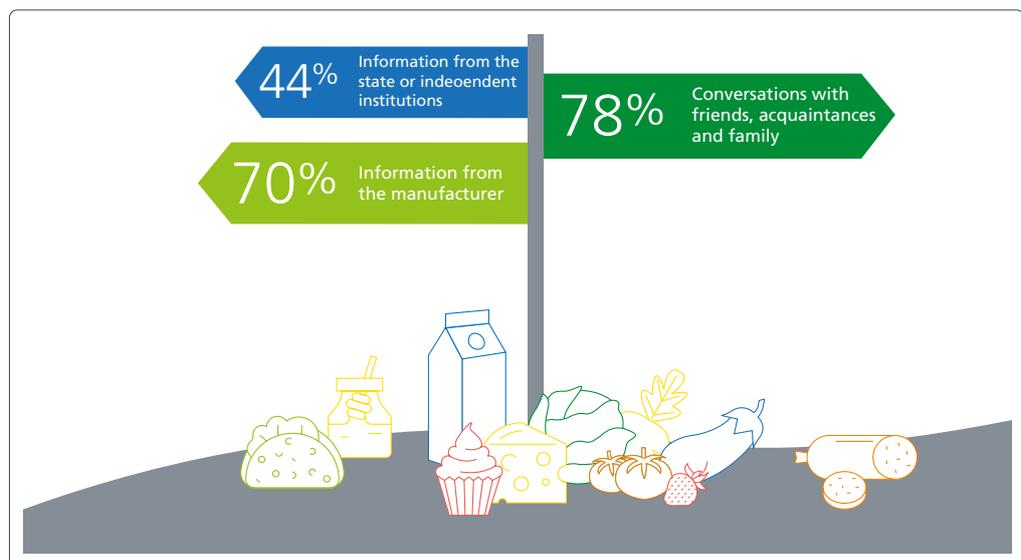


What do you think should be the two main responsibilities of farmers in our society?
(European Commission, 2017)

Information along the value chain

In the food sector, some platforms connect customers and companies, while other act as a delivery service for food from supermarkets. The expansion of knowledge in all directions along the value chain is imaginable. Who will be able to use these information most effectively and how important will data protection be?

Retailer is the information hub	Accepted platform with seamless information flow	No acceptance of digital platform but rich analog information
Retailers have a major influence on prices, quality, product lines and production conditions. AI is used for intelligent pricing and data for customer profiles is collected to maximise profit.	New technologies and the expansion of network coverage allow more people to retrace agricultural production methods. Information is exchanged between producer and customer.	There is a resistance to digitalisation and privacy loss is not accepted. Customers shop locally regional food and exchange information at the point of sale.

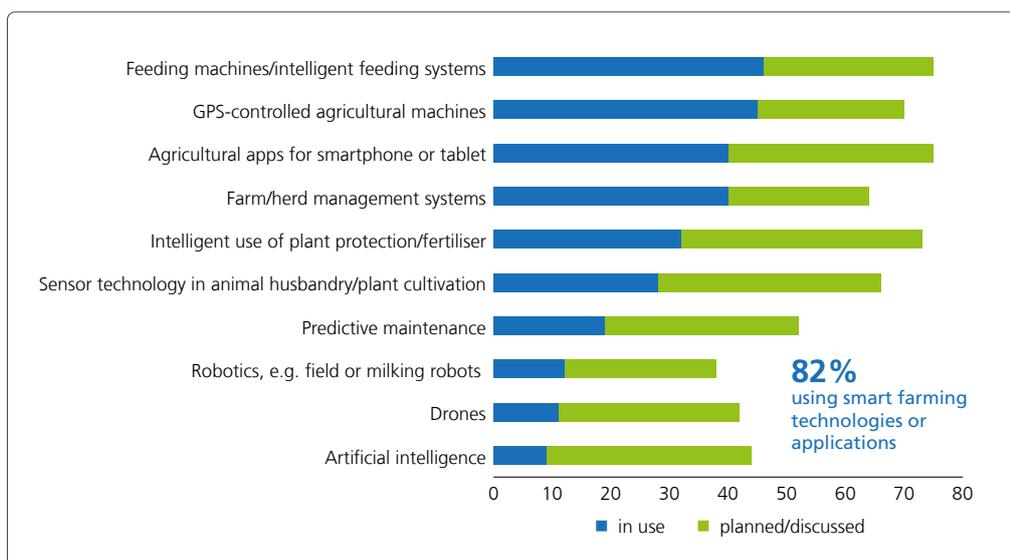


What sources are used to obtain information about food? (BMEL, 2019)

Technologies in primary production

Digitalisation has completely captured the food industry. Whether as sorting machines in logistics or as sales robots in supermarkets – the use of artificial intelligence will change the food industry. Will new technologies and digitalisation change the agriculture and offer new opportunities to improve policy?

Machine farm	Hybrid farm	AI farm
Only parts of the farming process are digitalised, most processes are still analog. There are manually driven huge machines for larger fields and assistant systems are being developed. The different production steps are smart, however there is no connection in between.	There is a mixture of large, manually operated machines and small autonomous robots capable of tracking factors such as soil moisture, plant health and animal diseases. Effective sensors are available and used for the partly smart food value chain.	Sensors are integrated in every part of the production chain and collect various kind of data. These information enable the use of artificial intelligence at every and between every stage of the value chain.



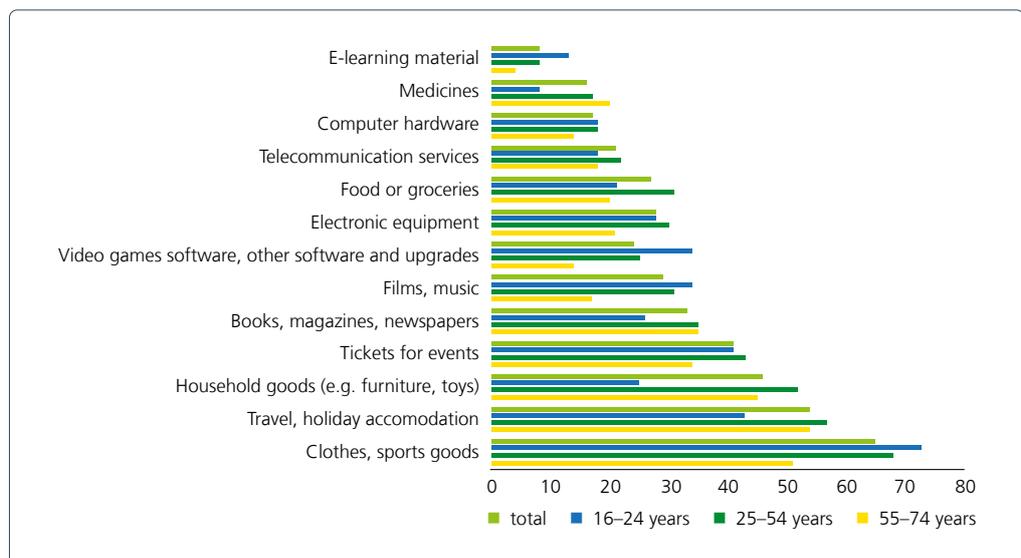
Which technologies or applications do you use or plan/discuss to use?

(Bitkom Research, 2020)

Diffusion of e-commerce

Supermarkets and discounters offer a comprehensive infrastructure for the distribution of perishable food. Due to the growing demands of consumers, supermarkets are under great pressure. Will online trading create new structures or will we return to the physical point of sale?

Highly centralised e-commerce	Distributed, decentralised, local retailers	Food-shopping as social event
<p>Most shopping takes place via online applications. New structures are created through online trading. Central retailers arise, which gain more power within the value chain.</p>	<p>There is a high level of cooperation between delivery and distributed, decentralised, local retailers. It is often possible for customers to be in direct contact with the production facility and apps offer support for private purchases.</p>	<p>There is not much e-commerce and shopping became a social activity: Consumers prefer going to the local market to get products directly from producers.</p>

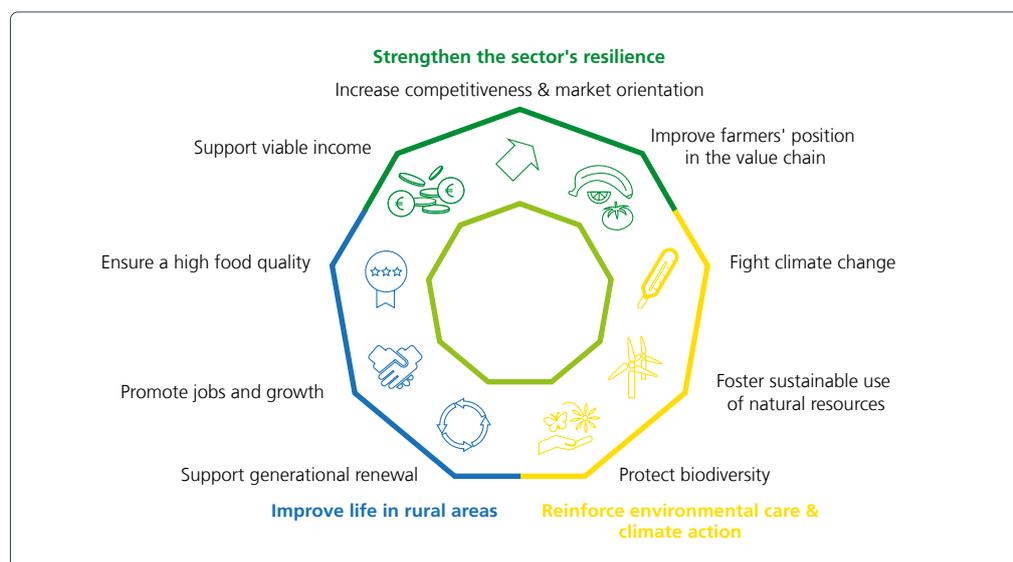


Online purchases, EU-28, 2019 (Eurostat, 2020)

Agri digital and agricultural law

Due to growing concerns about data loss and the economic consequences of technological progress, the new regulations on data protection and privacy have been tightened. Will the legal framework be able to enable the intended technological transformation or is it lagging behind?

Law is lagging behind the technological development	The legal framework works as an enabler for the intended technological transformation	Worldwide harmonisation of legal standards
<p>The legal framework consisting of the Common Agricultural Policy (CAP), the Basic Data Protection Regulation (GDPR) such as other data laws are kept in their current form. Traditional Data Law is focused on data-based services without special regard to agriculture and food economy.</p>	<p>The upcoming CAP-reforms and new legal acts and their integration by the model of well-ordered law provide a stable legal framework. A new field of jurisprudence integrates Agri Digital Law, Agricultural Law and Agri Environmental Law and provide security for the use of new technologies and the participation in new business models.</p>	<p>Development of a global and coherent Agri Digital Law which provides a comprehensive legal framework for the consideration of multilateral interests between actors from agriculture, food economy, enterprises, politics, and consumers. A coherent supranational law on the level of the EU is created and comparable models are implemented in different parts of the world.</p>



What are the objectives of the future CAP? (European Union, 2018)

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