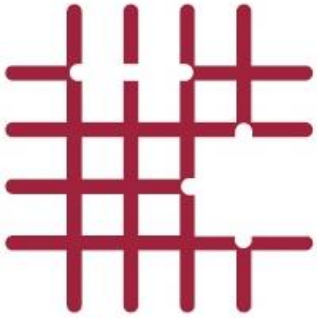
Digitisation of the livestock farming sector



COUNCIL ON ANIMAL AFFAIRS

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Summary

The digitisation of the livestock farming sector is in full swing. Digitisation will become commonplace on livestock farms within five to ten years. This also has consequences for the animals. Increasingly opportunities are opening up for gathering data, using data for control purposes and sharing data. This is accompanied by opportunities as well as threats. Opportunities arise from the faster availability of more data throughout the entire livestock production chain and from combining different data to yield new information and insights. Livestock farmers will have greater opportunities to ensure the living environment for the animals matches their needs, with positive implications for health and animal welfare. Replacing physical actions conducted on animals will improve working conditions and potentially reduce stress for the animals. The uneven distribution of information between parties in the supply chain (supplier, livestock farmer, processor, marketing organisation, consumer) can be addressed. Increased transparency will boost confidence in the sector and present consumers with a greater range of options for buying animal-friendly products.

Digitisation also brings threats. The steps leading from big data to reliable and relevant information and then to well-informed correct decisions are not automatic, and are also complex. Caution and restraint should be exercised for the time being, particularly as regards the automatic control and adjustment of process equipment based on sensor data. In addition, among other things the autonomy of animals and livestock farmers may diminish and consumers may feel they have fewer possibilities for identifying with social-cultural values implied in the food.

Digitisation will have an impact on interrelationships in the livestock farming sector: between humans and animals, among humans, and among animals. The Council on Animal Affairs wishes to provide further insight into the impact of digitisation on animals in the livestock farming sector and how they are cared for. This is jointly determined by the impact of digitisation on the people caring for animals/livestock farmers. They are obliged to take good care of their animals. However, the fulfilment of this responsibility by the livestock farmers is a result of the interplay between their individual standards and values, working conditions and income. The ultimate impact of digitisation on animal well-being depends not just on technological developments as such, but also on the standards and values in society, legal frameworks and the economics of the food chain. The impact of digitisation is therefore viewed as a whole from the perspective of the animals, livestock farmers, and the market and society. A distinction is made between the effects of digitisation on:

- The health, welfare and freedom of behaviour of animals;
- The income, working conditions and management freedom of livestock farmers;
- Food health and safety, the values implied in food, and consumers' freedom of choice.

By focusing our efforts on the above topics, we will strengthen the opportunities while ensuring the threats are limited. In this light, the Council on Animal Affairs therefore advises that:

1. systems be based increasingly and more inherently on target requirements, where;

    a) supplementary to the steps taken by the Government to base environmental regulations on real-time data, the same should also be done in respect of welfare. This also allows the opportunity to make the welfare indicators developed under the EU Welfare Quality programme more suitable for use by livestock farmers.

    b) Public authorities increasingly base their licensing systems on real-time measurements on the quality of the human and animal living environment in and around the animal barn rather than on the barn configuration.

    c) monitoring bodies place greater emphasis on these new target requirements as soon as they become available, on the understanding that the measurement results can also be related to the actions of the livestock farmer.

    d) public authorities and market parties jointly create a quality mark for reliable digital information, including a voluntary code of conduct, with a corresponding code commission, enabling objections and appeals to be filed against misleading digital information.

2. parties working on data sharing do so in such a way that administrative tasks on the farm are reduced, thereby cutting the amount of duplicate paperwork livestock farmers and animal carers have to complete, enabling them to spend more time looking after their animals.

3. the government assume responsibility for maintaining open data networks by establishing appropriate frameworks and setting up a contact point for reporting unavailable networks.

4. the government and market parties encourage open innovations, guaranteeing easy mutual access for high tech and the livestock farming sector. This can be achieved, for instance, by encouraging meetings where information can be shared openly. These meetings must be clearly announced and easy to find, including for businesses, institutions or persons who currently do not (yet) work in the livestock farming sector.

5. digitisation be integrated in research and education, so that livestock farmers and consultants gain more skills in correctly interpreting information and can learn to act accordingly. As a result, the information is used more for the benefit of the animals, and fewer or no adverse effects occur. This means that research universities and universities of applied sciences need to incorporate digitisation in their curriculum.

6. technology providers for the livestock farming sector should provide insight at the request of monitoring authorities into the validation and robustness of the algorithms that have been developed and are used.

7. the debate on digitisation of the livestock farming sector not be conducted separately from the debate on policy measures in other fields, such as the debate on the new guidelines for data ownership, data sharing between banks or number portability, as well as circular agriculture, for example. This helps to limit the risks of unforeseen, adverse side effects.

1. Introduction

Until recently, the data routinely collected on livestock farms consisted mainly of traditional key figures and indicators that were used in management support systems, for instance. The recent emergence of the Internet of Things and precision agriculture[1] means that wireless connection and combination of management systems, process equipment, Radio-frequency identification (RFID) tags[2], infrared measurement, audio-visual equipment, sensors and other big data are becoming increasingly commonplace. Increasingly opportunities are opening up for gathering data , using data for control purposes and sharing data. Measurement of temperature and humidity in animal barns, for instance, is already commonplace, as is the use of pedometers and direct analysis of milk quality by milking robots in the dairy farming sector. Levels of particulate matter and concentrations of carbon dioxide, ammonia and other odour components are measured on a limited number of farms. At the moment, however, there are only prototypes available of movement stimulators, blockchain applications, camera applications that monitor behaviour and particulate sensors designed specifically for the livestock farming sector.

With the increasing availability of online real time data, the development of information and communication technology in the livestock farming sector potentially also leads to easier data management, more targeted delivery of feed, medication and care, guarantees of food safety and quality, opportunities for increased transparency toward consumers and increased added value of the products from the livestock farming sector.

Better monitoring of production conditions in the livestock farming sector, and the prospect of lower monitoring costs, also means a further increase in the potential benefits of specialisation as well as less contact between livestock farmer and animals, and increases the attractiveness of economies of scale and other, more industrial, business models than the traditional family-run farm (Allen & Lueck, 2003). However, digitisation can also be used to optimise the traditional family-run farm and the growing and marketing of regional products, for instance. Digitisation will have an impact on interrelationships in the livestock farming sector: between humans and animals, among humans, and among animals.

The Rathenau Instituut published an exploratory report that examined precision livestock farming though the use of smart technology[3]. It highlights the importance of the question how digital innovation will be embraced by the agricultural sector and which trends this will reinforce – from economies of scale to attention for animal welfare or regional production.

The extent to which these trends have positive or negative outcomes for the livestock farmer, animals, the supply chain and ultimately consumers is a relevant question. A further important question is what the government can and should do.

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[1] Precision agriculture, or precision farming, is a very precise and efficient method of automated farming that uses GPS, sensors on the ground or from the air (drone or satellite) and computers mounted on agricultural equipment or vehicles.

[2] Technology for remote recording of data in and reading of the data from so-called *radio-frequency identification (RFID) tags* that are fitted on, to or in animals.

[3] Jacqueline Bos and Geert Munichs (2016) Digitalisering van Dieren – Verkenning Precision Livestock Farming (An Exploratory Report on Precision Livestock Farming). The Hague, Rathenau Instituut.

It is not just a matter of what the agricultural sector can do, but also which parameters and frameworks must be set and who has responsibility for this.

Building on the exploratory report of the Rathenau Instituut, the Council on Animal Affairs wishes to provide further insight into the impact of digitisation on animals in the livestock farming sector. The impact of digitisation on animals and their care is determined in part by how digitisation impacts on the people caring for the animals/livestock farmers. They are obliged to take good care of their animals. However, the fulfilment of this responsibility by the livestock farmers is a result of the interplay between their standards and values, working conditions and income. The ultimate impact of digitisation on animal well-being depends not just on technological developments as such, but also on the standards and values in society, applicable legal frameworks and the economics of the food chain. The impact of digitisation is therefore viewed as a whole from the perspective of the animals, livestock farmers, and the market and society. We distinguish between the effects of digitisation in terms of:

- The health, welfare and freedom of behaviour of animals;
- The income, working conditions and management freedom of livestock farmers;
- Food health and safety, the values implied in food, and consumers' freedom of choice.

These developments are not separate from the future of the livestock farming sector and circular agriculture and will therefore be examined and described also in conjunction with these issues.

Digitisation presents opportunities as well as threats. Identifying these opportunities and threats provides reference points for public and private policymaking. The reflection section in this report therefore concludes with recommendations for strengthening the opportunities and limiting the threats by using instruments suited for that purpose.

2. What is available on the market and what is under development?

2.1 Introduction

The possibilities for measuring, sharing and making adjustments based on data are increasing. The availability of ever cheaper and more robust sensors as well as the recent emergence of wireless sensor networks allows (barns accommodating) farm animals increasingly to be fitted with digital sensors and connected wirelessly with other process and management systems. The data flows can be analysed and stored by special software and specially developed algorithms can send the information in real time to the livestock farmer and parties advising the farm. Systems are expected to come onto the market that will use sensor data to regulate the interior climate by automated means or through targeted intervention in the behaviour, health and welfare of the individual animal, by stimulating movement, for instance.

Measured values from sensors can also be linked for the purpose of promoting the animals' care. This can lead to better care of the individual animals, while potentially also enabling a single worker to care for multiple animals simultaneously. If data from different systems and/or businesses are linked, data mining can be used to identify underlying connections. Measuring devices can be fitted directly on, or even in the animal, enabling direct monitoring also of the animal's biological system.

These techniques and methods that are based on digitisation can have different purposes:

- Monitoring the livestock farm conditions and emissions from the animal barn(s);
- Regulating animal behaviour (e.g. access to feeding stations);
- Direct regulation in animals' neurobiological systems, by sending impulses, for example
- Obtaining greater insight into the interrelationships between animal care, climate, animal and human health, behaviour and production;
- Acquiring more insight into the animals' health and welfare;
- Sharing data with parties in and around the production and distribution chain.

This section describes the main digital technologies that are available as well as the leading digital developments in the various livestock farming sectors. Digitisation is not considered a synonym for automation. They are two separate terms that are frequently used in combination and interchangeably. However, digitisation is possible without automation. While digitisation promises to provide livestock farmers with more information, in many cases the decision whether or not to carry out a certain action will still remain with the farmer, either out of volition or need. Where digitisation is combined with automation, the system can take over many of these decisions. In many ways automation demands even more careful checks and balances to prevent errors than digitisation, where the livestock farmer retains control over the choices that are made.

The techniques described are in various stages of development. Some techniques are still in their infancy and are currently only used in test environments, while others are at an advanced stage of development and are already used in actual practice. Table 1 gives an overview of the development stage of each digital technology. These technologies are described further in this document.

Technology	Under development	Prototype ready	Used in several farms	Broader application
Measurement of temperature (air)				X
Infrared measurement of skin temperature		X		
Measurement of ear temperature			X	
Measurement of humidity				X
Measurement of CO2 concentrations			X	
Measurement of concentrations of particulate matter		X		
Measurement of NH3 concentrations	X		X	
Measurement of concentrations of odorous substances/aromatics		X		
Fire detection meters			X	
Measurement of water usage				X
Optical sensor - water turbidity			X	
Bloodstream sensor - hormone measurements	X			
Noise measurements - coughing			X	
Camera - observe behaviour		X		
Thermographic camera		X		
Camera - barn/observation			X	
Camera - groups of animals			X	
3D camera for weight measurements			X	
RFID animal identification				X
Blockchain applications			X	
Pedometers				x
Milking robot				x
Calving sensor			X	
Litter robot			X	
Egg collection robot		X		
Movement stimulator		X		
Gestation meters			X	
Silo weighers			x	
Animal facial recognition		X		

Table 1. Applicability of digital technology for livestock farming

2.2 Digital technologies

The development of digital technologies has progressed rapidly in recent years, and this will undoubtedly continue in the coming years. This report is not intended to present a comprehensive overview of everything that is currently available, but rather to describe several important aspects by which these technologies can be distinguished.

We distinguish between the following in terms of available digital technology for the livestock farming sector:

- Sensors for conducting measurements on or in individual animals, groups of animals, and in the barn and its immediate surroundings, such as the feeding systems;
- Technology for observing animals and their behaviour; RFID, camera technology;
- Analysis methods for converting big data into information: data mining, artificial intelligence fuzzy logic;
- Network technology: Internet of Things, Blockchain, LoRa networks.

Sensor technology

It is possible to measure all manner of things in an individual animal. One example is counting the movement in terms of steps taken by dairy cattle, allowing the oestrus (and hence the optimum moment for insemination) to be predicted or enabling certain aspects that are associated with animal health to be monitored (reduced activity, excessive lying or standing), (in)sufficient or irregular rumination. The measuring devices for these technologies are fitted externally to the animal, often around its leg or neck, although there are also internal sensors under development as well as external camera systems and animal recognition. A technology being tested on pigs is sound measurements as an indication of health problems (coughing frequency). Infrared can also be used to estimate the skin temperature externally, and there are sensors for measuring the gestation status based on hormone levels.

Individual measurements can be performed by inserting[4] something into the animal, such as a sensor in the bloodstream or the stomach. The sensors can measure temperature, hormone levels or blood counts, for example, possibly providing an indication of the health of the animal. These technologies are in the full throes of development. Implanting internal sensors can cause distress[5] and may have health and safety risks, for instance if the coating dissolves or if a sensor begins to move through the body.

In addition to measurements of, on or in (groups of) animals, it is also possible to conduct measurements in the barn (and its immediate surroundings). This can include measurements of climate parameters, such as temperature, humidity, CO2 and NH3, for

[4] Section 2 of the Animal Disease Specialists Decree (*Besluit Diergeneeskundigen*) (https://wetten.overheid.nl/BWBR0035091/2015-06-01#Hoofdstuk2) describes which interventions are permitted, and which are not permitted.

[5] For an assessment of the admissibility of interventions in animals, see RDA advisory report: Grip op ingrepen (Getting a Grip on Intervention), RDA, The Hague, 2013.

instance, as well as concentrations of particulate matter and drinking water consumption and quality. Water usage is measured for each nipple drinker and an optical sensor measures the water turbidity in the pipes. The amount of liquid feed dispensed is measured for each pen. These technologies also are currently under development, although some are already being put to practical use at a number of farms.

These data have a direct or indirect impact on the individual animals. To enable interpretation of these measurement data (e.g. how stable is the interior climate?) and their translation to recommended action (e.g. faster temperature adjustment), the measurement data can be related to data on the climate in the immediate vicinity of the barn, such as wind force and wind direction, that are available online.

Real time measurement of the air quality around barns is also enabled by sensors that measure concentrations of odorous substances (hydrogen sulphide, butyric acid and other volatile organic substances) and particulates. Fire detectors are also increasingly being used, and there are several developments in the field of biosensors for detecting the presence of pathogens in the barn. Technologies such as these are currently being developed and are being tested in actual practice.

A wireless connection via a LoRa network (one of the potential technologies behind the Internet of Things) is both possible and important in due course in the case of all the innovations referred to above. LoRa stands for Long Range Low Power and makes it possible to wirelessly connect devices that use limited power and data with one another in a cost-efficient manner via the internet. LoRa also makes it possible to extend the application range of existing technology. At various farms, for instance, automatic silo weighers have been installed that are in permanent contact with the feed factory, enabling stocks to be monitored remotely and new feed to be delivered in good time. Another example, at a number of poultry farms, is the use of scales that are connected to a computer for remote online monitoring of the weight of the chickens. A further example is a facility enabling virtual permanent reading of sensors fitted to cows, even when they are at a (considerable) distance from the barn. Such networks are still in their infancy in the Netherlands. Nonetheless, the further application of artificial intelligence[6] and fuzzy logic[7] methods will allow these measurement data to tell the user when, and also offer him/her the possibility, to make adjustments in a timely manner.

Identification technology

RFID is a technology that uses a radio signal for the identification and tracking & tracing of animals. RFID-tags are minuscule chips containing an identification code that can be remotely read out via radio signals. They can simplify processes and procedures so enabling gains in terms of time and costs savings, and they can also be used to increase transparency. To allow the identification of bovine animals, an ear tag containing an identification chip must be fitted.

[6] *Artificial intelligence* a system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation.
[7] *Fuzzy logic* is a logical system of thought that takes into account the possibility that something may well be partially true. Classical logic only permits two conclusions: something is either true or false. Fuzzy logic adds to this the idea that something may be 'partially true or untrue'.

Electronic means of identification and registration are currently being used for goats and sheep in the form of an electronic ear tag, a ruminal bolus or a leg band.

Experiments involving electronic ear tags fitted to pigs are currently being conducted to see whether they can also be used to record antibiotics usage for individual animals and for feeding back slaughter findings in the abattoir to the pig farmer.

With effect from 19 July 2019, EU Member States may permit the use of electronic ear tags as one of two means of identification for bovine animals.[8]

Camera vision

Camera technology could be used for registering animal movements and translating the data obtained into information on health and behaviour. This enables an animal that is low in the social hierarchy, or that remains on the fringes of a group and is less easily able to get to water and feed, to be noticed in good time, for instance. In addition, 3D cameras are available that estimate the weight development of a group of animals on a day-to-day basis. In contrast to the practice with weighing systems, this does not necessitate any action to be performed on animals. Monitoring animal behaviour is also possible. If the camera registers that a pig exhibits anxious behaviour in a group, for example, it may be because it is afraid of another pig. Behaviour indicating boredom and lack of diversion can also be detected in this manner, enabling the pig farmer to undertake early action to prevent tail-biting, for instance.

Furthermore, technology is being developed in China that will enable facial recognition of pigs. This would eliminate the need to fit mandatory ear tags. The technology is still at a very early stage, however. Automatic individual recognition of bovine animals using cameras is further advanced and is already being put to practical use.

Thermographic cameras can be used for making remote temperature measurements. This can be useful for detecting animals with a fever, for example, and among other things is used for identifying possible mastitis (udder infection) in dairy cattle. It can also be used to reveal stress, since the ears and tail of a stressed animal are cooler and the area around its eyes warmer.

Ordinary cameras can also be used to allow consumers to view what is happening in the barn, or to track an individual animal whose milk or meat they can buy later. In this way the consumer is 'taken into the animal's accommodation' and learns more about how the animal is cared for. Bringing the consumer and the producer together in this way also reduces the non-committal element in their relationship for the livestock farmer. There is a risk that certain images may be taken out of context, or may be incorrectly interpreted by the consumer due to a lack of knowledge. Privacy should also be taken into account. The livestock farmer's consent should be required for this type of camera usage.

Most abattoirs have been using cameras to monitor their operating processes for some time. However, incidents in the abattoir can be missed with the current camera systems

[8] Regulation (EU) No 653/2014 of the European Parliament and of the Council of 15 May 2014 amending Regulation (EC) No 1760/2000 as regards electronic identification of bovine animals and labelling of beef. This permits electronic I&R with effect from 18 July 2019.

if no one happens to be looking at the monitors when an incident occurs. It is also very time-consuming to go through past recordings to check for possible incidents. Algorithms can be developed for recognising incidents in the abattoir and to warn the operators so that corrective action can be taken where needed and to enable the relevant images to be quickly selected later from the copious footage.

Big Data

For the livestock farming sector, Big Data[9] are comprised of frequent measurements of various characteristics and features of animals and their environment (in the broad sense of the word) that produce large quantities of measured values, which can be compared with one another. This results in potential new information and insights. Analysing these continuously expanding volumes of digital data (which can quickly run into tens of thousands of measured values per farm per month) and relating the data to other data that are already available can have a positive impact for animals and livestock farmers alike. Data analysis opens great opportunities. It also comes with risks, however, in particular caused by incorrect interpretation of data where misleading patterns are discerned which suggest connections or causality that do not exist, and conversely where connections or problems that do exist are missed because crucial relevant data might be lacking. A major pitfall is that the enormous volume of data gives the suggestion of reliability and small margins of error. Many mechanisms underlying connections are not always known, however, and the things that can be measured are sometimes no more than indirectly linked to the insights that are sought. The pitfall is that 'voluminous' and 'representative' are not the same.

The interlinking of data relies on available data for which consent has been given for their use. The legal framework is constituted by the General Data Protection Regulation (GDPR), which came into force in May 2016, the purpose of which is to protect personal data and also to guarantee the flow of data in the European internal market. In spring 2019, the EU adopted the FAIR Data Principles: data must be findable, accessible, interoperable and reusable. The absence of a single body with control over all data and the fact that interoperability does not (yet) exist makes this complicated in the animal farming sector.

More and more solutions are being developed with the aim of facilitating the step from big data to relevant information and from there to making the right decision on whether or not to take a particular action. Artificial Intelligence and Fuzzy Logic allow digital camera images to be converted to data on animal behaviour (if the piglets lie too closely together, for instance, it may be too cold; if they lie too far apart it may be too warm). Machine learning, new software techniques that train computers to recognise patterns, count or group objects and make predictions about future events, can also make an important contribution. This is already being used to predict oestrus among cows based on so-called accelerometer data (pedometers) (Connecterra, Amsterdam), for instance, or for analysing video images of animals and warning of any anomalies detected (Serket, Amsterdam; Noldus, Wageningen).

[9] Big Data is high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision making.

Digital platforms

Alongside the fact of the large volume of data and its real-time availability, a further, and perhaps even more important, aspect of Big Data is the ability to make combinations – integrating and interconnecting information. Sensors, for instance, can measure the humidity and concentrations of particulate matter in the air of the animal barn. This yields a useful dataset.

It becomes even more interesting, however, if the dataset can be combined with information on endotoxins. Linking this also to information on the quantity of feed consumed should make it possible to examine how a particular breed behaves under varying conditions. This provides new opportunities for insight that previously did not exist. That perhaps is one of the most challenging aspects of Big Data.

Exchange of data between all the links in the food chain – feed companies, livestock farmers, veterinarians, processing industry, transporters, retailers and consumers – for the purpose of monitoring and benchmarking has been stepped up significantly. Licensing authorities, public authorities and monitoring and certification bodies are also embracing these developments. Integrating livestock farming with data management (alongside the farmer's role as a data user) has the potential to not just greatly improve animal health, but also to boost productivity and efficiency. The results depend on the livestock farmer's competencies in this area. Benefits include more efficient and economical water usage, less raw material wastage and improved animal care. Another example is provided by the levels in feed silos that are continuously shared with the feed supplier. New feed is automatically ordered when the level falls below a certain minimum. This not only saves time and effort, but also ensures an optimal care process.

There is increasing attention for the traceability of food products. This is driven not just by legislation, such as the EU General Food Law[10], but also by increasing numbers of consumers who want information on the quality, safety and sustainability of food products. Where do the ingredients come from, is it safe, how is it produced? This means that data on the previous links in the chain must be provided right up to the end product. Businesses in the agrifood sector also want to know more, and are learning more, about their suppliers. The agrifood sectors can develop to become data-driven chains in which companies make increasing use of data from other links in the chains. This increases the importance of reliable data, and with it the complexity of sharing and securing the data. An example is Agriplace (www.agriplace.com). They digitise on behalf of farmers and traders all the certification requirements, which are often based on the same data, but are still commonly entered manually. This enables compliance requirements to be met by the farmer at the press of a button. Blockchain technology may also be useful in this context. JoinData also is a non-profit cooperative that aims to enable secure and transparent data distribution in the Food & Agri sector. They provide a data platform where the agricultural entrepreneur decides who to share data with, they give an overview of the data flows from all data sources and offer a data platform which is accessible to all suppliers (www.join-data.nl).

[10] https://ec.europa.eu/food/safety/general_food_law_en

Internet of Things

The Internet of Things refers to the interconnection via the internet of physical devices and everyday objects enabling them to identify themselves to other devices and hence exchange data. The Internet of Things is playing an increased role, in part because it can reduce administrative burdens and increase the options for performing measurements. The development of LoRa and similar networks is an important factor in accelerating the application of wireless sensor networks.

Blockchain

Blockchain is a public, digital ledger that can record all the transactions that are performed over a peer-to-peer network[11](P2P). This may be public, although most operational applications are in non-public blockchains. Blockchain technology creates an historical overview in which transactions can be reliably and transparently saved, transmitted and chronologically retrieved. It gives parties insight into (transaction) data, product specifications and goods flows. Blockchain can give supply chain partners and consumers, among others, clarity regarding the precise origin of raw materials and the plants where the products are made. This reduces the risks for all the parties and can improve the relationship between producer and customer.

The transparency embedded in blockchain technology potentially gives consumers greater insight into where a product comes from. While a blockchain is transparent regarding transactions, that does not mean that the content of those transactions is also transparent. Complete origin identification of an animal from birth to slaughter and processing, up to the meat product in the shop, does not necessarily tell us anything about the animal's living conditions, prior history, health and medication usage. Despite this, blockchain does empower consumers only to buy food products whose origin they considerable acceptable.

2.3 Digital applications in the various sectors

The developments vary from one sector to the next. The dairy farming sector can highlight many developments in relation to individual sensors (fitted on, to or in animals), while developments in the pig farming and poultry sectors are focused at group level and barn level for the time being.

One topic that has recently attracted considerable attention is measurement of the interior climate. Sensors can give livestock farmers more precise information about the climate in the animal enclosures. This can be achieved by installing climate sensors that measure temperature, CO2, NH3, particulates, relative humidity and air movements in real time and then display the results online on a smartphone and tablet for interpretation by the user. Increased measurement parameters, and linking the measured values, calls for precise indication of deviating values compared to what is

[11] is a logical network of computers that are equivalent in this network and can provide services to one another. This type of network has no fixed workstations and servers, as in the client-server model, but rather several equivalent connections that function as server and workstation for the other connections in the network.

'normal'. It also calls for understanding of the potential relationship between these deviations and animal health, animal welfare and production metrics, and what measures can or need to be taken for improvement.

Dairy cattle

In the dairy farming sector the predominant practice is individual measurement. With animals spending multiple years at the farm, it makes sense to collect information at the level of the individual animal.

Several of the main digital techniques that are currently applied or are at an advanced stage of testing include: milking robots, health parameters (ear temperature), pedometers, (oestrus), rumination activity, calving sensors and rumen bolus for measuring temperature and activity.

So, a dairy farmer receives plenty of information at the level of the individual animal. While many systems currently only pass on the data to the dairy farmer for him/her to draw his/her own conclusions, there are also systems in use that provide automated advice on what to do based on the data. More and more systems do not pass raw measured data to the user, but rather process the data using algorithms (that may not always be public) to produce derived information or targeted advice. An example is the early detection of less healthy animals with the advice to keep an extra eye on them and, if necessary, to administer earlier treatment. Or a dairy farmer is sent a notification to check on an animal that is calving and that may be in difficulties.

Pigs

In the pig farming sector, digitisation has so far focused in particular on conducting measurements at group level. These are used to gather data on climate and feed and water usage of animals in indoor pens, for instance.

Climate data are related to the exterior climate so as to provide insight into the extent to which the entrepreneur allows the interior climate to be influenced by the weather outside the barn. Data on daily water usage of a group of piglets, for example, are compared with data from the previous rounds. A noticeable variation is a relatively good indicator for the likelihood of emerging health problems. Sound measurements are used to determine whether animals cough to such a degree (cough frequency) that health problems may exist.

To date, very few individual measurements were performed on fattening pigs, if any. But I&R now enables us to identify where an animal was kept. This is turn enables us to establish links. Data on the location of animals on the farm and the climate at that location and the slaughter findings can be compared and interrelated. This possibility increases the application range of electronic identification. By fitting individual fattening pigs with electronic identifiers, it is possible to establish a link between the slaughter findings (e.g. pleuritis, pulmonary diseases) and the climate in the pen or area where the animal was kept. Individual animal identification can also be used by the individual feeding stations for sows that are currently also on the market, for instance. There, the sow is individually recognised and fed, and may also be weighed to ensure an optimum

diet can be created for her. The first pig farmers have already begun to fit piglets with ear tags and fattening pigs with RFID chips. The products from these animals can be traced up to the moment the carcass is cut up. Data on care can be traced to individual animals provided the information is recorded via the RFID. RFID technology also offers possibilities for optimising the feed of individual animals. If the birth weight as well as the breeding value of the parents is known for fattening pigs, it is possible to feed the animals according to their individual growth potential (and that is made easier by digitisation/automation). In addition, RFID can be used to record whether or not antibiotics were used, so that this information is available, if required, to the feed supplier, veterinarian and others who have access to the data through the livestock farmer.

Poultry

The developments in digitisation in the poultry farming sector are focused in particular on feeding and water systems, climate systems, reducing particulate emissions, among other things, and administrative systems. There are also robots for loosening litter, collecting eggs and for activating chickens (to prevent them laying floor eggs and for keeping broilers active. Systems are also being developed that will be mounted just above the chickens and that can measure different variables, such as temperature, activity and closeness (if the animals are close together it may be too cold, and if they are far apart it may be too warm).

A recently developed monitoring system provides poultry farmers with ongoing information on the size and development of a poultry mite (Dermanyssus gallinae) population in a barn, enabling them to determine when best to treat the infestation. The system consists of a plastic perch containing advanced electronics, linked to a data management system.

Ownership

Digitisation has stirred the debate on the ownership of data. The systems on the livestock farms gather large quantities of data. But who do all these data belong to, who can use them and who can extract value from them?

Many commercially available measurement systems, in particular in the dairy farming sector, do not provide raw data of the measured variables (or of the variables that are claimed to be measured), but instead give a composite variable that is calculated on the basis of an algorithm of the manufacturer, who may opt in a number of cases to shield the algorithm. It additionally raises the question whether these data may be combined with those from other sensors and products and, if so, who is allowed to do this and how should it be done? There is often a lack of transparency regarding the degree to which the reliability of the measurement and the algorithmic processing has been scientifically demonstrated for the statements that are made on the basis of them.

Technology providers improve their product with the data made available by the livestock farmer. Livestock farmers are, in principle, the owners of the data they generate on their farm. However, the data, which are generally unprocessed, only have value for the farm

on which they were collected, by monitoring the farm's operating processes, for instance. The added value of these data is only created by integrating different data sources, aggregating data, sharing data for the purpose of reducing administrative processing tasks (duplication) and for benchmarking purposes, and by translating them to more widely applicable advice and recommendations. These actions are currently largely carried out by the providers of digital products, who therefore claim the value created by these actions for themselves. The added value of this for the livestock farmer is that, thanks to the fact the data are made available, the digital products improve all the time, and with them the advice and recommendations based on them.

Cross-fertilisation with other sectors

Digital technology applied in other sectors can also be of significance for livestock farming. Successful cross-fertilisation relies on links being established between the world of agri-food and that of technology.

Contact between entrepreneurs from different sectors is no guarantee of successful development, due to differences in culture and working method, for example. The likelihood of successful links is greater, however, in open innovation networks with easy mutual access for the partners. It is important that all the stakeholders in and around the livestock farm share the same commitment. The more consultants and veterinarians learn to utilise the possibilities of digitisation, the greater the added value of their contribution. The same applies to the education sector. Institutions should ensure they also focus on the various aspects of digitisation in their curriculum, such as metrology, data analysis and careful interpretation, ownership of data.

3. From the animal's perspective

This section looks at the threats and opportunities presented by digitisation in the livestock farming sector from the animal's perspective. It covers the effects on animal health and welfare, but also addresses the autonomy of animals. The latter refers to the ability of an animal to exhibit species-specific behaviour and its capacity to make its own choices, given that the animal is a kept animal. Finally, we also address the intrinsic value of animals, i.e. the inherent value of an animal separate from human interests. For instance, attaching sensors, which can be painful, must be weighed against the envisaged interest. Below we list the opportunities and threats for the state of health of the animal, the extent to which it is able to make decisions itself, and the state of animal welfare.

Almost 4 million bovine animals, 12 million pigs and more than 100 million chickens, as well as goats, sheep and horses, are kept on livestock farms in the Netherlands.[12] The farms have grown in size in recent decades, with a single farm often employing several workers. The degree and manner of digitisation varies from one animal group to the next. Where the focus in dairy farming is largely on measurements performed on and with the individual animal, in the case of pigs and poultry the focus is more on measurement at group and barn level. These differences in focus also have an impact on the opportunities and threats of digitisation for animals. RFID and sensor technology can offer greater opportunities for individual attention and care for animals in sectors where matters are currently largely regulated at herd level.

The three distinct themes (health, freedom of behaviour and animal welfare) are shown in Figure 1, together with the opportunities and threats. This is an abbreviated version of the framework included in Annex 1. An important starting point in this regard is that there is a 'minimum' applicable in the Dutch livestock farming sector for all three themes.

3.1 Good physical health

Thanks to digitisation we know more and more about factors that are directly or indirectly related to animal health. We can now access information on which animal received what medication when, for example; whether they are growing well and how much they move and rest; how much and often they feed and drink; and what the contents of health indicators in milk are. This produces more up-to-date and better knowledge about the health and proper care of the animals. Combining these measurement data with available data from existing management systems yields in-depth knowledge and insight. Feed can be optimised by matching it with real-time data on the animal's growth and the interior climate in the barn. It is now possible to tailor feed to individual animals' nutrition needs, even in a group.

[12] opendata.cbs.nl, consulted on 02 January 2019

Figure 1: Opportunities and threats of digitization in the livestock farming sector form the perspective of the animal.

The collected data are used for drawing attention to possible deviations (e.g. diseases or abnormal behaviour) in a timely manner, facilitating faster interventions and allowing problems to be avoided. Sudden unusual water intake, for example, is an indication of emerging disease issues. The ability to detect diseases at an early stage and provide animals with targeted treatment before a disease takes hold also contributes to low medication usage. As a further example, early alerts that an animal is starting to bite or peck other animals can allow examination of the possible underlying causes sooner so that they can be addressed, by boosting enrichment components in feed, for instance, or by eliminating other stress factors. If necessary, technology can enable problems that occur anyway to be resolved more quickly, for instance by removing a biter or pecker from the group.

On the other hand, digitisation can have the negative effect of reducing contact between animal and livestock farmer, because of the farmer's (over)reliance on digital data for running his/her agricultural business.

The risk of this is that animals are increasingly viewed as objects that can be controlled entirely digitally. Whereas a good human-animal relation is positive for animal and human alike.

A lot is known about observing animal welfare and health in individual animals. As part of the EU Welfare Quality[13] project, protocols have been developed for bovine animals, pigs and poultry to measure welfare indicators on the animal as far as possible. Implementing these protocols can be time-consuming and costly, however. If digital measurements are used in such a way that correct application of these protocols becomes feasible in practice, that has positive effects on the animal. On the other hand, incorrect use or misinterpretation of data poses a threat to sound animal health. Where a limited number of variables, representing a small part of the system, are frequently measured, there is a danger of reaching an erroneous conclusion with a high degree of precision. In addition, there is a possibility that variables that are directly related to what you want to know or measure cannot be measured frequently, clearly or accurately. Measurement of stress, for instance. At the same time, not using digitisation can result in the real cause of welfare and health problems being missed. You don't see it until you can actually see it. If young cattle in the barn is troubled by coughing, real-time measurement of ammonia concentrations can indicate immediately whether or not ventilation vents need to be opened. You will not know this unless you measure the concentration of ammonia. Big Data is not just about complicated models, but can be extremely helpful simply by virtue of its ability to make data visible.

3.2 Animal welfare

Sound animal welfare is dependent on animals' ability to adjust to their surroundings and changes in those surroundings and the existence of physical integrity, good accommodation, nutrition and health[14]. This can be translated to criteria such as the presence of lying comfort, thermal comfort, freedom of movement, absence of injury, disease and pain, normal social and other behaviour (ease of establishment of hierarchies) and a good human-animal relationship, free of anxiety.[15]

Digitisation's ability to ensure fewer actions need to be conducted on animals (e.g. weighing using camera images versus weighing on scales) can result in lower stress levels. Apps could enable livestock farmers to share photos with the veterinarian, for instance, allowing faster correct diagnosis of a (potential) problem.[16] Real-time sensors that send alerts when a particular measured value is reached (e.g. heat or cold, or concentration of carbon dioxide or ammonia) enable faster interventions in case of unusual or deviating climate conditions. Sensors help livestock farmers to monitor the functioning of climate control systems and make adjustments where necessary. Integration of digitisation provides opportunities for improved animal welfare. Faster alerts and diagnoses, better insight and resulting recommendations and advice can lead to a better living environment for the animals.

[13] http://www.welfarequality.net/en-us/home/
[14] RDA Conceptual Model, 2018
[15] Based on principles and criteria from the Welfare Quality welfare protocols.
[16] Livestock farmers are reluctant to use this. There is a fear such photos will be misused.

The living environment could also be improved by using digitisation for the purpose of environmental enrichment[17] or to provide activities for animals, with computer games designed especially for animals, for instance, or VR goggles, etc.

Digitisation can also pose a threat to animal welfare. Firstly because sensors fitted in or on the animal are an interference in the animal's physical integrity (pain, discomfort, possibility of inflammation). Digitisation can also lead to reduced contact between animals and humans, giving rise to increased stress and anxiety among the animals when there is contact (e.g. during medical treatment, physical interventions, transportation and in the abattoir). Digitisation can result in people viewing animals more as a means of production and less as beings with feelings ('objectification'), with less care for the well-being of the animal as such, other than in terms of its economic value (see also Bos et al., 2018).

The step from Big Data to the right information cannot be taken for granted, and the possible consequences for animal welfare of decisions based on a correct or incorrect interpretation are significant. Improper use can mislead and suggest connections that do not exist. Variables that can be measured easily, cheaply and frequently are usually indirectly related to what one wants to know, however. While algorithms that convert data from sensors into information on animal behaviour should be scientifically validated, that validation is often not carried out even today. On the other hand, improper use can result in actions that actually improve animal welfare.

Digitisation that is one-sidedly focused on boosting animal performance (faster growth, higher production, more offspring) can wipe out the previously achieved benefits of digitisation for animal welfare and health, and exceed the natural capacities of animals.

At the same time, digitisation can also lead to marketing organisations and society in general demanding greater transparency. The knowledge that others are looking over your shoulder reduces the likelihood of careless practices and may have a positive effect for animals. This transparency can also help to create a clearer picture for society about how animals are treated in the livestock farming sector.

3.3 Freedom of behaviour

Digitisation offers animals the chance to indicate more clearly what they do and do not want, since it can give individual animals greater freedom of behaviour. Most animal species in livestock farming are social animals by nature that live in groups. Digitisation can increase the possibilities for them to express this social behaviour. It also presents increased and more affordable opportunities to ensure animals that are lower in the social hierarchy have access to feed and drinking water as well as shelter.

The fact remains, however, that it is humans that eventually decide what choices a livestock farming animal can and may make, and that an animal will be fitted with a particular sensor. An animal does not make this choice itself, and cannot alleviate or dispel any discomfort that may be caused by a sensor. Where an animal does make this choice itself, if that is at all possible, the animal is usually seen as awkward or difficult,

[17] Enrichment should preferably be deformable, degradable, edible and rootable.

and is generally sent for slaughter. This is the solution for resolving the problem of unwanted choices by animals.

In addition, operational control based on digitisation can also turn into too much control resulting in animals losing freedom. Finally, if digitisation leads to greater 'social distance' between humans and animals, there is a risk that animals will be seen as things and respect for the physical integrity of animals can decrease.

In its report titled 'Grip op ingrepen' (Getting a Grip on Intervention) (2013), the RDA published an assessment tool in the form of a step-by-step plan comprising four steps:

1. Will the action permanently affect the welfare and/or integrity of the animal?
2. Is the intervention necessary in the light of animal-oriented objectives?
3. Is the intervention necessary in the light of human-oriented objectives?
4. Where impairment of an animal's welfare and/or integrity is considered necessary from the livestock farmer's perspective, this should be followed by ethical assessment of whether the intervention and resulting impairment of welfare and/or integrity is socially acceptable.

This step-by-step plan can be used as a guide for assessing, where necessary, whether an intervention should or should not be carried out.

4. From the livestock farmer's perspective

The livestock farmer is responsible for taking care of the animal. The impact of digitisation on animals and their care is determined in part by how digitisation impacts on the people caring for the animals/livestock farmers. They are obliged to take good care of their animals. However, the fulfilment of this responsibility by the livestock farmers is a result of the interplay between their standards and values, working conditions and income. The ultimate impact of digitisation on animal well-being depends not just on technological developments as such, but also on the standards and values in society, applicable legal frameworks and the economics of the food chain. This section examines the opportunities and threats posed by digitisation for livestock farmers. Autonomy refers to the fact that people can take decisions independently. It also covers the fact that people can have their own possessions. This freedom may sometimes be restricted by a government decision. In the case of a contagious animal disease to which mandatory control measures apply, for instance, restrictions may be placed on the transport of animals, and the government may even order the destruction of healthy animals on a farm. The livestock farmer must ensure good working conditions so that he/she can provide the animals with optimum care. In order to define the livestock farmer's perspective, we distinguish between the factors income, management freedom and working conditions.

According to the May Tally produced by Statistics Netherlands (CBS-Meitelling) there were 25,400 cattle farms, 4,160 farms with pigs and 1,650 poultry farms in the Netherlands in 2018. Dairy farms collect data on the production and fertility of individual animals. Pig farms collect data on groups of piglets, sows and fattening pigs as well as individual sows. Poultry farms only collect data on groups of animals.

The three distinct themes (income, management freedom and working conditions) are shown in Figure 2, together with the opportunities and threats. This is an abbreviated version of the framework included in Annex 1. An important starting point in this regard is that there is a 'minimum' applicable in the Dutch livestock farming sector for all three themes.

4.1 Income

Digitisation provides opportunities for a better income, due to the faster availability of improved data. Operations can be optimised and adjustments made more quickly. The availability of more data and the combining of those data facilitate more efficient production. Sharing the data across the links in the supply chain, with the animal feed manufacturer, the abattoir and the dairy industry, for instance, makes it possible to improve coordination and alignment within the supply chain. The processing industry benefits from increased scope for differentiating products. However, far-reaching changes need to be implemented throughout the supply chain if the improved data on how animals are kept on the farm is actually to be translated to a better, or at least stable, income for the livestock farmer.

Transparency can ensure closer ties between farmers and consumers, which can lead to greater understanding among consumers. There are consumers who are willing to pay

more for increased animal welfare, provided that it is guaranteed. Digitisation provides opportunities for achieving this.

The threats posed by digitisation for the income of livestock farmers should be sought in particular in the incorrect use and interpretation of data, resulting in wrong decisions being made. In addition, greater insight by other parties, e.g. retail, can also lead to a stronger negotiating position on that side, with a corresponding potential for lower output prices.

Using sensor data to regulate process equipment in the interest of a good living environment for the animals requires all the relevant factors to be incorporated in the algorithm. There is a possibility that insufficient knowledge is available on which factors are and which are not relevant in this regard. There may also be partly conflicting interests between the various links in the supply chain. This can provide an inducement intentionally to selectively share or not share certain data and thereby deliberately manipulate the information level of others. This can result in a negative impact on the income of the livestock holder, and occasionally also on the income of other supply chain partners. Furthermore, digitisation that has a one-sided focus on cost price reduction will push down consumer prices, possibly resulting in reduced possibilities for the livestock farmer to address animal welfare.

Figure 2: Opportunities and threats of digitization in the livestock farming sector from the perspective of the livestock farmer.

4.2 Management freedom

Digitisation offers a significant opportunity for management freedom since increased available data produce greater insight into available alternatives for improving the farm's operations and real-time measurements enhance the possibilities for making timely adjustments.

A drawback of digitisation for management freedom can be the feeling it can induce in the livestock farmer of being hemmed in. His/her way of working is controlled by system alerts and algorithms which he/she neither controls nor understands. The sense that 'big brother is watching you' can also be felt as an invasion of privacy. Mounting cameras so as to be able to closely monitor animals, for instance, can produce situations where every action and movement of the livestock farmer also can be continuously monitored.

Third parties often lack the context and knowledge to properly assess the choice of actions taken, which may encourage them to draw incorrect or too strong conclusions. Furthermore, there is always the risk of power outages and of digital devices being hacked.

Digitisation and the information it produces can also be used by suppliers and customers to demand data and check out the operations on the livestock farm. While it is true that the livestock farmer needs to take greater account of other (supply chain) partners, it also offers the possibility of providing additional guarantees to monitoring and certification bodies.

4.3 Working conditions

The potential benefits of digitisation with regard to working conditions are in the easing and reduction of the burden of physical work in particular. Animals no longer need to be lifted/pushed onto weighing scales, for instance, but can be 'weighed' by algorithms using a camera. Integrating all the systems reduces the need for duplicate records and gives the livestock farmer a better and faster overview.

However, livestock farmers can also experience stress from using new digital technologies and have the feeling they are dealing more with data than with animals and therefore have less opportunity to practice their profession. Once systems are connected to a network there is a risk they can be hacked. People with malicious intent can interfere in the systems, thereby directly influencing the livestock farmer's working conditions.

Freedom of choice

You are a dairy farmer and have a milking robot and feed concentrate feeder areas from the same manufacturer. The data that are collected by both systems are displayed in a clearly designed dashboard that gives off alerts if an animal is not getting sufficient nutrition, milk production drops, and you can make adjustments by dispensing feed concentrate, etc. But the feeder areas need replacing and another make appears to be a better fit for your operating needs. But will you switch to another make? Do you have the option as a livestock farmer to choose yourself who to work with, or are you stuck with your current supplier? The so-called 'vendor lock-in' is if anything an even bigger challenge in the agricultural sector than in other sectors since software is often linked to technical systems and installations. Freedom of choice means being able to migrate/transfer data to new software. Not only that current data can be imported, but also that historical data can be migrated, preferably with alerts.

The new way of working – a day in the life of a dairy farmer in 2025

06:30 The alarm goes. You get up and check your dashboard over breakfast. Did anything happen during the night that needs attending to? Did any cows calve in the night? You open the screen displaying animals requiring special attention and walk over to the barn.

07:00 You walk over to the cow that the alert list tells you calved during the night. As expected and indicated on the dashboard, everything looks fine. You check mother and calf and take the calf to the Igloo where it is automatically weighed, registered at the calf rail and quickly gets the first colostrum. The remainder of the day the colostrum is automatically dispensed by the calf rail based on the programmed colostrum protocol, which has been agreed with the veterinarian. The amount of antibodies in the colostrum is determined and recorded each time it is dispensed.

7:30 You inspect the young animals. One calf appears less fit and has also drunk less at the calf rail. You bring in the rail again and help the animal to drink. You also give the calf some additional minerals. Via RFID this is immediately recorded in your management system and is also seen by the veterinarian.

8:00 You check the milking robot list. First you take a look at the animals that have not been at the robot for a long time (too long). You move two animals toward the robot and they are then milked.

08:30 Ping: a message from the vet: 'John, cow 5217, appears to have mastitis, based on her data: check it out and start with Mastitis Treatment Plan, if necessary.' By chance, this is the third animal you planned to check on. She is mentioned on the alert list because the milking robot had noticed a significant change in the milk composition and at the same time the activity meter had detected reduced activity and increased body temperature. You check her udder, which feels warm; test milking shows up lumps in the milk. So you treat her for mastitis. The veterinarian sees this immediately via the RFID and the data you enter about the treatment.

09:00 The feed cart that received an alert yesterday that the silo was almost empty comes to replenish it.

10:30 Skype consultation with feed consultant. Based on the data, he has several suggestions for adjustments that you then immediately enter in the system together. The outside temperature is set to rise within the space of a week. To prevent heat stress among the cattle, the amount of feed is adjusted slightly and a switch is made to smaller amounts per

11:30 You receive an alert on your smartphone that two cows have been placed aside in the separation area. A scan of the hoof soles carried out in the milking robot detected that the hooves need to be trimmed, and the activity meter detected an abnormal walking pattern for these animals. The sole scan displayed on your smartphone enables you to determine immediately the most appropriate treatment.

NH3 concentrations are measured in real time throughout the day and the results are used to determine the frequency of dung scraping to ensure lower emissions and drier floors.

Throughout the day the animals can decide themselves whether to go outside or remain in the barn. The space each animal is given for grazing is automatically determined by means of virtual fencing. In this way young animals and animals in early lactation have earlier access to new pieces of grazing land.

In the afternoon the land needs to be worked on. Temperature sensors in the grassland indicate that the soil temperature is high enough for spreading fertiliser. A job card is automatically created using data from soil scans and harvest yields from previous grass cuts and preceding years. The software fitted in the tractor helps you to determine the correct quantities.

Whilst working on the land you receive an alert: there is a problem with one of the animals calving. You need to take a look. You can see from the live camera images on your smartphone that the cow is having difficulty. Via the App you indicate that a veterinarian is needed, and he/she is automatically phoned. When you arrive at the barn you try to help the cow as best you can. Once the vet arrives, you work together and a healthy calf is born. The cow is given a drip and the calf is attended to and moved to the Iglo. Everything is recorded in the software.

17.00 You have to take a cow to the robot and check out two cows that have not been very active during the day. You then walk through the stable to inspect everything, and in particular the young animals.

18:00 Via the App the veterinarian asks how the cow and calf are doing, and you discuss another animal requiring special attention.

19:00 The inseminator arrives with the right sperm (via stieradvies (bull advice) programme) and inseminates the animals that have been automatically placed apart. These animals have been separated from the others based on pedometer and hormone measurements.

5. From the perspective of the market and society

This section looks at the threats and opportunities presented by digitisation in the livestock farming sector from the perspective of the market and society. We begin by outlining the key driving forces in the market. We then list the threats and opportunities of digitisation in the livestock farming sector for the health and safety or our food, the degree to which values are present in our food and for the range of options available to consumers.

Marketing organisations such as supermarkets compete for market share, mainly on the basis of price. The basic marketing consideration is and remains that a product with decent turnover and margin is always stocked. Although 'animal-friendliness' is considered important by many consumers, it is not an integral part of the purchasing behaviour of most consumers. Buying food is a matter of habit. Most people buy what is on special offer, for example, or what they have bought for years. With generally little to no idea about how what they buy is produced. Changes in the social (standards, identification) and the physical (range) consumer environment do influence purchasing behaviour, however (Backus et al., 2011). The recently increased share of products with an environmental and animal-friendly sustainability label, for instance, is due in no small measure to the limitation of the range on sale to products certified in this manner as well as the trust consumers place in these certifications.

The three distinct themes (healthy and safe food, having a range of options and food of value) are shown in Figure 3, together with the opportunities and threats. This is an abbreviated version of the framework in Annex 1. An important starting point in this regard is that there is a 'minimum' applicable in the Dutch livestock farming sector for all three themes.

5.1 Healthy and safe food

Digitisation presents opportunities for reinforcing the focus on quality, for safeguarding quality and for providing transparency. If the origin of products is known, the parties marketing food to us feel a greater degree of obligation, thereby helping to increase the focus on quality. Real-time sensor data that are available online and the use of RFID technology can improve the effectiveness of quality assurance systems and increase transparency.

Less certain at the moment is what opportunities blockchain offers for quality assurance. The promise of blockchain is that certification can be managed throughout the entire process from production to supermarket shelf with the aid of blockchain technology. Further upscaling will make clear to what extent this provides opportunities for quality assurance.

Data manipulation poses a threat to the health and safety of our food. There are many ways in which data can be intentionally transmitted or made available so as to give an incorrect impression of the production conditions and/or the product quality and composition. For instance, by emphasizing good aspects of welfare while omitting to mention any negative aspects for the environment. Where precisely in the barn are the

sensors that measure the interior climate installed, what happens to an RFID tag if it is lost by an animal, etc.?

The availability of more data about the composition of food leads to an increased risk of misinterpretation by consumers. Digitisation that focuses more on consumer food choice behaviour itself probably has a more positive impact than extending labelling guidelines. More and more apps with this focus are also becoming available.

Figure 3: Opportunities and threats of digitization in the livestock farming sector from the perspective of the market and society.

5.2 Range of options

Information and communication technology improve the ability to provide information on how a product is made, alongside the product itself. This is valuable to consumers who want to base their choice also on the production conditions at the farm. Additional information also results in more features that consumers can use to compare products.

This will probably lead to greater product differentiation, since consumers can base their choice on more product and process features. This also increases the possibilities for quality assurance.

A threat to consumer choice is posed by the automated personalising of product offers, based on information on the consumer's purchasing behaviour. The consumer is placed in a bubble of their own making and experiences limitations on searching for information about other products on the market. All this while the relationship between attitude, intention and actual food choice behaviour has yet to be definitively established. A positive attitude toward products that bear an animal-friendly sustainability label says nothing about the intention to buy those products, let alone about actual purchasing behaviour. There is a significant likelihood that personalised product offers based on purchasing behaviour represent only a small part of what consumers consider important.

5.3 Food of value

A wide range of values plays a role, consciously or unconsciously, in consumers' choice of food products. Many consumers prefer food labelled pure and honest, natural, slow food, artisanal, etc. This can refer to product origin (regional or local farm products, made on farms near you), the product conditions (the traditional family-run farm, greater attention for animal welfare), or the manner in which (traditional) products are made.

Digitisation presents new opportunities for sharing information with consumers on the origin and manufacture of food products and on the production conditions on the farm. It also becomes easier to put a name and face on the farmer and/or the animal where the product comes from. Consumers are more likely to place trust in a person than in an anonymous certificate. Digitisation therefore makes it possible to strengthen relational trust in the food system. But it can also have benefits for quality labels themselves, since the possibilities for sharing information on the production conditions on the farm are increasing with the emergence of wireless sensor networks that make data available online in real time.

Digitisation also brings threats, however. In addition to enabling data measurement and sharing, it also makes it possible to use data for the purpose of controlling or managing. Food providers communicate with consumers via traditional media (newspapers, radio and TV) and by smartphone and tablet, based on data and algorithms. The corresponding guideline is largely derived from targets based on turnover and margin and generally includes no guidelines that focus on what is right or good for the consumer (and the animal, and the livestock farmer). These guidelines determine whether digitisation will produce opportunities or threats.

Digitisation can heighten the process of reduced interpersonal contacts and can additionally lead to further specialisation within production and distribution chains. This can result in interpersonal contacts being replaced with anonymous customer-supplier relationships. The decreasing possibilities for consumers to identify with food products can hence pose a threat to the continued existence of values embedded in food. It is incidentally debatable what impact this will have, since the livestock farmers from whom much food on the market originates can only be traced after a thorough search using track-and-trace, following a food scare, for instance. Even the labels and product number on packaged cheese do not refer to the cheesemaker, but to the packager.

6. Reflection and recommendations

Digitisation is set to become commonplace on livestock farms within 5 to 10 years, and with it the related consequences for animals. It brings opportunities as well as threats, including for human-animal relationships. Opportunities arise from the faster availability of more data throughout the entire livestock production chain and from combining different types of data to yield new information and new insights. Livestock farmers will have greater opportunities to ensure the animals' living environment matches their needs, with positive implications for health and animal welfare. Replacing physical actions conducted on animals will improve working conditions and potentially reduce stress for the animals. The uneven distribution of data between parties in the supply chain (supplier, livestock farmer, processor, marketing organisation, consumer) can be addressed and increased transparency will boost confidence in the sector and present consumers with a greater range of options for buying animal-friendly products.

Digitisation also brings threats. The steps leading from big data to reliable and relevant information and then to well-informed correct decisions are complex and not automatic. Caution and restraint should be exercised for the time being, particularly as regards the automatic control and adjustment of process equipment based on sensor data. In addition, among other things the autonomy of animals and livestock farmers may diminish and consumers may experience fewer possibilities for identifying with social-cultural values implied in the food.

The significance of digitisation for animals ultimately depends on how it is used. If timely alerts ensure that a diseased animal or an animal suffering from reduced welfare is spotted sooner, or disease and welfare problems are even prevented, then it will be positive. If, however, it leads to reduced human attention for animals in livestock farming, then it may potentially be negative (van Erp – van der Kooij, 2016). Protocols and algorithms are often better able to assess the best method of treatment than experienced veterinarians (Greenhalgh, 2002). But there is insufficient guarantee that human focus and attention can be fully and adequately replaced with variables that are measured digitally. The interaction of direct human attention and the additional information provided by digital data has the potential to be a positive development.

FOR ANIMAL	FOR LIVESTOCK FARMER	FOR MARKET AND SOCIETY
Health	Income	Healthy and safe food
Freedom of behaviour	Management freedom	Range of options (consumer choice)
Animal welfare	Working conditions	Food of value

Table 2. Relevant aspects that are important for animals, livestock farmers and consumers and for which digitisation can mean opportunities and/or threats.

The following section examines in more detail various aspects that can affect these opportunities and threats. These include the consequences of digitisation for business forms in the livestock farming sector, consequences of digitisation and precision agriculture for the view of animals, physical integrity of animals, other standards for keeping animals, licences and quality marks, data ownership and information sharing, data quality and resulting conclusions, and the impact on our living environment.

Consequences of digitisation for farm types in the livestock farming sector

Once the production processes in the livestock farming sector are more manageable, it becomes more likely that the farmer will opt to enlarge his/her farm structure. (Allen and Lueck, 2003). In this sense, digitisation can lead to increased scale in the livestock farming sector. On the other hand, the incentive to expand the scale of operations can decrease since digitisation can result in more differentiated chains where a higher price for distinctive quality and experience reduce the economic need to expand. There are also other factors that can prevent this expansion, such as environmental space, measures to maintain biodiversity, etc.

Leaving aside the question of whether scale expansion leads to improvements or deteriorations in animal welfare, a larger size increases the risks if a contagious animal disease to which mandatory control measures apply breaks out. And any management error will affect more animals in a larger farm. It is also more likely that there will be less frequent contact between animal and livestock farmer on larger farms with more automation. On the other hand, there will be more known about animals' living conditions and there will be less need to move and transport animals on large farms. It is therefore only natural to focus more attention on the factors that influence animal welfare than on the appearance of the livestock farm itself.

Consequences of digitisation and precision agriculture on the view of animals

A key question is whether digitisation leads to the objectification of animals and hence to a different attitude toward and care for animals. It is also important to consider to what extent livestock farmers' care for their animals has changed and to what extent the views on care for animals in our society has changed. Whatever the case, digitisation is

potentially a tremendous supplement to the possibilities available to livestock farmers for caring for their animals. However, whether this actually happens depends also on the attitude of livestock farming with respect to animal care and on the livestock farmer's position in the food chain (Bos et al., 2018). If accompanied by a one-sided focus on cost reduction in the food chain, digitisation is more likely to represent a threat than an opportunity. This focus is a consequence of the actions taken by all the parties concerned, including consumers.

Physical integrity of animals

Digitisation increases the possibilities for attaching sensors to animals, whether externally or internally. With the animal having no choice on this physical intervention, the government has therefore introduced rules for this procedure. According to the Animal Disease Specialists Decree (*Besluit Diergeneeskundigen*), an animal may undergo no more than two physical interventions for the purpose of identification. Digitisation, however, also has the potential of reducing identification procedures to a single animal intervention, with the RFID chip incorporating other sensors in addition to providing unique identification of the individual animal.

This single intervention remains necessary in connection with the essential ability to trace of animals in case of an outbreak of a contagious animal disease to which mandatory control measures apply or for which an exemption is requested for trade purposes. The law needs to be clarified and/or extended since the current or future sensors are not primarily designed for the purpose of identifying an animal. The current wording of the law allows other measurement instruments to be attached to the animal, or inserted into it, which the legislator could not foresee at the time of drafting.

In terms of the animal's interests, the following parameters should be considered to ensure digital techniques are correctly applied:

- Whether this (also) results in improvement of animal welfare, or in any event not to any deterioration; Whether it helps to improve animal welfare monitoring in the case of the individual animal;
- Whether it does not lead to additional physical interventions on the animal;
- Where digitisation becomes automation and the system takes over decision-making, regular human checks and evaluations of the results need to be built in, including the possibility of making adjustments where necessary;
- Where its sole purpose is to increase production, and its effect is to exceed the animal's natural capacities, permanently change animals, or cause more welfare and health problems and/or increased mortality, digitisation should be rejected.

The assessment framework formulated by RDA can be used for this purpose (RDA, 2017).

Other standards for keeping animals

Digitisation will see the introduction of new standards for a different way of keeping animals. As our monitoring ability is increased and accelerated, we will find it necessary to place other requirements on keeping animals. This will also change the role of the adviser, with it becoming more focused on supporting the livestock farmer in translating big data to relevant information and then determining the right course of action.

As regards the effects of digitisation in the livestock farming sector, it is quite possible that something may be missed that ends up having unintended and potentially adverse consequences. It is important to be constantly aware of 'new risks', developments that cannot be foreseen at this moment. While digitisation enables us to measure and know more, will livestock farmers necessarily look after their animals better as a result? Subjecting animals to automated decision-making requires alertness, since animals are unable to indicate their discontent or disagreement. To ensure the possibilities of digitisation serve the interests of animals they need to have greater scope for making choices as regards their behaviour.

Licensing and quality marks

Many certification and licensing systems in the livestock farming sector are to a large extent based on design criteria such as space per animal, climate and feed. Not infrequently they fail to correctly reflect the situation regarding the quality of the process at any given moment.

First and foremost, welfare criteria in relation to the animal should be measured that demonstrably reveal information on behaviour, health and physiology, for instance. At present this is only done on a very limited scale, since it is often difficult and time-consuming. The emergence of sensor and camera technology can potentially enable animals' actual behaviour, welfare and health as well as the quality of their living environment to be measured far more efficiently and effectively 24/7. But this is only possible if we succeed in measuring suitable variables and developing algorithms that have a demonstrable relationship with what we seek to quantify. This also raises the prospect of new perspectives, for public authorities and market parties (quality labelling, licensing) as well as farming entrepreneurs keen to ensure their animals are well cared for and to deliver a good product. It presents public authorities and market parties with an opportunity to improve the efficiency and effectiveness of existing policy and related assurances and to design better variants, with livestock farmers being paid (or punished) based on discernible results in relation to animal welfare, animal health and the environment (such as the aforementioned Agriplace).

Real-time measurements on animal health and behaviour and animal care (climate, provision of feed and water, distraction for play and natural behaviour) also make it possible to switch (partly) from prescriptive regulations to goal-oriented regulations in the context of licensing, supervision and enforcement. The livestock farmer provides transparency and measurements conducted on the animal give the enforcement or certification authority insight into the actual situation. Real-time measurement increases livestock farmers' scope for action since it empowers them to choose which means and resources to use, so long as the goal is achieved. Monitoring is carried out on actual measured values. These measurements also raise the potential for objectifying, and

hence to building trust. In this way, licensing, monitoring and enforcement also contribute to making livestock farming more sustainable by introducing a change in focus, from prescriptive regulations to goal-oriented regulations.

Data ownership and information sharing

Increasing evidence that sharing information results in lower failure costs and boosts mutual trust will lead to information sharing becoming more commonly a part of economic transactions, in part due to economic market incentives. The code of conduct based on a checklist drawn up by the European farmers' organisation COPA COGECA in collaboration with major suppliers is a good step toward creating an infrastructure for data sharing[18]. The US Farm Bureau Federation also has launched a similar initiative and defined a set of Core Principles for The Privacy and Security Principles for Farm Data[19]. This can also provide a role for chain and sectoral organisations for supporting livestock farmers and their suppliers and customers in formulating a sound legal framework. This is of particular importance in relation to privacy and data ownership, for instance. It should be noted that parties maintaining a shared standard often benefit in terms of network effects: the more parties using the standard, the less attractive it is for others to use something else[20].

The government plays an important role in this regard in maintaining open networks and encouraging innovations. It is also important that high-tech start-ups and the livestock farming sector should have easy access to one another.

Some needs of society are so imperative that data sharing is subject to regulatory measures. Timely detection and control is important in the case of contagious animal diseases to which mandatory control measures apply. Consequently, there is a requirement to report cases to the national contact point. Other statutory obligations cover action that must be taken, in relation to early warning programmes for avian influenza and classical swine fever, for instance.

Data quality and resulting conclusions

It is essential to consider the quality of data obtained via new technologies, particularly where the data are used for policy-making and also when they have been collected for purposes other than those for which they are used. If digital technologies enable full coverage, for instance, this may reduce the importance of traditional questions relating to sampling and statistical quality, while questions on the quality of data collection and processing and representativeness become more important.

Frequently, the algorithms and methods of analysis with which patterns and links are identified in large complex datasets and which form the basis for advice and recommendations are 'black boxes'. This lack of insight into how advice and recommendations are arrived at and whether the links and patterns that are established

[18] https://copa-cogeca.eu/img/user/files/EU%20CODE/EU_Code_2018_web_version.pdf
[19] https://www.agdatatransparent.com/principles/
[20] Shapiro and Varian: The art of standard wars, in: California Management Review vol. 41 no.2, winter 1999.

are robust and are backed up by underlying causal principles is a risk when making 'blind' use of the advice or recommendation.

It is promised that ultimately the combined sensor data and algorithms will prove to be better at providing information on health and welfare, making them good for the animals. But this situation is still some way off. An important task is to consider how the system and the animals can be protected from errors in the intervening period.

The rapid emergence of sensor technology and its potential usefulness for the livestock farming sector mean that multiple technology providers are thrusting themselves into the limelight. This technology has yet to take full shape, however, and providers additionally often have limited knowledge of the requirements that the varying composition of barn air places on the sensors, for instance. It is therefore advisable that basic requirements be defined for this technology in the livestock farming sector. Especially where the measurement data will be used by private organisations (quality labels) and public organisations (licences).

Impact on our living environment

Digitisation also yields increasing amounts of data on the impact of livestock farming on the environment. More and better insight into water and air quality is becoming possible. More and more livestock farmers and citizens are incentivised to measure concentrations of particulate matter themselves. Livestock farmers want to know whether they are performing to standard, and whether there is more they can possibly do. Ordinary citizens want to know what their health risks are. Real-time measurement of air quality can make an important contribution to the dialogue between livestock farmer and neighbouring residents.

There is a significant danger of misinterpretation, however. Many sensors currently available on the market are not accurate, and measured values begin to deviate after a short while. Local authorities can play an important role by taking control of these regional processes and facilitating the establishment of good measurement networks.

Recommendations

Digitisation has an impact on practices at the farms, and hence directly or indirectly effects on animals. As digitisation is set to become commonplace on livestock farms within 5 to 10 years, it is important that the recommendations be acted on soon.

Digitisation presents opportunities as well as threats for animals in livestock farming, livestock farmers and consumers alike. By focusing our efforts in this regard, we will strengthen the opportunities while ensuring the threats are limited. In this light, the Council on Animal Affairs therefore advises that:

1. systems be based increasingly and more inherently on target requirements, where;

    a) supplementary to the steps taken by the Government to base environmental regulations on real-time data, the same should also be done in respect of

welfare. This also allows the opportunity to make the welfare indicators developed under the EU Welfare Quality programme more suitable for use by livestock farmers.

b) public authorities increasingly base their licensing systems on real-time measurements on the quality of the human and animal living environment in and around the animal barn rather than on the barn configuration.

c) monitoring bodies place greater emphasis on these new target requirements as soon as they become available, on the understanding that the measurement results can also be related to the actions of the livestock farmer.

d) public authorities and market parties jointly create a quality mark for reliable digital information, including a voluntary code of conduct, with a corresponding code commission, enabling objections and appeals to be filed against misleading digital information.

2. parties working on data sharing do so in such a way that administrative tasks on the farm are reduced, thereby cutting the amount of duplicate paperwork livestock farmers and animal carers have to complete, enabling them to spend more time looking after their animals.

3. the government assume responsibility for maintaining open data networks by establishing appropriate frameworks and setting up a contact point for reporting unavailable networks.

4. the government and market parties encourage open innovations, guaranteeing easy mutual access for high tech and the livestock farming sector. This can be achieved, for instance, by encouraging meetings where information can be shared openly. These meetings must be clearly announced and easy to find, including for businesses, institutions or persons who currently do not (yet) work in the livestock farming sector.

5. digitisation be integrated in research and education, so that livestock farmers and consultants gain more skills in correctly interpreting information and can learn to act accordingly. As a result, the information is used more for the benefit of the animals, and fewer or no adverse effects occur. This means that research universities and universities of applied sciences need to incorporate digitisation in their curriculum.

6. technology providers for the livestock farming sector should provide insight at the request of monitoring authorities into the validation and robustness of the algorithms that have been developed and are used.

7. the debate on digitisation of the livestock farming sector not be conducted separately from the debate on policy measures in other fields, such as the debate on the new guidelines for data ownership, data sharing between banks or the right to number portability, as well as circular agriculture, for example. This helps to limit the risks of unforeseen, adverse side effects.

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www.join-data.nl
www.agriplace.com

Annexes

Annex 1: Digitisation of livestock farming sector: overview of threats and opportunities

OPPORTUNITIES AND THREATS		ANIMAL		
		Animal health	Freedom of behaviour	Animal welfare
Collecting data in animals	*Opportunity*	Alerts - cross checks - improved genetics- improved nutritional care	Increased freedom for individual animal	Improved care - decreased use of drugs - alerts (fire alarm)
	Threat	Misinterpretation of data	Animal cannot choose sensor. Animal viewed as an object	Intervention in physical integrity
Collecting data on animals	*Opportunity*	improved and timely observations - cross checks - improved genetics- improved nutritional care		Weighing scale replaced by camera - helping animals lower in social hierarchy
	Threat	less human-animal interaction	Animal cannot choose sensor. Animal viewed as an object	Too many sensors linked to the animal
Collecting data on herds	*Opportunity*	Cross checks	Enable social behaviour	Improved living environment
	Threat	loss of data on individuals - improper use of data	Directing of herd without considering individuals - Animal cannot choose sensor. - Animal viewed as an object	unsufficient attention for individuals
Collecting data on the animals' environment	*Opportunity*	Improved interior climate / cross checks		Improved interior climate
	Threat	Improper use of data - misinterpretation of data		Iimproper use of data
Directing of external behaviour of animals	*Opportunity*	Facilitates timely intervention	More freedom on individual level	Improved care
	Threat	Misinterpretation of data	operational control resulting in animals losing freedom	Misinterpretation of data
Directing of external behaviour of animals	*Opportunity*	Timely intervention	More freedom on individual level	Improved care
	Threat	Misinterpretation of data	operational control resulting in animals losing freedom	Misinterpretation of data
Directing of behaviour animal caretaker	*Opportunity*	Exclude human errors		Improved care
	Threat	Misinterpretation of data		Misinterpretation of data
Data sharing within company	*Opportunity*	Improved control of operational system		Enables interventions on environmental conditions
	Threat	Faulty control of operational system		Reduced human-animal interaction
Data sharing between companies	*Opportunity*	Insight into opportunities for improvement		preventative veterinary care
	Threat			
Data sharing within operating sector	*Opportunity*	Insight into quality of product		animal welfare quality marks
	Threat			
Data sharing beyond sector	*Opportunity*			animal welfare quality marks
	Threat			

OPPORTUNITIES AND THREATS		LIVESTOCK FARMER		
		Income	Management freedom	Working conditions
Collecting data in animals	*Opportunity*	Improved return by improved animal health	More responsibility	Less uncertainty
	Threat	Uncertain lifespan sensor	Misinterpretation of data	Frustration with new technology - less human-animal interaction
Collecting data on animals	*Opportunity*	Improved return	More responsibility	Minder onduidelijkheid - camera vervangt weger
	Threat	uncertain lifespan sensor	Misinterpretation of data	Frustration with new technology - less human-animal interaction
Collecting data on herds	*Opportunity*	Improved return	More responsibility	Less uncertainty
	Threat	uncertain lifespan sensor	Misinterpretation of data - More time spent on data than animals	Frustration with new technology - less human-animal interaction
Collecting data on the animals' environment	*Opportunity*	Improved return	More responsibility	Less uncertainty
	Threat	uncertain lifespan sensors - Misinterpretation of data		Frustration with new technology
Directing of external behaviour of animals	*Opportunity*	Improved control data		Easier to adjust settings process equipment
	Threat	Misinterpretation and over-interpretation	Autimation makes farmer feel hemmed in	
Directing of external behaviour of animals	*Opportunity*	Improved control data		Easier to adjust settings process equipment - Lower physical demand
	Threat	Misinterpretation and over-interpretation	Autimation makes farmer feel hemmed in	
Directing of behaviour animal caretaker	*Opportunity*	Exclude human errors		Ease of burden on animal carer
	Threat	Misinterpretation and over-interpretation	Autimation makes farmer feel hemmed in	Stress
Data sharing within company	*Opportunity*	Improved efficiency due to comprehensive data analysis	Easier to adjust settings process equipment	Faster and improved overview
	Threat	Misinterpretation - Risk of hacking	More time spent on data than animals - pressure by external parties	More time spent on data than animals
Data sharing between companies	*Opportunity*	Benchmarking - Improved animal disease control	Awareness on alternatives	Less duplicate paperwork
	Threat	Manipulation of data - Misinterpretation	Violation of privacy	Risk of hacking - unconnected systems - more time spent on data than animals
Data sharing within operating sector	*Opportunity*	Chain optimisation	More opportunities for communicating with supply chain partners	Less duplicate paperwork
	Threat	Manipulation of data	More control by supply chain partners - Violation of privacy - Lock in	Risk of hacking - unconnected systems - more time spent on data than animals
Data sharing beyond sector	*Opportunity*	Improved value of products by sharing of information on the product - Market concepts	More opportunities for communicating with consumers and society.	Less duplicate paperwork
	Threat	Manipulation of data	Violation of privacy - More time spent on data than animals - lock in - pressure by external parties	Risk of hacking - unconnected systems

OPPORTUNITIES AND THREATS		MARKET AND SOCIETY		
		Healthy and safe food	Range of options	Food of value
Collecting data in animals	*Opportunity*	Transparency - higher quality standards	Product differentiation - more information on product conditions	Personalised nutrition - Quality control
	Threat	Misinterpretation of data		Lack of identification with traditional values
Collecting data on animals	*Opportunity*	Transparency - higher quality standards	Product diferentiation - transparency	Personalised nutrition - Quality control
	Threat	Manipulation of data - Misinterpretation		Lack of identification with traditional values
Collecting data on herds	*Opportunity*	Higher quality standards	Product diferentiation - transparency	Quality control - Build trust
	Threat	Manipulation of data - Misinterpretation		Lack of identification with traditional values
Collecting data on the animals' environment	*Opportunity*		Product diferentiation - transparency	Quality control - Build trust - better conditons for the animal
	Threat	Manipulation of data - Misinterpretation		Lack of identification with traditional values
Directing of external behaviour of animals	*Opportunity*			
	Threat			Too much 'robotisation'
Directing of external behaviour of animals	*Opportunity*			
	Threat			Too much 'robotisation'
Directing of behaviour animal caretaker	*Opportunity*			
	Threat			
Data sharing within company	*Opportunity*	Better quality of food products	Quality assurance - more attention for proper care	
	Threat			
Data sharing between companies	*Opportunity*		Ability to compare	
	Threat			
Data sharing within operating sector	*Opportunity*	Transparency - Quality assurance	Quality pay-off	Quality pay-off - Quality assurance - Origin known
	Threat	Manipulation of data	Misinterpretation of data	
Data sharing beyond sector	*Opportunity*	Transparency - Quality assurance - Greater attention to quality		Personalization - Quality assurance - Origin known
	Threat	Adverse cosumer response - Manipulation of data	Misinterpretation of data	

Annex 2: List of persons interviewed

Brainstorm Digitisation, 12 February 2018 at the Reehorst, Ede

Jan Staman (chairman RDA)
Ad Kemps (RDA)
Bas Haring (RDA)
Hans Heesterbeek (RDA)
Ge Backus (RDA)
Franck L.B. Meijboom (RDA)
Bas Kemp (RDA)
Marc Schakenraad (first secretary RDA)
C. Graumans
Dr. Jan Willem Kruize (scientific Researcher information Management, Agri Food)
Richard ten Kate (Farmresult)
Jeroen van Mechelen (LedgerLeopard BV)
Henri Holster (Wageningen Livestock Research)
Bennie van der Fels (Wageningen Livestock Research)
Arjan Dijkstra (RVO)
Merijn Jansen (senior strategist GD Animal Health Service)
Wim Thus (LTO-Nederland)
Cato Bechtold (Innovation officer Ministry of Economic Affairs and Climate Policy)
Frank Pisters (VAA)

Meeting: 'Impact of digitisation af animals on human and society'
3 July 2018 at Kasteel Groeneveld, Baarn

Jan Staman (chairman RDA)
Marc Schakenraad (first secretary RDA)
Ad Kemps (Forum participant RDA)
Gé Backus (Forum chairman RDA)
Kirsten van Hees (deputy secretary RDA)
Erik de Bakker
Ronald Leenes
Wim Dubbink
Bas Haring

Interviews

Anne Bruinsma – Co-Founder FarmHack.nl

Claudia Kamphuis –Wageningen University & Research, Researcher on Animal Breeding and Genomics

Frido Hamoen – CRV, managing director business unit Data

Han Smits – CEVA SANTE ANIMALE, Global Technical Swine Expert

Henk van Kuyk –De Heus Mengvoeders

Lenny van Erp – HAS University of Applied Sciences, Lector Precision Livestock Farming

Pieter Rambags – Nippur, Managing Director

Wim Thus – LTO-Nederland

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This advisory report is therefore a product of the Council as a whole. The Council on Animal Affairs consisted of the following members on 1 January 2019:

Prof. Dr. J.J.M. van Alphen
Dr. Ir. G.B.C. Backus
G.P. van den Berg
W.T.A.A.G.M. van den Bergh
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