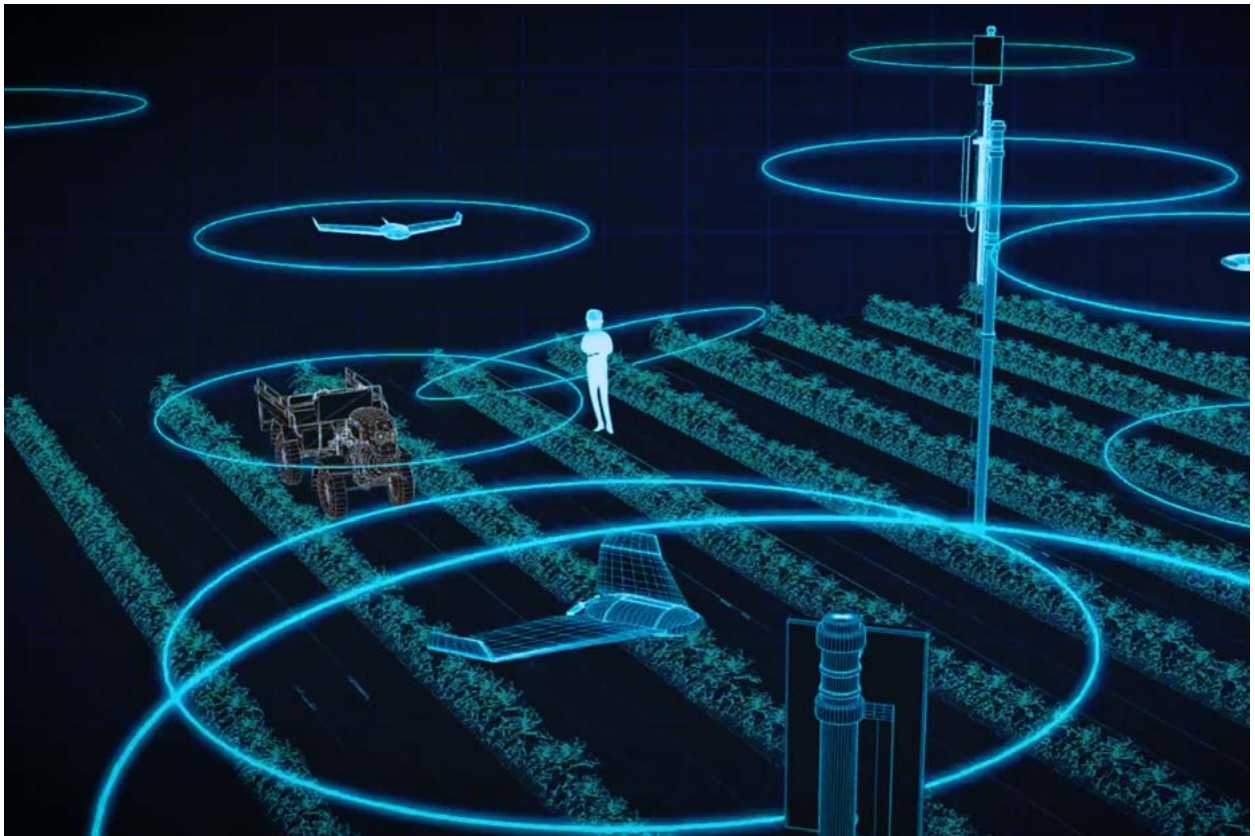


# AVOIDING A 5G IMPLEMENTATION DEADLOCK IN THE AGRICULTURE SECTOR



**TNO** innovation  
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# 1 ABSTRACT

To meet the increasing demand for food as the world's population continues to grow, farmers will have to use the latest technology, not only to produce more with less labour but also to ensure sustainability. The next advancement in wireless telecommunication is fifth-generation (5G) technology, which offers faster speeds and response times than its predecessors and enables new options for farmers, such as precision agriculture.

The Netherlands has very high 4G coverage and is expected to have the same level of 5G coverage. The country can therefore be seen as fertile ground for 5G innovation and application for the agriculture sector. In the rest of the world, and even in the EU, the situation is very different: in most other countries there is little or no 4G coverage on farms, let alone in the fields. There is no business case or incentive for telecom operators to invest in rural areas and there are few, if any, regulatory requirements. The small proportion of rural areas that will eventually have 5G coverage is not a large enough potential market for multinational agricultural manufacturers to invest in costly 5G development. There is therefore no prospect of 5G-based products and services developed by global agricultural manufacturers being available (in the Netherlands or anywhere else in the world) in the near future.

This paper identifies 5G innovation opportunities for the agriculture sector and suggests directions for possible solutions to avoid or resolve a 5G implementation deadlock. This will require collaboration between stakeholders. Hence, this paper has been written for agricultural manufacturers, (EU) telecom companies, private network providers, farmer collectives, national governments and the EU.



## 2 INTRODUCTION

The UN Food and Agriculture Organization claims<sup>1</sup> that, to meet the needs of a growing global population, in the next 30 years farmers will have to produce 70% more food. To meet this demand, farmers will have to employ the latest technology to produce higher yields and better quality with less labour.

The Netherlands is one of the world's leading agricultural producers and the second largest exporter of agricultural food products.<sup>2</sup> The country is also a forerunner in using the latest agricultural technologies. Precision agriculture is becoming increasingly popular and the technology being developed to increase farm productivity also supports more environmentally friendly and circular agriculture.

The next advancement in wireless telecommunication is 5G technology, which offers faster speeds and response times than its predecessors. It also enables new possibilities for precision agriculture and increases ease of use by having a single communication technology for indoor and outdoor applications. Low-maintenance devices, such as soil monitoring sensors that operate for years, are now a reality, as are complex AI machine vision systems that rely on direct input of massive amounts of data and the processing of video streams to distinguish weeds from crops, thereby enabling mechanical weed removal, or more targeted pesticide application instead of full-field spraying.

As part of its investigation of 5G innovation opportunities for the Dutch agriculture sector, TNO interviewed farmers, farm advisors and (Netherlands-based) farm equipment manufacturers with a global market. The fourteen people interviewed were asked what they thought of current trends, including the role of digitalization and the potential of 5G in agriculture. The position outlined in this paper is based on these interviews and our expert opinion.

## 3 CONNECTIVITY IN THE NETHERLANDS AND BEYOND

Given the Netherlands' leading position in agricultural and related technologies worldwide, it is unsurprising that many agricultural innovations originate in the Netherlands. Precision agriculture is a hot topic and exploration of the potential of 5G for the agriculture sector is well underway.

In terms of telecom infrastructure, the Netherlands is one of the most connected countries. There is very high average bandwidth availability in homes. The density of the population makes a strong business case for telecom operators to deploy (4G and 5G) wireless connectivity. And for the few areas that are not as economically attractive for mobile operators, the Dutch government issues incentives and regulations so operators provide almost complete (98%) coverage nationwide.<sup>3</sup> Hence the rollout of 5G coverage in rural and agricultural areas in the Netherlands is expected to be relatively straightforward. The country can therefore be seen as fertile ground for 5G experimentation.

Elsewhere in the world, the situation is very different. In most countries the business case for telecom operators is less attractive. Coverage is confined to more populated areas such as cities and along highways. In rural and agricultural areas there is very little if any 3G coverage, let alone 4G or 5G. In most countries it does not make economic sense for the government to force operators to provide total coverage. Governments have to strike a balance between license obligations (coverage requirements) and the expected return (the value of the license).

1 <https://www.agritechtomorrow.com/article/2020/07/5g-is-coming-to-agriculture/12275>

2 <https://www.wur.nl/en/newsarticle/Dutch-export-of-agricultural-products-exceeds-90-billion-in-2018.htm>

3 <https://www.rijksoverheid.nl/actueel/nieuws/2018/07/03/voor-alle-nederlanders-in-2023-vast-snel-internet>

## 4 THE DEADLOCK BETWEEN THE TELECOM AND AGRICULTURE SECTORS

The lack of connectivity in agricultural areas in most countries is a disincentive for global agricultural manufacturers to invest heavily in the development of products and services that require and depend on connectivity. These large(er) manufacturers operate internationally and want to provide global solutions. The small proportion of rural areas with (5G) coverage is not a large enough potential market to justify costly development.

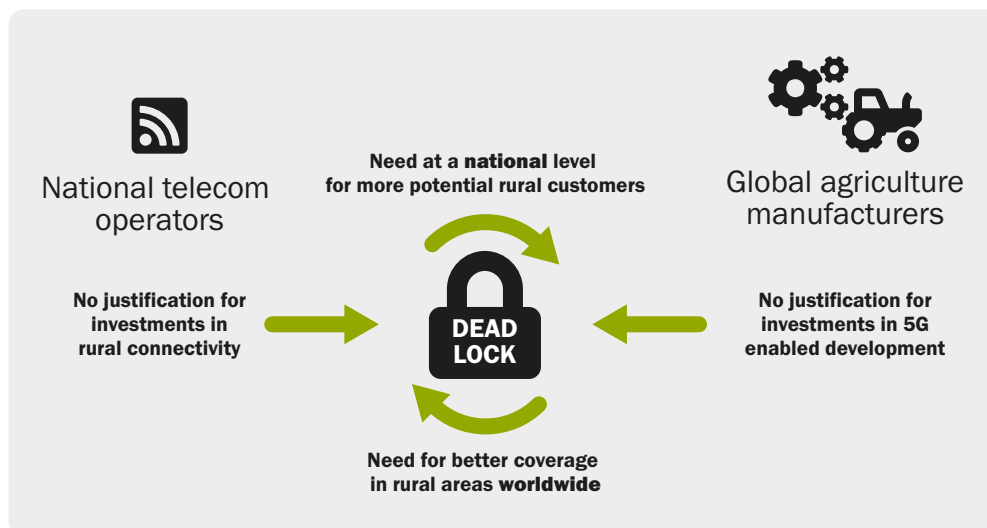
Even if manufacturers were to have produced these products, the farmers would still not have purchased them due to the lack of connectivity on their farm or in their fields. A few manufacturers have the knowledge to provide connectivity other than 5G on customer farms, but this is not common.

Therefore, there is currently little prospect of 5G-based products being developed by global agricultural manufacturers. This does not apply to (Dutch) SMEs: they can focus on the Netherlands as their main market and supply the few farmers in other countries that do have connectivity on their farms. These SMEs will provide effective (niche) solutions but will be unable to exploit the full innovation potential of 5G for most agricultural equipment such as tractors and machinery.

As a result of the factors outlined above, there is a brake on innovation in 5G-enabled precision agriculture not only in the Netherlands, the leading country in this field, but also worldwide. If nothing changes, only a small number of connected precision agriculture solutions will be available in the near future.

The telecom and agriculture sectors both face a potential deadlock that is hampering innovation. Unfortunately, there is no simple solution:

- Manufacturers require connectivity in rural areas to make massive rollout of 5G-enabled precision agriculture commercially viable (to justify investment in (development of) 5G-enabled services).
- Telecom providers do not have enough customers in (most) rural areas to justify investment in 5G coverage in these areas. The 'guaranteed' demand in rural areas is insufficient to justify the major investments involved.



*Potential deadlock between the telecom and agriculture sectors*

In the interest of resolving this prospective deadlock, in the next two sections we take a closer look at the potential of 5G in the (Dutch) agriculture sector and discuss possible ways of breaking the deadlock.

## 5 OPPORTUNITIES FOR 5G IN THE (DUTCH) AGRICULTURE SECTOR

The agriculture sector is grappling with a number of challenges: the working population is aging, labour is becoming scarce, costs are increasing and pesticide use must be reduced (some pesticides will be banned). The need to address environmental issues led to the development of circular agriculture. Technology that enables precision agriculture is an effective data-driven approach to solving environmental challenges. Precision agriculture uses data-gathering technologies to (automatically) monitor and control farm processes. The insights and recommendations provided by these systems help farmers improve plant and animal health and enhance soil, air and water quality, thereby ensuring sustainable production.

### 5G TECHNOLOGY IN BRIEF

5G, which stands for fifth-generation wireless technology, is the successor to 4G: the current standard for wireless mobile communication. 5G brings a number of innovations to the mobile network:

- Narrow Band IoT (NB-IoT): a low-bandwidth protocol with a radio range of up to 10 km above ground and around 40 cm underground and in water<sup>4</sup> enables extensive use of IoT sensors in the open field, as well as indoor applications. It is highly energy efficient and can support battery life of up to 5 years.
- Enhanced Mobile Broadband (EMBB): up to 10 times more bandwidth than 4G enables real-time UHD video streaming for drones and virtual and augmented reality applications.
- Ultra-low latency communication (URLLC): 3 times lower latency than 4G enables very short response times for autonomous systems, such as self-driving vehicles, real-time remote machine operation (including drones) and technologies such as virtual and augmented reality applications.
- Mobile Edge Computing (MEC): enables data and video stream processing capabilities very close to the user (at the edge of the mobile network), resulting in low and almost deterministic latency.

The new capabilities offered by 5G (see the information box) can play an important role in helping farmers meet the challenges they face. A shortlist of 5G-enabled agricultural technologies would include:

### REMOTE SUPPORT TOOL FOR FARM ADVISORS AND SUPPLIERS

The high bandwidth (EMBB) and low latency of the 5G network supports high-quality video connections that provide much better experience than is possible with today's video conferencing, including augmented and virtual reality. High-quality video streams with no glitches or delays enable partners such as farm advisors, suppliers and veterinarians to provide remote support. This allows them to assist with all kinds of problems: diagnosing minor faults in tractors and machinery, identifying unrecognised plant disease, offering feeding advice, etc.

### SMART FENCING

Smart fencing is an integrated solution for pasture and cow management. Cows wear permanent GPS collars with NB-IoT tracking. The pasture is divided into virtual sections. Cows are allowed to spend a certain amount of time grazing in each section. This gives the grass time to recover and ensures that the cows are fed high-quality grass. The collar detects the edge of the virtual section and issues a small vibration or audio signal to nudge the cow in the right direction. The sections are changed gradually and automatically. The farmer no longer has to move fences by hand, saving considerable time and effort.

<sup>4</sup> <https://www.twtg.io/insights/whitepapers/twtg-proved-that-nb-iot-and-lora-wan-can-connect-up-to-40cm-underground/>

### COW MONITORING

GPS collars with NB-IoT tracking enable long-life monitoring of cows in the field and in the barn. Sick cows that do not approach the robotic milker are quickly identified by their absence. The sensors in the collar continuously monitor indicators such as activity, rumination and temperature and provide warnings much sooner. GPS tracking enables the farmer to quickly locate a sick cow in the fields.

### CROP INSPECTION DRONES

The high bandwidth (EMBB), low latency and mobile edge computing capability of the 5G network can enhance the precision of drones used for crop inspection. Instead of manually downloading the data from an SD card or USB device after the flight, HD video can be livestreamed from the drone to the edge. The raw video is automatically converted into a detailed map of crop types, plant health, weed growth and other factors, so the farmer can immediately see the condition of the fields and crops.

The map can be used to instruct the (autonomous) tractor to perform the required tasks, such as spreading manure where it is needed to feed underperforming plants and spraying precise amounts of pesticide on individual weeds.

### WEEDING ROBOTS

The high bandwidth (EMBB), low latency and mobile edge computing capability of the 5G network can support real-time operation of autonomous robots, such as weeding robots. The HD cameras on the robot send a live video stream to the edge, using massive computing power to convert the images into instructions for the local spot sprayer and robotic arms that remove weeds while leaving crops intact.

### UNDERGROUND SOIL MONITORING

NB-IoT's ability to support long battery life combined with its extensive above-ground and limited underground radio range extends coverage to remote areas. This enables in-situ soil monitoring. Sensors monitor environmental conditions in the field throughout the life cycle of the crop and transmit data to the farmer's management system a couple of times a day. The farmer can then issue specific work instructions. The sensors are collected during the normal harvesting process and can also monitor the effects of harvesting on the crop.



## 6 POTENTIAL WAYS OF AVOIDING A DEADLOCK IN RURAL AREAS WORLDWIDE

In this paper we have indicated the huge potential of 5G applications in the agriculture sector and the Netherlands' suitability as a leading living lab for the development of these applications. We also explained that investments in 5G-based agricultural applications may be hard to justify if there is little prospect of 5G availability -and therefore no market- in other countries. What can be done to improve the situation? How can we incentivise the development of connectivity-based solutions that can potentially be rolled out internationally? Below we suggest ways of organising supply and demand that may help prevent or resolve the deadlock. We believe these are avenues worth exploring in collaborative approaches. There is unfortunately no simple solution for this situation.

### COMBINATION OF MULTIPLE TECHNICAL SOLUTIONS BASED ON 5G

In addition to a public 5G network operated by major telecom operators, it is possible to set up private 5G networks with private network licensing (the 3.5 GHz band in the Netherlands). This solution can be used for farms that cannot access the public network, with the necessary 5G equipment being installed on the farm. Deployment, operation and maintenance can be arranged as an additional service provided by a new or existing telecom operator (through the manufacturer), or as a new service offered by the agricultural manufacturer (or a delegate). Where a combination of public and private network connectivity does not provide sufficient coverage, (in the future) one could use 5G over satellite or HAPS (High Altitude Platform Stations). The fact that 5G is the only communication technology involved reduces development and hardware costs. Obviously, the cost of public, private and/or satellite network coverage would need to be offset by added value created by the manufacturers and the farmers.

### COOPERATIVES AND AS-A-SERVICE BUSINESS MODELS

In the last decade we have seen a rise in citizen-led renewable energy and fibre optic cooperatives. In the Netherlands there is a long-standing tradition of agricultural cooperatives that share risks and revenues. Is it possible for the availability of 5G connectivity to be organised as an infrastructure owned or guaranteed by a cooperative of, say, on-farm equipment suppliers, such as those united in CEMA, the European Agricultural Machinery Association,<sup>5</sup> who would benefit from having a reliable communication infrastructure, or contractors who would benefit from data throughput in their business operations? Such a cooperative could generate the equity necessary for investments and/or arrange for a supplier to provide connectivity as a service.

In the construction sector companies agree Design, Build, Finance, Maintain and Operate contracts, in which they build an infrastructure and operate and maintain it in accordance with agreed conditions. These is an approach we can learn from. We are also seeing a rise in as-a-service business models in the energy sector. Energy service companies (ESCOs) provide an agreed level of energy (or in-home comfort) for a subscription or usage fee. In return, the company manages the equipment and guarantees energy savings. In other words, these companies manage a technological risk in exchange for a performance-based reward. Such models can be translated to connectivity-as-a-service, which could also include computing power and data storage.

<sup>5</sup> <https://www.cema-agri.org>

### LEARNING FROM AN INCLUSIVE PERSPECTIVE ON INNOVATION IN DEVELOPING REGIONS

In developing regions, 5G technology is an opportunity to simply bypass wired connectivity, as many developing countries have shown. There are also many examples of Base-of-the-Pyramid (BoP) or inclusive innovations, from which we can learn a great deal. These types of innovations are purposefully designed to be accessible to very large numbers of low-income citizens. M-Pesa, a money transfer service that uses mobile phone accounts rather than bank accounts, is a well-known example. Also in the field of impact investing and creating shared value there are excellent examples of how regional farming supported by technology and socially responsible global business can be used to build infrastructures, by, for example, also using communication infrastructure for remote schooling and agritourism. European Structural and Investment Funds, such as the European Regional Development Fund (ERDF), the European Agricultural Fund for Rural Development (EAFRD) and the Recovery and Resilience Facility (RRF), provide grants for this purpose. In other words, by adopting a more inclusive regional perspective and looking beyond food production efficiency, it may be possible to secure investments from other sources.

In summary, in seeking to create a European and global market for 5G innovations, with the Netherlands serving as a living lab for experimentation, it may be helpful to consider less conventional approaches.

## 7 CONCLUSIONS

Although somewhat counterintuitive, the lack of mobile (5G) coverage in rural areas in other countries has a major impact on innovations in the Dutch agriculture sector. There appears to be a (potential) deadlock that has nothing to do with 5G technology itself. But the lack of global coverage in the rural areas that are important for agriculture means that the larger agricultural manufacturers have little incentive to develop innovative 5G applications. They do not have a business case for a global solution. And the telecom operators do not have a business case to provide connectivity coverage in rural areas because it will hardly be used.

As a result, while a country such as the Netherlands has good 4G (and soon 5G) coverage in rural areas, the larger agricultural manufacturers will not be able to achieve the economies of scale required to develop 5G-enabled innovations for agriculture. There is therefore no prospect of 5G-based products and services developed by global agricultural manufacturers being available (in the Netherlands or anywhere else in the world) in the near future.

SMEs do have the potential to develop (and are already developing) innovations in 5G-based precision agriculture on a commercial basis together with farmers and researchers. However, they lack economies of scale and do not cover the entire range of agricultural machinery.

## 8 CALL TO ACTION

The deadlock cannot be resolved by a single party: cooperation is required. TNO is therefore hosting a roundtable discussion to address this potential deadlock (autumn 2021). Together we will identify and explore options (those described section 5 and others) with a view to promoting innovative 5G solutions for farmers in the Netherlands and worldwide.

### WILL YOU JOIN US?

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