Five Years of the **OnePlanet** Research Center

Gelderland Innovations with Global Impact

2019 - 2024

OnePlanet
Research Center

Contents

From left to right: Richard van Wezel, Thea van Kemenade, Chris Van Hoof, and Liesbeth Luijendijk

Foreword

“Groundbreaking innovations with societal impact.”

“A professional innovation center where around 100 experts work daily on technologies for a healthy and sustainable world. This is the OnePlanet Research Center as of 2024. Together with motivated colleagues, the four founding partners, the Province of Gelderland, companies and education, we have worked hard on this in recent years. We are incredibly proud of the result. We could only dream of these five years ago.

We are convinced that technology can contribute to solutions for various issues in health, agriculture, and the environment. By combining imec’s technological expertise with the domain knowledge of Radboud University, Radboudumc, and Wageningen University & Research, we can work together towards achieving breakthroughs. This collaboration is far from business as usual, but it creates the potential for groundbreaking innovations.

In the area of health, for example, we developed an ingestible sensor pill that can take measurements in the gastrointestinal tract. Initial studies on healthy volunteers have already taken place, thanks to the combined efforts of sensor and chip experts, health scientists, clinicians, and care providers. We’ve also explored solutions for the nitrogen crisis by developing scalable sensor technologies for monitoring nitrogen in outdoor air, as well as a data platform where this information can be shared securely and efficiently. Objective data measurements aid in finding effective nitrogen-reducing measures.

Societal impact is a recurring theme in all OnePlanet’s activities. We create value at various levels, from regional to global. Rooted in the soil of Gelderland, many innovations start here, from close collaboration with local companies, educational institutions, residents, and the province, which serves not only as a funder but also as a partner. Together, we build a strong region and ultimately bring these innovations to the world, addressing broader societal challenges.

In addition to reflecting on learning points and results, we also like to look ahead. Looking ahead, we see the growing availability of new technologies, such as photonic chip technology. We are exploring specifically how to use these technologies for a healthy and sustainable world. The possibilities are limitless, and we are in the middle of this playing field. Fortunately, we are joined by many young, international talents with societal ambitions, and together, we are strong enough to achieve these ambitions.”

The Management Team

Chris Van Hoof
General Manager, OnePlanet Research Center, imec
Liesbeth Luijendijk
Director AgriFood & Environment,
Wageningen University & Research
Thea van Kemenade
Director Health, Radboud Universiteit and Radboudumc
Richard van Wezel
Director Health, succeeding Thea van Kemenade
as of January 1, Radboud Universiteit and Radboudumc

About OnePlanet Research Center

OnePlanet envisions a society where everyone can live healthily and have access to sustainably produced food. OnePlanet is an innovation center for nano and digital technology in agriculture, food, health, and the environment. It is a collaboration between imec (a microchip research center), Wageningen University & Research (WUR), Radboud University (RU), and Radboudumc. These four founding partners bring together all the necessary expertise.

At the intersection of agriculture, food, health, environment, and high-tech, OnePlanet develops groundbreaking innovations that contribute to solving major societal challenges, such as the nitrogen crisis, climate change, and pressure on healthcare. OnePlanet combines domain expertise with the knowledge of sensors, sensor connectivity, data science, and artificial intelligence to create innovative applications.

From the development of innovations to their commercialization, OnePlanet works across the entire spectrum. In every phase of it, we closely collaborate with companies, from small- and medium-sized enterprises (SMEs) in Gelderland, to national and international industrial partners. Through its OpenEducation program, OnePlanet also makes its knowledge and technology accessible to students from vocational, applied higher, and university-level education.

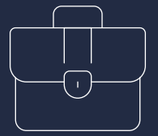
Facts and Figures
OnePlanet Research Center
Key Figures (as of 2024)

128
Full-Time Equivalents (FTEs)

170
Collaborations in research projects

78
Publications (**31** scientific and **47** in professional journals/media)

599
Students



29
Funded ongoing projects

35
PhD-students

21
Collaborations with SMEs
5 Companies outside Gelderland

46
Patent applications

Domains

01 | Health, nutrition & behavior

The pressure on healthcare is increasing due to aging populations and a growing number of people with chronic and lifestyle-related diseases. OnePlanet's "Health, nutrition & behavior" program aims to relieve this pressure through innovative (sensor) technologies that measure and monitor mental and metabolic health.

By measuring (at home) and collecting more data, you can identify health problems earlier and prevent worse. For example, OnePlanet's smart toilet can detect dehydration early, and the ingestible sensor pill can map digestive processes and potentially identify intestinal inflammation. OnePlanet also conducts research on eating behavior and mood. The ultimate goal is to link all the data together and better understand the relationship between the gut and the brain.

OnePlanet is also developing digital twin models, such as for the intestines. In the future, treatment and medication parameters can be tested in these virtual models first. The patient is not burdened, and healthcare professionals gain insight for (preventive) interventions. All this data can be securely analyzed and reused on the OpenPlanet data platform, ensuring privacy and security in line with the requirements for handling healthcare data.

"Our team has grown tremendously over the past five years and works with a focus on impact. Highlights so far include the approval of the ingestible sensor pill for human studies and its testing on the first group of healthy volunteers. We are now exploring how to bring the first innovations to market along with various industry partners."

Annelies Goris,
Program Manager Health, Nutrition & Behavior

Co-creation

In recent years, OnePlanet has carried out several European and nationally funded health projects, including the EFRO projects IntoEat and INGE3, in collaboration with various Gelderland-based companies. A third EFRO project, Stuff4Life, was recently launched. (EFRO translated to English stands for the European Regional Development Fund).

Inhabitants of the Province of Gelderland could participate in several studies, such as a citizen science study on technology and health, the testing of the smart toilet seat during the Nijmegen Four Day Marches, and a study on snacking behavior and mood. Together with the Dutch Digestive Disease Foundation (Maag, Lever Darm Stichting), OnePlanet is also conducting a study on the use of the smart toilet for patients with chronic bowel diseases.

Gut Health: Ingestible Sensor Pills

An ingestible sensor in the form of a pill is as innovative as it sounds. OnePlanet is currently testing the first generation (GEN1) in a clinical study. Once inside the body, the pill measures components such as acidity, temperature, antioxidant capacity, protein fermentation, and the transit time in the gastrointestinal tract. This provides, among other things, insight into the digestion process.

OnePlanet aims to learn more about digestion, gut health, and the influence of food and medicines on those topics. The first study focuses on understanding protein digestion. In addition, OnePlanet is working on next-generation sensor pills to detect inflammation early and determine if certain medications or therapies are effective, such as for bowel disease patients. Swallowing a pill is far less burdensome than an extensive gastrointestinal examination in a hospital, and it provides additional information. In the future, the pill could also be used for other diseases, such as Parkinson's disease, where gut problems are known to play a role in the disease process and treatment. Conducting these studies and combining the expertise of the four founding partners in OnePlanet is essential for developing new generations of sensor pills.

OnePlanet has worked extensively on the regulatory, safety, and ethical approval of the pill, allowing the first human study to start in 2023. The infrastructure for reading and transferring the pill's data to the cloud has also been developed.

Sample Collection Pill: Status of the Microbiome

In addition to the sensor pill, OnePlanet is working on a pill that can take samples from the gastrointestinal tract. This enables more detailed research into the abnormal composition of the various microorganisms in the gut (the microbiome), which can help in the early detection of problems, such as infections.

"Our microbiome and gut health are a 'black box'. We want to change that. Not to create the perfect human but to ensure that everyone is optimally informed about their own health."

Chris Van Hoof,
General Manager OnePlanet Research Center

Home Health Monitoring

OnePlanet is developing sensors for measurements in and around the toilet. These sensors are connected to a digital platform, allowing experts to interpret the data, detect trends, predict future health issues, and offer personalized advice.

For instance, with a smart toilet, it becomes easier to monitor physiological indicators such as blood pressure variation and heart rate variability over long periods, capturing individual changes. This can help detect conditions and worsening chronic diseases early. A prolonged high blood pressure can, for example, lead to further cardiovascular disease. Cloudy urine can be an early indication of disturbances like urinary tract infections.

In the project "Home Health Monitoring," OnePlanet is conducting further research using different types of sensors and techniques, such as electrochemistry and spectroscopy, to find measurable indicators for dehydration and potentially the early detection of other conditions.

Eating Behavior & Mood: Personalized Model

In the "Eating Behavior & Mood" project, OnePlanet investigates the relationship between mood and eating behavior, particularly snacking behavior in daily life, such as at work. This has been studied over the past years with the Smart Snackbox, which accurately measures when participants eat and drink between meals. Using wearable sensors and short questions on a phone, a link can be established between what people are doing at that moment. This provides new insights into the effects of eating behavior on stress, health, and alertness at work.

The first study showed that women tend to snack more under stress in daily life than men. This finding had already been established in lab studies, but it has now been confirmed in real-life settings.

Follow-up research focuses on methods for offering healthy choices when people crave a snack. OnePlanet is developing a model for eating behavior, which, combined with individual sensor data, provides researchers and health professionals with deeper insights into how eating behavior relates to mood. This information is useful for personalized health and dietary advice.

New Study

In combination with the data from the ingestible sensor pill, OnePlanet can study the relationship between behavior, the brain, and the gastrointestinal tract. A new study on this topic is being prepared. For example, to assess what exactly is the influence of stress on digestion? In this way, OnePlanet is working towards personalized health models. These models can be useful for the health, pharmaceutical, and food industries, as well as for individual consumers.

Domains

02 | Agriculture & Food

Food security is the focus of the “Agriculture & Food” program. By 2050, we will need to feed around ten billion people worldwide, while we are already approaching the limits of the planet. How can we produce enough healthy food in a sustainable and affordable way? OnePlanet contributes by developing technologies that address food production concerns under the motto: more output with less input, including energy, resources, water, and skilled labor.

This program emphasizes the development of autonomous cultivation systems for greenhouse and fruit cultivation. Globally, the number of growers is decreasing, along with the number of people knowledgeable in cultivation. Autonomous systems can supplement this role and eventually even “take over.” They independently determine the status of crops and trees and the timing and execution of necessary interventions, such as pruning or harvesting.

OnePlanet is developing a wide range of technologies needed for more autonomous cultivation systems. From sensor systems that can directly measure the status of a tree or plant, to data platforms where data can be stored and analyzed, and even digital twins. For example, a digital copy of an orchard that can predict which actions (such as pruning) are needed.

“Agro-robotics is advancing rapidly. New sensors, robust sensor combinations, smart camera systems, algorithms, and artificial intelligence models are increasingly able to handle complexity and unpredictability. This paves the way for innovative applications of intelligent robotics in horticulture and fruit cultivation.”

Renske Landeweert,
Program Manager Agriculture & Food

Autonomous Greenhouse

Typically, a grower enters the greenhouse in the morning to check on the plants. Should a window be opened? Do the plants need water? Together with the climate computer, crop observations determine what is needed for the day. In the “Autonomous Greenhouse” project, OnePlanet seeks to capture the grower’s climate knowledge in a digital control system.

The ultimate goal is for the plants themselves to control the climate system in the greenhouse. With existing and new sensor technologies, OnePlanet can measure all sorts of parameters in and around the plant: from leaf temperature, humidity, light levels, to the amount of water. This data is supplemented with other data and analyzed using artificial intelligence. From this, decisions can be made about climate adjustments and growth conditions, optimizing yield, quality, and harvest timing of crops sustainably.

A greenhouse with autonomous climate control could be set up worldwide in places where food production was previously impossible due to a lack of local cultivation knowledge. This is particularly relevant for densely populated cities.

Such a greenhouse could also be linked to a store where the cultivated vegetables and herbs are sold directly. OnePlanet is developing such a socially beneficial application of an autonomous greenhouse with SME partner LocalDutch. In such an autonomous greenhouse, algorithms for autonomous climate control can be practically tested, validated, and improved. Innovative plant sensors can gradually be added to the control system to further improve autonomous climate control in greenhouses.

LiDAR

LiDAR technology is also known from self-driving cars. LiDAR uses laser light to measure the distance to an object and create a 3D image through scans. OnePlanet uses this technology to map tree structures. This enables a pruning robot in fruit cultivation to position itself well and handle pruning shears precisely.

Digital Orchard

OnePlanet is also working on the development of image and recognition technology for comparable autonomous cultivation systems in outdoor environments, such as an orchard. This is complex, as cameras, scanners, sensors, and future robots need to be robust enough to handle varying outdoor conditions, such as weather and lighting.

Within the “Digital Orchard” research program, OnePlanet is creating a three-dimensional digital copy of fruit trees in an orchard using LiDAR technology. Researchers perform scans of each individual tree, down to the branches. This results in precise 3D models that form the basis of a digital twin of the orchard. These models can be used to train robots for work in the orchard. By digitally monitoring the growth of the trees, the robots will eventually know exactly which branches to prune for optimal harvest and when.

In addition, OnePlanet is working on a Virtual Reality (VR) environment of an orchard to train workers. With VR headsets and consoles, they learn to prune fruit trees in a virtual world.

OnePlanet’s initial focus is on automating the pruning process by capturing pruning knowledge in models. In Europe, fruit trees are often pruned in winter when it is physically demanding work. Automating part of this process could make a big difference.

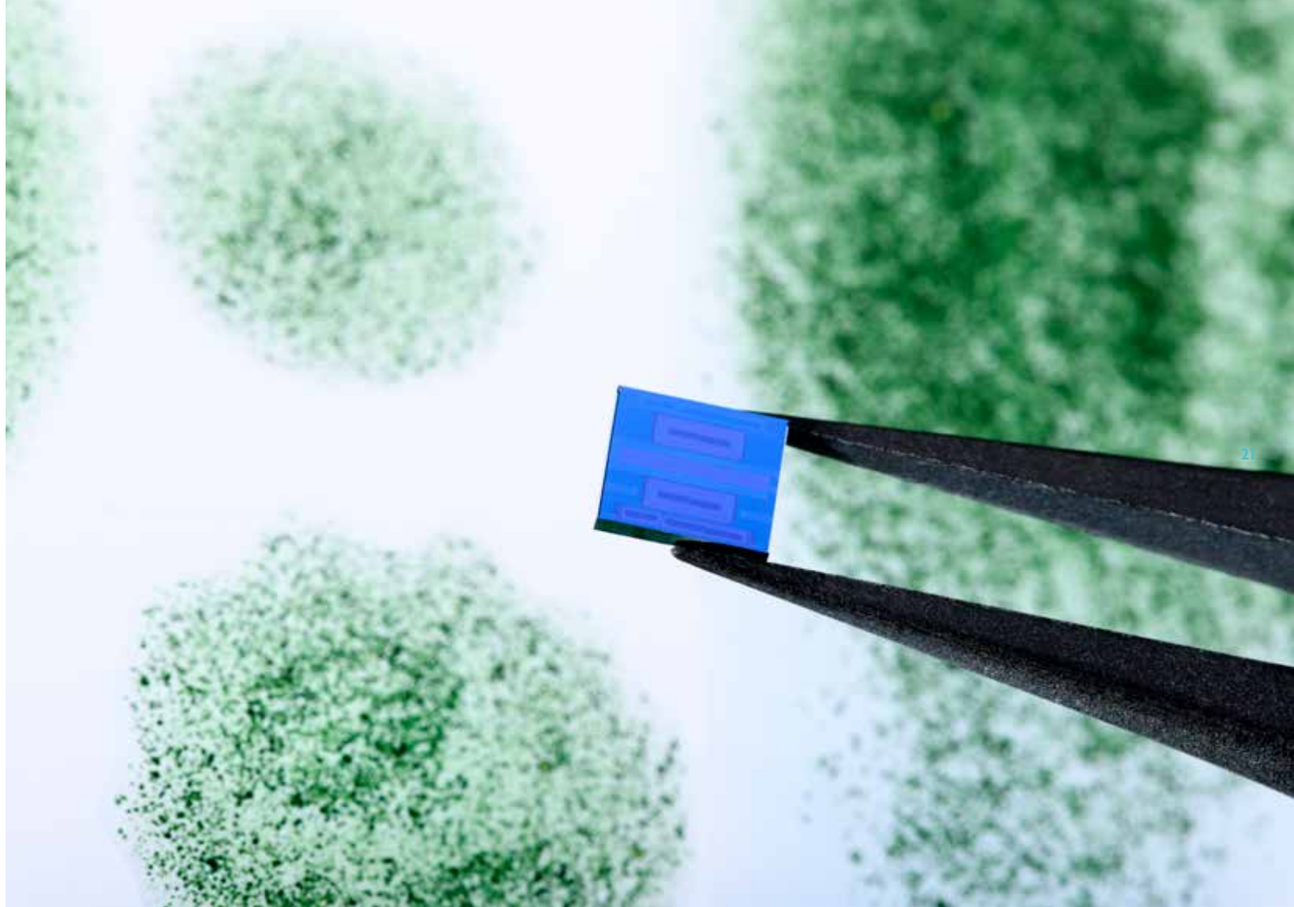
> “Digital technology and sensors make an important contribution to efficient production of alternative proteins, for example through (precision) fermentation by microalgae, bacteria, or yeasts. This accelerates the protein transition, or the shift from animal to plant-based proteins.”
>
> **Lex Oosterveld,**
> Program Manager Smart Food Processing

But the greatest benefit of such an autonomous system is that it preserves the valuable knowledge of growers. This is relevant considering the shrinking workforce, but also because managing an orchard requires specific knowledge and a forward-looking perspective. For example, the way trees are pruned now will affect the harvest two to three years later. By pruning each tree at the right time, the likelihood of a consistent yield increases.

Digital Food Factory of the Future

In addition to autonomous systems, new forms of food production contribute to the transition to a more sustainable and affordable food system. Under the name “Digital Food Factory of the Future,” OnePlanet is working on various projects involving sensor and digital technologies for the production of new proteins. Examples include protein production through fermentation or with the help of microalgae. Such solutions help accelerate the protein transition, the shift from animal to plant-based proteins.

This research is part of REALM, a large-scale project with European funding. In this project, international knowledge institutions and companies are developing an innovative, sustainable, and cost-effective system for growing microalgae. OnePlanet is therefore working on new sensors that can monitor the growth and physiological condition of microalgae in real time. With this sensor data, OnePlanet is developing digital twins and predictive models essential for automating production and harvesting. This leads to better quality products, reduces waste, and prevents unnecessary use of energy and resources.



Domains

03 | Environmental Monitoring

Nitrogen, climate change, and air pollution—environmental issues are the order of the day. As humans, we are exceeding the limits of the planet. But to what extent are we doing this? Where and when do these exceedances occur? And how can we reduce our negative impact on the environment? This requires more accurate measurement and monitoring of air, water, and soil quality. In the "Environmental Monitoring" program, OnePlanet works on innovative sensor and digital technologies to make this possible.

"With fine-scale nitrogen measurements, we contribute to the enormous nitrogen challenge that the Netherlands faces. By measuring more frequently and in more locations, activities can be linked to local measurements. This leads to greater insight into the cause of the problem and provides more direction for possible courses of action."

Remco Suer,
Program Manager Environmental Monitoring

Focus on Nitrogen

In terms of air quality, the main focus now is on nitrogen in the outdoor air. This concerns nitrogen dioxide (NO_2, primarily emitted by industry and transport) and ammonia (NH_2, primarily emitted by agricultural activities). Currently, measuring nitrogen in outdoor air is mainly done with monthly test tubes and expensive sensors at a limited number of large monitoring stations. OnePlanet is working on a solution with the benefits of both: an affordable, scalable, and reliable sensor technology that can continuously measure both nitrogen dioxide and ammonia. In this endeavor, they collaborate with TNO and other organizations involved in air quality, such as RIVM.

Data Platform

Measuring and monitoring alone does not lead to reduced emissions. Translating measurement data into actionable insights is just as important. That's why OnePlanet and TNO are collaborating on a data platform where sensor data across domains can be shared in a reliable, transparent, and traceable way. This includes data on nitrogen dioxide emissions from transport and industry as well as data on ammonia emissions from agriculture. This gives citizens, entrepreneurs, scientists, and governments real-time insight into their actions and the effects of emission-reducing measures.

Moonshot

Ultimately, all this research should lead to a fine-scale, continuously measuring, and reliable environmental monitoring sensor network. A network that generates insights into emissions and provides a direct link to actionable perspectives. Not only for nitrogen and air quality, but eventually broader: for water and soil quality as well. This is OnePlanet's moonshot—a strong ambition for the future that they cannot realize alone. Intensive cooperation with governments, knowledge institutions, and companies is crucial, and OnePlanet is fully committed to it.

Integrated Sensor Solution

In addition to reducing nitrogen emissions, cutting greenhouse gases like CO_2, methane, and nitrous oxide is high on the (international) agenda. OnePlanet is working on the next generation of sensor technologies that can measure multiple substances simultaneously, for example, by using integrated photonics. This way, businesses only need to invest in one sensor instead of acquiring five different ones.

Measuring in the City...

With the increasing number of traffic movements, air quality is deteriorating in various cities, leading to high concentrations of nitrogen dioxide and fine particulate matter in the air. Through the European project CompAir, OnePlanet is addressing this issue by accurately measuring nitrogen dioxide levels locally using its nitrogen sensor.

Together with project partners, OnePlanet is also developing a monitoring system for local authorities and citizens. This is a Citizen Science project where residents can measure and contribute ideas for solutions.

...and in the countryside

In the “Tailored Measurement with Purpose” project, OnePlanet locally measures the levels of nitrogen dioxide and ammonia in and around the Groningen Natura 2000 area called Liefstingsbroek. This is done in collaboration with Wageningen University & Research, the University of Amsterdam, RIVM, and TNO. They use both proven effective and new experimental measurement methods to enhance accuracy.

An interesting aspect of this project is the involvement of local farmers and nature organizations. They report on activities related to nitrogen emissions, such as grazing, mowing, mixing, and spreading. Measurements can therefore be directly linked to specific activities, aiding in targeted advice to reduce nitrogen impact on the natural area.

At the agro-innovation center De Marke near Hengelo, OnePlanet and TNO measure ammonia levels in the air around two stables. This data provides insights into the spatial distribution of ammonia and the influence of wind direction and deposition on its spread.

Acceleration in Gelderland

The nitrogen problem is urgent, as is water quality and climate goals, which require new measurement technologies to be more accessible. Support from the Province of Gelderland accelerates this process. This enables OnePlanet to continue developing existing technologies while also investing in new measurement technologies, such as integrated photonics. The first prototypes of this technology are now being tested in De Marke’s stables.

To accelerate further, OnePlanet collaborates with Wageningen Livestock Research and Utrecht University in the Foodvalley Regional Test Garden. This is a business and environmental measurement network for emission reduction in livestock farming. OnePlanet’s new experimental nitrogen sensor is used here as well.

OnePlanet is also developing part of the data infrastructure for the corporate network. Through the BarnSense platform, sensor- and company-specific data can be fed back to farmers, enabling them to take targeted emission-reducing measures.

Water and Soil

In the area of water quality, OnePlanet sees new challenges. Its ambitions in this area are still in the early stages. For measuring water quality in horticulture, it developed a prototype handheld nitrate sensor. Together with Radboud University, a PhD student at OnePlanet is working on developing an “electronic nose,” a sensor technology that allows farmers to measure soil health.

Effects of manure spreading the first results

With OnePlanet’s nitrogen sensors, elevated concentrations of nitrogen in and around the farmyard can be measured and linked to different activities. For example, it appears to be possible to measure the mixing and spreading of manure. While discussing the first results, the question arose whether you can also measure what happens when a sprayer drives behind the tractor. Can you measure whether emissions are reduced with this method? OnePlanet will investigate this during the next manure spreading season.

"When I heard about the establishment of OnePlanet Research Center, I thought this could be the missing link for addressing digital challenges efficiently."

Mirjam van 't Veld serves as an independent observer of provincial goals, with special attention to societal impact. Her extensive experience as a former mayor and Chair of the Board of Gelderse Vallei Hospital brings valuable insights and leadership to OnePlanet.

Interview with Mirjam van 't Veld

Independent Observer

"At the time, the province of Gelderland approached me for the role of Independent Observer in my capacity as chair of the Board of Directors of the Gelderse Vallei Hospital. In our hospital, prevention was already high on the agenda, with involvement in regional collaborations and the Alliance for Nutrition in Healthcare with Wageningen University & Research. Before that, I had been a mayor for ten years and was therefore familiar with the dynamics of governance."

"What specifically appealed to me about OnePlanet was the opportunity to find solutions for issues in the fields of preventive health, agriculture, food, and the environment through technological innovations, with a clear societal impact. My belief in the possibilities of this unique collaboration led me to quickly agree. As an observer, I act as a bridge between the worlds of science and public administration, where I serve as a constructive critical supervisor and simultaneously as an ambassador. I also use my network to help build connections.

The health technologies at OnePlanet, such as the smart toilet and the ingestible sensor pill, offer opportunities to support healthcare and health. Through this toilet and pill, important data is collected that can provide insight into the development of diseases, the effects of nutrition, and the action of medications. In the environmental field, nitrogen sensors have been developed for precise measurements and improved modeling, which is very relevant. Furthermore, I see opportunities in the food field, where technology can contribute to the food transition, for example, through autonomous greenhouses, even in deserts.

In recent years, OnePlanet has built strong relationships and gained recognition, both regionally and internationally. The collaboration with educational institutions in Gelderland, via the OpenEd program in which vocational and higher education students work together on technological issues, has successfully taken off. I find it fantastic to see that. Additionally, there has been valuable collaboration with SMEs.

For the province of Gelderland, OnePlanet is a valuable initiative that offers opportunities for residents in education, the labor market, the economy, and society. The possible implementation of technologies, such as the smart toilet in Gelderland care institutions or the possibility for farmers to perform their own nitrogen measurements, will have a significant societal impact. These technological developments contribute not only regionally but also (inter)nationally. Think, for example, of the potential of the ingestible pill. With this, stomach and intestinal examinations worldwide can be carried out in a much more patient-friendly way, and we can improve our knowledge of gut flora."

Our technologies

01 | Sensor Technology

Chip and digital technologies play a key role in all the innovations OnePlanet works on. The emphasis is on sensor technologies, data platforms, artificial intelligence, and digital twins. These are innovative technologies that can be used independently but gain even more value when integrated.

All data collected from these technologies is ultimately used to improve processes, ranging from the growth process of plants and the production of proteins from new sources to people's snacking behavior.

Small and inexpensive sensors

Innovation development is based on sensor technologies because they allow for measurement and data collection. The demand for (new) affordable sensor technology is high, as there is much, we still cannot measure. Lab measurements are often expensive and time-consuming, making quick adjustments impossible. OnePlanet develops new small and affordable sensors using various technologies such as radio frequencies, electrochemistry, and photonics.

A Broad Palette of Sensor Technologies

Not every technology is suitable for every purpose. Therefore, a diverse range of sensor technologies is essential. The choice depends on the properties of the object being measured. Each material has different properties that determine how deep electromagnetic radiation, such as light or radiofrequency waves, can penetrate the material. For example, the ripeness of tomatoes is related to their sugar content, which can be measured using infrared light.

OnePlanet developed a device that can measure how a potato grows underground using radiofrequency waves, as they penetrate deeper into the soil than light waves. Light waves are more commonly used to measure objects with lower material density, such as apples.

Integrated Photonics

Among all sensor technologies, integrated photonics is the most groundbreaking. Photonics revolves around generating, transporting, manipulating, and detecting light. The technology is similar to electronics but uses photons (light particles) instead of electrons for measurements.

OnePlanet is exploring integrated photonic sensors that are manufactured using wafer-scale technology on silicon, just like traditional chips. This technology makes it possible to create sensors that are small, affordable, energy-efficient, and more robust than current sensor technologies. These sensors offer opportunities in the fields of agriculture, food, and health, as they can be placed directly on robots, drones, or other applications to measure plants, food, people, or gases in the air, allowing direct adjustments to be made to production processes or health.

PhotonDelta

In the National Growth Fund program PhotonDelta, OnePlanet works with various partners to develop integrated photonics. The focus is on the development and (reliable) production of the technology, but also on investigating possible agricultural food and health applications and whether there is a market for them. Ultimately, these things must come together.

At the end of this program, validated prototypes are expected, after which (Gelderland) companies can bring the technology to the market.

Revolutionary Development

Although integrated photonics is still in its infancy, this is the start of a revolution. Just as measuring your heart rate with a smartwatch has become commonplace and affordable, other measurements will become more accessible over time. For example, fine-grained air quality measurements will allow farmers and industries to monitor their emissions and adjust accordingly. Or consider measuring the growth process of individual plants, allowing farmers to optimize the use of resources like water and nutrients more easily and reduce losses.

Our technologies

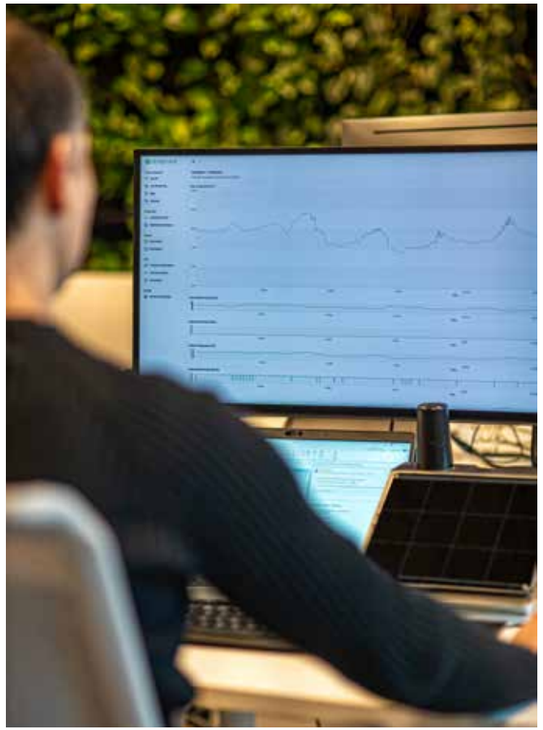
02 | Data Platforms

Sensor data is read and stored on data platforms. These platforms are a crucial link between all the technologies OnePlanet is working on. They also serve as a digital space where data analyses can be performed, providing the basis for developing digital twins, and where data can be shared with researchers and end users, such as farmers and patients. OnePlanet develops different types of data platforms for reading, storing, analyzing, and sharing sensor data. Our two largest are Senseiver and OpenPlanet.

Senseiver

Senseiver combination of “sensor” and “receiver,” is mainly focused on receiving and processing data from sensors. Researchers can easily connect various types of sensors to this platform to gain real time insights from measurements. It’s even possible to further develop the sensors while the data streams to the platform. Senseive can also support large numbers of sensor measurements. At over 100 locations in the Netherlands, for example, air quality sensors are in place that send live data to the platform via a SIM card.

Senseiver started as a platform for air quality measurements but has now become so generic that it’s used for multiple OnePlanet programs. For instance, sensors are also connected to measure the water composition in algae reactors, and the ingestible sensor pill is monitored for measurements in the intestinal tract. This way, one platform serves multiple users, making the development of sensors significantly more efficient through this form of reuse of functionalities. To ensure security, each user group has its own access to the platform, comparable to various enclosed rooms in one house.



OpenPlanet

OpenPlanet, created with EFRO funding, is a platform where providers and users of data come together. It functions as a sort of catalog where researchers can search and use datasets, with approval from the provider. OnePlanet has added an 'artificial intelligence workbench' to it, allowing users to perform analyses and create digital twins.

While Senseive is used for several domains, OpenPlanet focuses primarily on the healthcare domain. University medical centers (UMCs) can use it, for example, to share patients' health data with researchers and other UMCs. Privacy plays an important role, especially with patient data. OnePlanet uses a technology called PEP, developed in collaboration with Radboud University, to pseudonymize data. This way, data can be combined while ensuring patient privacy is protected.

Continuous Development

In developing data platforms, OnePlanet employs an agile approach. In two-week blocks, a team builds a new part of the platform. The user provides feedback on that process, which is continuously repeated. This way, the user has more input, adjustments can be made early, and the result aligns better with the end-user's needs. This is fully in line with OnePlanet's mission to realize societal impact together with the business community. In this respect, this method also serves as an example for other teams within OnePlanet that want to accelerate innovations.

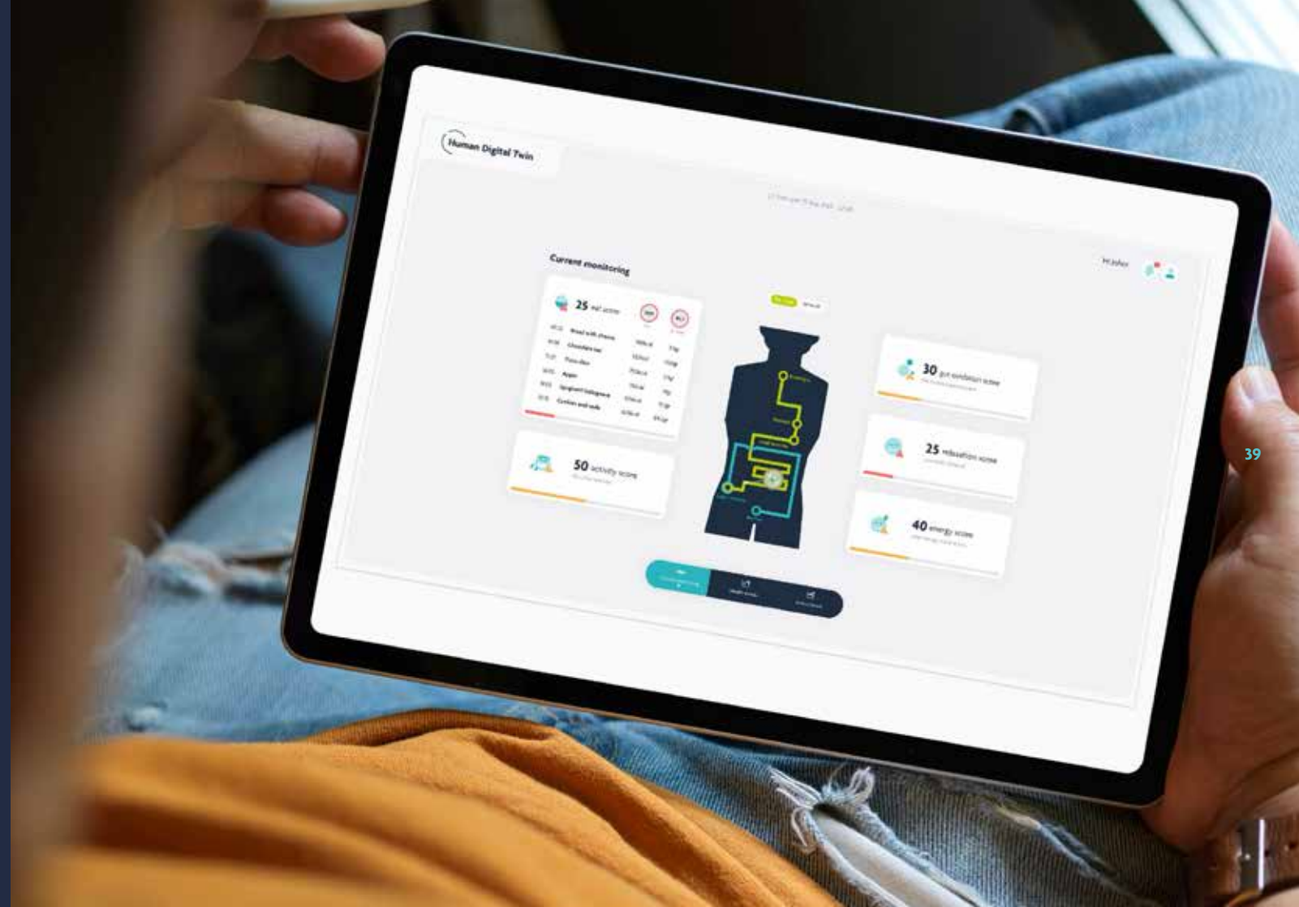
Although OnePlanet has achieved many successes in data platforms, there are still many challenges. For instance, how do you set up platforms so that they remain flexible enough to adapt to new types of sensors? And how do you lower barriers to sharing and registering data? Many parties need data but are also cautious about sharing it. OnePlanet continuously seeks solutions to these kinds of issues. As a collection point for data from sensors and as a basis for digital twins, data platforms play an important facilitating role.

Our technologies

03 | Digital Twins & Artificial Intelligence (AI)

Digital twins are virtual copies of a system or part of a living organism, such as a human or plant. They offer us a “window into the future.” Because these copies are digital, simulations can be run without burdening the real human or plant. This provides insights into the (long-term) effects of interventions and helps facilitate decision-making.

OnePlanet develops both the hardware and software for digital twins, leveraging artificial intelligence (AI) to gather insights from data by recognizing patterns in previously collected data. These algorithms continuously improve by processing new data, making it possible to predict current or future measurements. This serves as the foundation for digital twins.



Various Applications

In the field of health, OnePlanet creates digital twins of the human intestines, for example. With the help of the ingestible sensor pill, OnePlanet measures a patient's intestinal health. By making one or more digital copies of the intestinal tract, researchers and doctors can identify the cause of complaints, experiment with treatments and medications, and provide patients with personalized advice. This spares the patient from uncomfortable endoscopic examinations and provides predictive insight into the long-term effects of treatments.

In the domain of agriculture and food, OnePlanet developed a digital twin of an apple orchard. This allows for digital monitoring of the growth of apple trees, predicting the best timing for pruning and maintenance. Over time, robots can carry out these tasks, allowing the orchard to operate without direct involvement from a grower.

For environmental monitoring, OnePlanet works on digital twins of the surroundings. Based on sensor data and models, simulations can be performed. Besides end users like farmers and patients, companies also benefit from the use of digital twins. A medical-technology company, for example, can use the technology to develop new strategies for treating specific diseases more quickly.

The Power of Collaboration

Creating digital twins is complex. It requires many different experts who must work together like an orchestra. From an organizational perspective, this is a big challenge, but OnePlanet succeeds by combining the expertise of Wageningen University & Research, Radboud University, and Radboudumc with that of imec. Due to the complexity, OnePlanet does not provide separate elements such as algorithms and models; instead, it offers companies the complete set of knowledge and resources needed to develop digital twins.

Funding of Innovation

Thanks to funding from the Province of Gelderland, OnePlanet got off to a flying start. This initial support made it possible to first innovate internally, resulting in dozens of patents. For example, OnePlanet worked on moonshots such as the ingestible pill, which now draws societal value by connecting with hospitals and patient organizations.

Mix of Sources

The development of such innovative technologies is focused on sustainable food production, preventive health, and a healthy living environment. But for broad dissemination of knowledge and increased innovation capacity, a mix of funding sources is needed to continue to have a societal impact.

Public funding, such as from the province and the state, ensures a societal focus and independence. It helps to think strategically and plan over the long term, preventing fragmentation.

Moreover, this type of funding provides flexibility. When developing innovations, you outline multiple routes, and some fall through. OnePlanet has already made choices and is now at the point of "pick your winners and kill your darlings." Innovation always involves taking certain risks. By reducing some uncertainty, the later application and market risks become smaller for OnePlanet, companies, and society.

Private funding, for example, directly from industry, keeps OnePlanet sharp on what the market wants. The world is constantly changing, and OnePlanet must be flexible to respond. Large companies also play an important role in scaling and making innovations affordable.

Public-private funding, such as from the National Growth Fund, combines the benefits of both. In principle, a Growth Fund project focuses on mission-driven innovation, an investment in the future. It is crucial to avoid shifting to a short-term focus during implementation and to ensure that it continues to create a launching platform for innovations that yield long-term value.

To be able to maintain both innovative strength and ssocietal impact, a mix of funding sources is needed.

From Funding to Value

The strength lies in the mix. Take the nitrogen crisis, for example. There is still no established market for sensor innovations to measure nitrogen emissions, but the government increasingly needs one. A sustainable revenue model is coming closer, although there are still technological challenges in developing scalable and affordable measurement systems.

Thanks to funding from the province, OnePlanet has been able to invest in sensor technologies for measuring air quality in recent years. With funding from the Integrated Photonics National Growth Fund, they can now further develop these technological innovations in collaboration with industry into air quality sensors. By bringing these technologies to market with Gelderland SMEs, farmers gain insight into the effects of their practices. Together, with a mix of funding sources, we create value for the region and, more broadly, for society as a whole. This is an approach we want to continue in the future.

Our Collaborations

01 | Collaboration with Residents

With its roots in Gelderland soil, OnePlanet is highly motivated to build a strong region. This is achieved by closely collaborating with Gelderland businesses and educational institutions, but also by actively involving residents in its work. Especially when done at an early stage, researchers learn a lot about the motivations and needs of residents. By incorporating this into the design of technological innovations, they can develop products that are affordable and widely accessible to everyone. This promotes equal opportunities.

Measuring in and around the Home

OnePlanet initiates and participates in various Citizen Science projects in the areas of health and environment. Citizen Science (community science) means that non-professional individuals, such as residents of Gelderland, are involved in scientific research and data collection. OnePlanet is involved in the project 'Home Monitoring for Health,' where residents use measurement tools such as a smart toilet in their home setting. This provides valuable data, such as blood pressure variation, that can detect the onset and worsening of chronic illnesses at an early stage. By involving residents in technology development, products and services can be created that consider their needs.

Another example is the 'Life Critical' project, where municipalities and their residents measure the effects of measures taken in their neighborhoods. Do residents notice changes in the neighborhood, such as less water damage or reduced heat? To monitor the situation and the impact of these measures, OnePlanet provides sensors and other measurement tools in public spaces or at residents' homes. In this way, local issues are addressed. It also teaches people something about technology, making them better equipped to participate in the digital society.

Vulnerable Groups

Involving residents also promotes inclusion. OnePlanet aims for innovations that are suitable for everyone, including people in vulnerable positions, such as the elderly, the chronically ill, or those with low literacy. This is exactly what 'Stuff-4-life' is about. In this project, OnePlanet offers residents a 'smart toilet' that monitors their health. Users go about their daily routine with the toilet, and their health is monitored without any extra effort. This is ideal support for elderly individuals living alone, residents of care facilities, or families dealing with health issues.

Specifically for people in vulnerable positions, OnePlanet, together with three SMEs, further develops eHealth products. Communication about measurement data (and what it means for the user's health) aligns optimally with their motivation and experience. More visualizations are used in place of complex text. OnePlanet engages in dialogue with end users, home care providers, and other involved care institutions for this.

In the mentioned examples, technological developments are made more accessible to people with different skill levels and limitations. This enhances digital inclusion, which is crucial for narrowing the digital skills gap between those who have them and those who don't.

Our Collaborations

02 | Collaboration with Companies

Innovations only gain value when they are used in practice, and they are only applied if they are feasible, affordable, and scalable. That's why OnePlanet works closely with companies on the development of innovations, the validation of prototypes, and the commercialization of technologies.

Tools for Lifestyle Interventions

Early risk signaling and lifestyle interventions to improve people's mental health is the result of the EFRO project INGE3. Thanks to close collaboration with Gelderland companies Noldus and IVIDO, there is now a complete and complementary package of products. OnePlanet focused its development on measurements and tools for home environments, Noldus did the same in the laboratory setting, and IVIDO developed the personal and care professional dashboard.

Role in the Region

From local SMEs to multinationals, OnePlanet collaborates with various types of companies. Creating local (Gelderland) economic impact through global collaboration is central to its mission. As a global innovation center, OnePlanet attracts partners and creates employment opportunities for the region. Furthermore, SMEs get the chance to invest in their own developments in subsidized projects in collaboration with OnePlanet.

Three Forms of Collaboration

Collaboration occurs in different ways. OnePlanet involves companies as much as possible in its R&D activities, either through one-on-one agreements or public cooperation projects. Where possible, OnePlanet links companies to its innovation roadmaps or connects them with other companies or networks. OnePlanet works closely with various regional networks, such as FoodValley, HealthValley, ICTValley, and OostNL. The region is rich in business networks, each with its own expertise. By combining these strengths, matchmaking becomes increasingly effective. They also organize themed events to share knowledge and bring parties closer together.

OnePlanet also enters strategic collaborations with companies for innovation development. These are often long and costly projects that can encourage large companies to join SMEs. However, with innovation funds like EFRO, it becomes more appealing for SMEs, making the investment feasible.

In the past five years, OnePlanet initiated four EFRO projects with mostly smaller companies, plus other subsidy programs.

The SME sector also plays a crucial role as a supplier. In recent years, OnePlanet has found strategic collaboration partners. An example is the supplier chain for the industrialization, production, and installation of 200 sensor boxes for nitrogen measurements. For these collaborations, the preference is always for companies from Gelderland unless the required knowledge and resources are unavailable.

After developing and validating prototypes, OnePlanet can apply various valorization routes, or ways to realize value from acquired knowledge and innovations. This might be through a spin-off by OnePlanet, transferring technologies to another company, or retaining technology and IP while licensing it.

Win-Win Situation

There is no blueprint for effective collaboration in innovation projects, yet OnePlanet excels in this. An important point for companies is that they can derive business value from it and know that OnePlanet and its partners are innovation-oriented from the early stages of collaboration. This way, companies can play their own role in an innovation project.

Our Collaborations

03 | Collaboration with mbo, hbo, and wo

OnePlanet's collaboration with the education sector is mainly expressed through the Open Education Program (OpenEd). The goal is to provide students and teachers in vocational (mbo), applied sciences (hbo), and university education (wo) with the knowledge and skills needed for a future filled with digital technology.

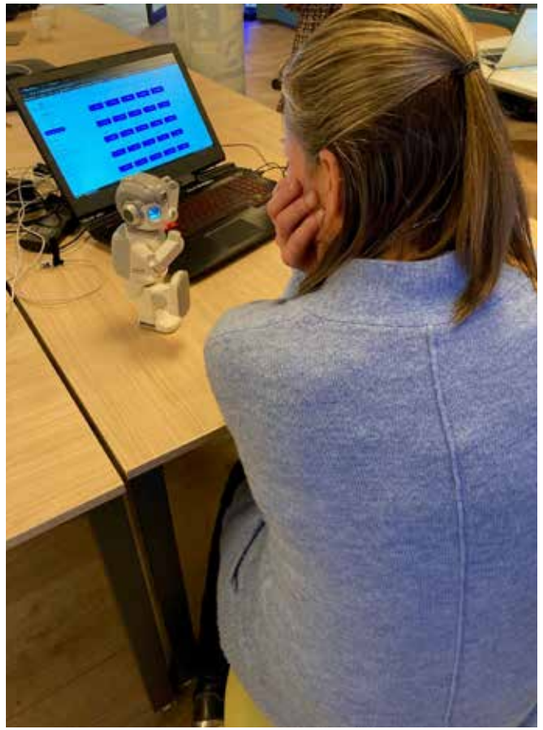
In the OpenEd program, OnePlanet develops internship placements, together with educational institutions and the work fiel. Students from different programs and levels work in groups on digital issues from the fields of agriculture, food, and health. For example, they investigate how a specific technology can improve the lives of caregivers or make work easier for farmers.

Technologies always contribute to solutions, whether in healthcare or agriculture. It is crucial to involve education early on to bridge the gap between education and practice. The goal is to give as many (primarily Gelderland) mbo and hbo students as possible the chance to experience this way of working.

"Working on societal issues with real-world partners greatly motivates students. For the OpenEd learning workspace, many teachers and students took a leap of faith. They embarked on an open process together."

Karien Vermeulen,
Program Manager Open Education

In addition to the learning workspaces, there are also healthcare technology challenges. Third-year nursing students from ROC Nijmegen conduct practical research on how technology can improve the lives of care recipients. They then provide advice to healthcare professionals. In this way, healthcare technology has become an established part of the ROC curriculum.



"I think it's amazing to use my creative thinking skills to contribute to healthcare. And I love making connections with healthcare professionals and with the patient themselves. Talking to them helps me understand what is needed. It broadens my horizon, and I will definitely continue exploring issues in healthcare."

Femke Kos (23),
student communication and multimedia design at HAN

Highlighted Learning Workspace: APPS

One of the learning workspaces is Activating Parkinson Patients with Sensors (APPS). Students of industrial product design work together with ICT specialists, embedded systems engineers, and nurses on wearables and applications to make the lives of people with Parkinson's disease safer and more comfortable. Over two hundred students have participated in this learning workspace.

Students and teachers from Hogeschool Arnhem en Nijmegen (HAN) and Christelijke Hogeschool Ede developed various product ideas, focusing on collecting data via wearables like smartwatches. They also researched new forms of feedback to improve speech through a speech trainer. Care facility De Liemerije, which has a Parkinson's department, serves as a case provider, bringing up issues and providing feedback to students.

Industrial product designers came up with the game "Puzzelpraat" to initiate a conversation about the effects of Parkinson's disease. HAN students created an interactive installation to stimulate movement in people with Parkinson's disease. The idea from these students was also presented at Parkinson Weekend in Nijmegen.

"The game Puzzelpraat is truly fantastic. It helps us prepare the conversation between the person with Parkinson's, their family, and the specialist better. It's careful designed and seems to meet a real need."

Rudie van den Heuvel,
senior lecturer in industrial product design at HAN

"I am proud of the role I could play as a bridge between research and the end user."

Aeres-student

GO! Digital

In the GO! Digital learning workspace, nursing students from Christelijke Hogeschool Ede, social work students from RijnIJssel, and communication and multimedia design students from HAN work together with child health coaches from Rijnstate Hospital on (digital) interventions to help children and young people with obesity develop a healthy lifestyle.

Students from HAN's Serious Gaming program developed a concept for a digital game for young people called Healthify. Pediatrician Annejet Plaisier commented: "The serious gamers have created something for a very complex target group. There are many useful elements in their app. The students did a great job of keeping it simple and making it engaging."

Soil Life Sensor

Students from Aeres University of Applied Sciences in Dronten and Radboud University conducted research on a (yet to be developed) soil life sensor, commissioned by OnePlanet and PhD student Rosa Boone (Radboud University).

The students interviewed various farmers in the Ooijpolder about the soil life sensor. What should such a sensor meet, and what value would it have for a farmer? They found it interesting to brainstorm with farmers while also working with a university. They noted that it is important to involve farmers early in the technology development process.

Open Education in Numbers

599 students in work-based learning environments

30 organizations from the field

6 work-based learning environments per year

8 partner educational institutions:

- Christian University of Applied Sciences Ede
- Aeres University of Applied Sciences
- Yuverta
- Van Hall Larenstein University of Applied Sciences
- ROC Rijn IJssel
- ROC Nijmegen
- HAN University of Applied Sciences
- Technova College / ROC A12

20 different study programs

40 teachers

Human Capital

Students develop an open attitude towards digital technology and gain more self-confidence, partly by working together across educational levels. They also become more aware of other disciplines. There is also much ethical reflection, which encourages critical thinking. The teacher learns more about technology and adopts an evolving role.

Educational Innovation

Mbo (vocational), hbo (applied sciences), and wo (university) students from various programs and institutions work together in an open process on a digital issue or challenge, based on digital and technological questions from real-world practice. Methods such as design thinking and exploratory research are applied.

Regional Ecosystem

New collaborations and interactions are emerging within schools and the workplace. OpenEd transcends institutions. Learning communities are working together on healthcare and agri-food issues.

Governance: Ensuring Impact

The social impact of OnePlanet's work is safeguarded in various ways. In particular, the dedicated societal impact committee focuses on this. They assess the (expected) social effects and advise the management on them. This committee includes representatives from social organizations, vocational education, the business sector, the province, and subject-matter experts.

In addition, OnePlanet's governance model includes a Foundation Board, an Observer, and a Program Council. The Foundation Board (consisting of four members) is accountable for the use of provincial funding. The Observer monitors the provincial goals, including social impact, and reports to the province. The Program Council, made up of six members, advises on program topics and strategic positioning.

Interview with Michel Meuwissen

General Practitioner and Member of the societal impact committee

"As the societal impact committee, we don't assess whether OnePlanet is doing things well, but whether it's doing the right things. In other words, does the work have sufficient social impact, especially in the Province of Gelderland? The conclusion is consistently that OnePlanet more than meets its social ambitions.

Social impact is a broad concept. The societal impact committee looks at the expected and actual social effects across five areas: 1) agriculture, food, environment, preventive health, nutrition, and behavior, 2) innovation strength, 3) equal opportunities, education, and the labor market, 4) economy, and 5) economy and business climate.

An important criterion in the assessment is social urgency. For instance, three years ago, the nitrogen crisis was pressing. By developing an instrument for accurate nitrogen measurements, OnePlanet directly contributed to part of the solution (the source and effects of interventions). Another criterion is how many people OnePlanet reaches and the diversity of this group. We need various professionals—from inventors to creators – to make innovations work. The OpenEducation program, for example, has been quite successful in reaching around 500 students from different levels and disciplines who work together on technological issues from the OnePlanet program.

The societal impact committee meets twice a year to form an understanding of OnePlanet's work and to provide advice to the management on both general and project levels. In 2023, we focused primarily on nitrogen measurement instruments and the ingestible sensor pill. In our assessment, we use the 'traffic light method' with green, orange, or red as the result. So far, OnePlanet has received a green light because their technologies address significant societal issues in agriculture, food, (preventive) health, and environmental concerns. Additionally, through the OpenEd program, OnePlanet bridges the gap between the labor market and education, promotes employment in Gelderland by engaging SMEs, and ensures the wide dissemination of its knowledge, including among citizens.

Personally, I am particularly impressed by the number of people OnePlanet has mobilized and the momentum it has developed in just five years. As a representative of the healthcare sector, I expect a lot from the ingestible sensor pill. Many people suffer from intestinal complaints, and this pill reveals the secrets of the intestines through specific markers for chronic conditions. This opens a completely new field of research. The smart bathroom offers techniques that could be broadly useful, especially in elder care where there is a severe shortage of personnel. Digital tools, such as wearables, are becoming increasingly important for detecting problems and identifying their causes.

Primarily, patients, the elderly, and healthcare benefit from these types of innovations, but the impact extends much further. We also hope Gelderland entrepreneurs will play a larger role in the production and marketing of these innovations, enabling startups and creating new job opportunities.

At the same time, one of the biggest challenges for OnePlanet is moving from prototypes to market. How do you establish a link with SMEs so they can produce and distribute these innovations? And how do you manage ownership? To ensure broad social impact, OnePlanet pays a lot of attention to these aspects.

I am fully confident that this journey, together with companies and education, will succeed. In five years, OnePlanet has built a professional innovation center with an extensive (regional) network around it. It's important now to consolidate this foundation and build on it. I look forward to what comes next with great anticipation."

Colophon

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