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# Role descriptions

## Professor and project leader of Plantenna

*Enactor, strong focus on innovation/precaution-sensitive*

As chairperson of the Plantenna research project[[1]](#footnote-2) and full professor in of the field of micro- and nanosystems you are a **knowledgeable, well-respected figure and the end-responsible of the project.** The chips you develop are plant integrated and can provide real time data in high resolution to optimise the growing conditions of the plant. You believe that these sensors can increase agrarian production worldwide to achieve the goal of zero hunger (SDG 2) under the circumstances shaped by climate change.

The sensors are fabricated by standard cleanroom techniques and are made from silicon and silicon nitride. **You are confident about the high-quality (material) properties of this fabrication method which is needed for the required measurements.** The fabrication process is expensive and needs scaling up to reduce costs. Your prototype chips have passed all functionality tests in the lab.

In light of these positive results, you have opened up ways to establish cheaper production of the chip and possibly roll-out the product on the market. An investor has shown interest to help you develop and market the technology. The investor wishes to go forward with the implementation of the sensor network and wants to attract as little requirements as possible. **Success criteria for the pilot should relate to the functionality and added value of the sensor.** Your main goal for the stakeholder meeting and the pilot is to gain the trust of the people at the table. You are confident in the potential of this technology to revolutionise precision farming.

*Interests:*  Micro- and nanotechnology, development of plant sensors, sticking to initial plans.

*Irritated by:*  People who do not think constructively, statements which are not scientifically supported.

*Habits:* Enjoys prestige and explaining subjects to others, becomes visibly irritated (e.g. playing with pen, glasses, looking away).

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| **Factsheet** |
| For the pilot only one chip per apple tree is needed, for more dense crops you expect to need at least five per m2. In general, the more plants with a sensor, the higher the resolution. |
| The nanostructures of the sensor are fully integrated in the form of solid structures and are not exposed to the environment if the sensor is intact. If the sensor would break or degrade, the risks of the released material for the direct environment and the crop’s produce are not yet evaluated. The pilot is an important moment to find this out. |
| Successful completion of the pilot will guarantee the funding by the investor. |

## Expert of the Centre for Safety of Substances and Products, RIVM

*Selector, precaution over innovation*

Working for the centre for safety of substances and products at the RIVM, the Dutch Institute for Public Health[[2]](#footnote-3), you are an expert on existing regulation of innovative technologies that may impact the safety and wellbeing of citizens and the environment. The centre develops methods and guidelines for the assessment and governance of innovative technologies.

You are here to ensure that the general policy guidelines are taken into account in this early-stage development and testing of the product. **There are no existing regulations for microchip implants in crops**, nor are you able to make rules for the people involved because such microchips have never been tried out before. **Safety does not end at choosing the right materials, it involves the whole process around the product**. The researchers and farmer have to act carefully and consider potential harms. You are very willing to help them in this process.

The general rules of similar environmental and food-safety policies can be used as guiding principles on this new terrain. You have identified three:

* Avoid the short- and long-term introduction of toxic- and rare earth materials in the environment. This applies to the EU ambition of reaching a non-toxic environment the RIVM committed to.
* Ensure the safety of all people involved during the product cycle, including the ones who manufacture the product, implement or install the product, utilise the product, and de-install or recycle the product. Human mistake and alternative use of the technology should also be accounted for (e.g. attaching the chip to the own body instead of the plant).
* Food-safety of the produce has to be ensured when it is sold for consumption. If this cannot be guaranteed, arrangements have to be made to label the product accordingly or to not sell it at all.

Together with the people in the meeting you wish to set up the pilot in such a way that these general rules are honoured. You need their collaboration and willingness. Ideally, a committee is installed to oversee the pilot and monitor any unexpected effects.

*Interests:*  Minimising risks for consumers and environment, making informed decisions, keeping all actors involved.

*Irritated by:*  Hasty innovators, disregard for safety, doubting RIVM measures.

*Habits:*  Can lecture others on the topic of safety, mediates when temper rises.

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| **Factsheet** |
| The regulatory framework cannot keep up with all innovations at the time they are developed, this is known as the ‘pacing problem’. **Therefore, the responsibility lies by the innovators to compare their material properties and device functionalities with existing regulations and make reasonable design decisions.** |

## Farmer

*Enactor of implementation, Selector of design, innovation over precaution*

As a farmer situated East from the city of Groningen you have been put forward to represent your fellow farmers in the Groningen region. You own a well-functioning, 15-year-old apple orchard. Just the other night you had to stay up to protect the flower buds of your apple trees again, this problem has frustrated you for a long time. You are among several willing orchard owners who are happy to collaborate on this research project.

As a person who is passionate about business, you see many opportunities arise with the Plantenna project. **The sensor network can significantly improve your crop yield, thereby your revenue, and it can enable you to scale up enormously because of the improved control over your lands.**

**The installation of the sensor network does require attention.** You want the servers of the network on the farm, and you want to be able to fix small problems of the network by yourself. To ensure fast and reliable internet, the glass-fiber network must be expanded to your farmland – a point you have lobbied for at the municipality a long time already.

Most of the risks for the research project are covered by insurance, still you have several **requirements**:

* You expect your orchard to live for at least another 15 years. Your orchard has to remain profitable and cannot run the risk of being banned from consumption indefinitely.
* The investments made to install the sensor network have to be reasonable. The system has to be reliable, and the output easily accessible and understandable.
* The outcome of the sensors has to be accurate, otherwise it costs too much money by either loosing produce or taking expensive precautionary measures unnecessarily.

*Interests:*  Increasing crop production and efficiency, reducing risk and cost of implementation, data-driven farming.

*Irritated by:*  Lectures by others, not being seen as important, too much precaution.

*Habits:*  Can be visibly disinterested when lectured, is keen to provide his/her perspective.

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| **Factsheet** |
| You are excited about this technology. Actually, you can imagine that the sensor can be of use to monitor the produce during transportation. |
| This technology could also be interesting for the flower industry. Your friend, a big player on the Dutch flower market, has been complaining about temperature and nutrition control on the fields as well. |
| You wish to retain the right to exploit the data as you wish, this in line with the EU Code of Conduct on Agricultural Data Sharing. This would strengthen your business case. |

## Alderman of Groningen

*Selector, precaution over innovation*

As an Alderman of Groningen, you are part of the board that governs the municipality of Groningen. Within this board you are the person responsible for agriculture, nature and well-being policy in the region. The board is supervised and scrutinised by the municipal council

**The council has specifically voiced a concern regarding the safety of the food from the orchards with these chips.** One council member actually called the crops with microchips “Cyblanta’s” (Cyborg plants). Do these plants produce safe food? What if the chip breaks, does that affect the produce? You are extremely cautious on this subject; it cannot happen that citizens get to unknowingly eat unsafe foods. To you it is clear, if the food safety cannot be ensured, the produce of the pilot cannot be sold for consumption.

In addition, the council has addressed a more long-term concern. Recent hacks targeting fertilizer factories in another municipality have shaken up the region. When implementing an “internet of plants” on farmlands that is used to automate processes and scale up activities, agriculture grows dependent on these sensors. Imagine wasted yields or crops because of a well-timed cyber-attack, this would be catastrophic to the region. **From your perspective, the research group and the farmer are responsible for the safety of this network and should put in extensive effort to have the best protection they can.**

Generally, you know the scrutiny the municipal council can subject you to. If this experiment caused a safety concern or general controversy within the community, you have to fear for your position. **To account for the risks that are not yet known, you want to set up a monitoring committee for the experiment which will have frequent meetings with the farmers and the researchers.** This way, unexpected events can be adequately responded to.

*Interests:*  *Food-safety; Stability in the region; Satisfied municipal council; Minimized risk.*

*Irritated by:*  *Hasty decision-making; Disregard for public concern; Disregard for role of the region*

*Habits:*  *Makes many notes of what is said by others; Often has an observant-mediating attitude*

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| **Factsheet** |
| The municipality is in the process of expanding its glass-fiber high-speed internet network. Farmers will have the opportunity to sign up for a connection to this network in about two months and be connected in two years. |
| Recently, a group of concerned small-scale farmers has sent you a letter. They had picked up the news of the internet of plants and fear for the further expansion of the ‘imperium’ certain farmers have built. **The small-scale farmers do not have the resources to acquire an extensive sensor network and they expect the ‘imperium owners’ to outcompete them.** |

**Director of *ResSus***

*Selector, Land System Change especially relevant, precaution focused*

As the director of the non-profit organization ResSus (Resilient Sustainability), you specialise in the analysis of novel technologies in a global context with an emphasis on the Global South. You are passionate about technologies contributing to the limitation of climate change.

**ResSus takes the global perspective on local initiatives.** In the case of the Plantenna project, you see an inherent risk. The potential benefits to precision farming are at the expense of introducing novel entities, the implantable microchips. This is mainly problematic when the chips are left or lost in the environment surrounding the farmland by storm, destruction or mere detachment. **The idea of having thousands of non-degradable and potentially toxic microchips left on the fields, in creeks, and in forests sickens you.** **A way to close the life-cycle of the product has to be agreed upon**, like the requirement to remove microchips from the crop before harvest and to use biodegradable material.

In addition, **you see a significant risk for the Global South since the internet of plants enables ‘remote farming’**: financially advantaged farmers could use the sensor to monitor ‘their’ crops in other countries and exploit this using automated farming techniques. This way, the remote farmer can minimise their need to be present on the field itself and outsource small jobs on the farm to local people. This leaves you worried for the livelihood and independence of small-scale farmers in the Global South.

The use of this technology in countries outside the EU also brings problems. The regulations currently discussed in the Netherlands will have to be followed in countries with a less strict regulatory framework as well to ensure limitation of the risks the technology introduces. Global import and export of foods can still expose the Dutch system to the potential food safety risks of the technology when this is applied abroad. **Therefore, the use of this technology should be coupled to strict rules for potential further application.**

*Interests:*  Sustainable development; Global Perspective; Global equity.

*Irritated by:*  Irrational behaviour; Neglect of sustainability.

*Habits:*  Can be activistic when irritated; Does not compromise on principles.

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| **Factsheet** |
| Cellulose nanofibrils, extracted from wood, can be formed into a paper-like material which is transparent and flexible, and therefore can serve as an alternative to standard silicon-based materials used in the electronic industry. Electrodes, transistors or other electronic components can be integrated on the paper-chips to fabricate biodegradable electronic sensors. Paper-based electronic sensors have only recently been demonstrated and mass fabrication must still be validated.[[3]](#footnote-4) |
| Important elements of life-cycle design are material choice, material use in processing, manufacturing process, transportation of the product, the use of the product, the lifetime of the product, and the end-of-life disposal. |

# Doubled roles

**Associate Professor, Plantenna project**

*Enactor, strong focus on innovation/precaution-sensitive*

As associate professor in the field of micro- and nanosystems you are a knowledgeable, ambitious and well-networked researcher. Currently, you have a leading position in the Plantenna research project. The chips you develop are plant integrated and can provide real time data in high resolution to optimise the growing conditions of the plant. You believe that these sensors can increase agrarian production worldwide to achieve the goal of zero hunger (SDG 2) under the circumstances shaped by climate change.

The sensors are fabricated by standard cleanroom techniques and are made from silicon and silicon nitride. **You are confident about the high-quality (material) properties of this fabrication method which is needed for the required measurements (.** The fabrication process is expensive and needs scaling up to reduce costs. Your prototype chips have passed all functionality tests in the lab.

In light of these positive results, you have opened up ways to establish cheaper production of the chip and possibly roll-out the product on the market. An investor has shown interest to help you develop and market the technology. The investor wishes to go forward with the implementation of the sensor network and wants to attract as little requirements as possible. **Success criteria for the pilot should relate to the functionality and added value of the sensor.** Your main goal for the stakeholder meeting and the pilot is to gain the trust of the people at the table. You are confident in the potential of this technology to revolutionise precision farming.

*Interests:*  Micro- and nanotechnology, development of plant sensors, goal-oriented.

*Irritated by:*  General and broad statements which are not directly related to the scientific facts.

*Habits:* Likes to lecture people on scientific facts, becomes visibly irritated (e.g. tipping nose, looking away).

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| **Factsheet** |
| For the pilot only one chip per apple tree is needed, for more dense crops you expect to need at least five per m2. In general, the more plants with a sensor, the higher the resolution. |
| The nanostructures of the sensor are fully integrated in the form of solid structures and are not exposed to the environment if the sensor is intact. If the sensor would break or degrade, the risks of the released material for the direct environment and the crop’s produce are not yet evaluated. The pilot is an important moment to find this out. |
| Successful completion of the pilot will guarantee the funding by the investor. |

**Expert of the Centre for Safety of Substances and Products, RIVM**

*Selector, precaution over innovation*

Working for the centre for safety of substances and products at the RIVM, the Dutch Institute for Public Health[[4]](#footnote-5), you are an expert on existing regulation of innovative technologies that may impact the safety and wellbeing of citizens and the environment. The centre develops methods and guidelines for the assessment and governance of innovative technologies.

You are here to ensure that the general policy guidelines are taken into account in this early-stage development and testing of the product. **There are no existing regulations for microchip implants in crops**, nor are you able to make rules for the people involved because such microchips have never been tried out before. **Safety does not end at choosing the right materials, it involves the whole process around the product**. The researchers and farmer have to act carefully and consider potential harms. You are very willing to help them in this process.

The general rules of similar environmental and food-safety policies can be used as guiding principles on this new terrain. You have identified three:

* Avoid the short- and long-term introduction of toxic- and rare earth materials in the environment. This applies to the EU ambition of reaching a non-toxic environment the RIVM committed to.
* Ensure the safety of all people involved during the product cycle, including the ones who manufacture the product, implement or install the product, utilise the product, and de-install or recycle the product. Human mistake and alternative use of the technology should also be accounted for (e.g. attaching the chip to the own body instead of the plant).
* Food-safety of the produce has to be ensured when it is sold for consumption. If this cannot be guaranteed, arrangements have to be made to label the product accordingly or to not sell it at all.

Together with the people in the meeting you wish to set up the pilot in such a way that these general rules are honoured. You need their collaboration and willingness. Ideally, a committee is installed to oversee the pilot and monitor any unexpected effects.

*Interests:*  Minimising risks for consumers and environment, making informed decisions, keeping all actors involved.

*Irritated by:*  Disregard for safety; doubts about the accuracy of RIVM; bragging scientists.

*Habits:*  Likes to point people to the importance of safety, tries to smooth down differences.

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| **Factsheet** |
| The regulatory framework cannot keep up with all innovations at the time they are developed, this is known as the ‘pacing problem’. **Therefore, the responsibility lies by the innovators to compare their material properties and device functionalities with existing regulations and make reasonable design decisions.** |

## Farmer

*Enactor of implementation, Selector of design, innovation over precaution*

As a farmer situated East from the city of Groningen you have been put forward to represent your fellow farmers in the Groningen region. You own a well-functioning, 17-year-old pear orchard. Just the other night you had to stay up to protect the flower buds of your pear trees again, this problem has frustrated you for a long time. You are among several willing orchard owners who are happy to collaborate on this research project.

As a person who is passionate about business, you see many opportunities arise with the Plantenna project. **The sensor network can significantly improve your crop yield, thereby your revenue, and it can enable you to scale up enormously because of the improved control over your lands.**

**The installation of the sensor network does require attention.** You want the servers of the network on the farm, and you want to be able to fix small problems of the network by yourself. To ensure fast and reliable internet, the glass-fiber network must be expanded to your farmland – a point you have lobbied for at the municipality a long time already.

Most of the risks for the research project are covered by insurance, still you have several **requirements**:

* You expect your orchard to live for at least another 15 years. Your orchard has to remain profitable and cannot run the risk of being banned from consumption indefinitely.
* The investments made to install the sensor network have to be reasonable. The system has to be reliable, and the output easily accessible and understandable.
* The outcome of the sensors has to be accurate, otherwise it costs too much money by either loosing produce or taking expensive precautionary measures unnecessarily.

*Interests:*  Increasing crop production and efficiency, reducing risk and cost of implementation, data-driven farming.

*Irritated by:*  Lectures by others, being marginalized, too much precaution.

*Habits:*  Can be visibly disinterested when lectured, engaged to join the discussion.

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| **Factsheet** |
| You are excited about this technology. Actually, you can imagine that the sensor can be of use to monitor the produce during transportation. |
| This technology could also be interesting for the flower industry. Your friend, a big player on the Dutch flower market, has been complaining about temperature and nutrition control on the fields as well. |
| You wish to retain the right to exploit the data as you wish, this in line with the EU Code of Conduct on Agricultural Data Sharing. This would strengthen your business case. |

**Policy advisor in Groningen**

*Selector, precaution over innovation*

As the policy advisor of the Alderman of Groningen who is responsible for agriculture, nature and well-being policy in the region, you stand alongside the Alderman during their toughest situations. The alderman is supervised and scrutinised by the municipal council, and it is important to address their concerns during the stakeholder meeting.

**The council has specifically voiced a concern regarding the safety of the food from the orchards with these chips.** One council member actually called the crops with microchips “Cyblanta’s” (Cyborg plants). Do these plants produce safe food? What if the chip breaks, does that affect the produce? You are extremely cautious on this subject; it cannot happen that citizens get to unknowingly eat unsafe foods. To you it is clear, if the food safety cannot be ensured, the produce of the pilot cannot be sold for consumption.

In addition, the council has addressed a more long-term concern. Recent hacks targeting fertilizer factories in another municipality have shaken up the region. When implementing an “internet of plants” on farmlands that is used to automate processes and scale up activities, agriculture grows dependent on these sensors. Imagine wasted yields or crops because of a well-timed cyber-attack, this would be catastrophic to the region. **From your perspective, the research group and the farmer are responsible for the safety of this network and should put in extensive effort to have the best protection they can.**

Generally, you know the scrutiny the municipal council can subject you to. If this experiment caused a safety concern or general controversy within the community, you have to fear for your position. **To account for the risks that are not yet known, you want to set up a monitoring committee for the experiment which will have frequent meetings with the farmers and the researchers.** This way, unexpected events can be adequately responded to.

*Interests:*  *Food-safety; Stability in the region; Satisfied municipal council; Clarity on plan.*

*Irritated by:*  *Hasty decision-making; Not taking into account the interests of the region and its citizens.*

*Habits:*  *Mediating attitude; listens intensely, especially on scientific topics.*

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| **Factsheet** |
| The municipality is in the process of expanding its glass-fiber high-speed internet network. Farmers will have the opportunity to sign up for a connection to this network in about two months and be connected in two years. |
| Recently, a group of concerned small-scale farmers has sent you a letter. They had picked up the news of the internet of plants and fear for the further expansion of the ‘imperium’ certain farmers have built. **The small-scale farmers do not have the resources to acquire an extensive sensor network and they expect the ‘imperium owners’ to outcompete them** |

**Board member of *ResSus***

*Selector, Land System Change especially relevant, precaution focused*

As a board member of the non-profit organization ResSus (Resilient Sustainability), you specialise in the analysis of novel technologies in a global context with an emphasis on the Global South. You are passionate about technologies contributing to the limitation of climate change.

**ResSus takes the global perspective on local initiatives.** In the case of the Plantenna project, you see an inherent risk. The potential benefits to precision farming are at the expense of introducing novel entities, the implantable microchips. This is mainly problematic when the chips are left or lost in the environment surrounding the farmland by storm, destruction or mere detachment. **The idea of having thousands of non-degradable and potentially toxic microchips left on the fields, in creeks, and in forests sickens you.** A way to close the life-cycle of the product has to be agreed upon, like the requirement to remove microchips from the crop before harvest and to use biodegradable material.

In addition, **you see a significant risk for the Global South since the internet of plants enables ‘remote farming’**: financially advantaged farmers could use the sensor to monitor ‘their’ crops in other countries and exploit this using automated farming techniques. This way, the remote farmer can minimise their need to be present on the field itself and outsource small jobs on the farm to local people. This leaves you worried for the livelihood and independence of small-scale farmers in the Global South.

The use of this technology in countries outside the EU also brings problems. The regulations currently discussed in the Netherlands will have to be followed in countries with a less strict regulatory framework as well to ensure limitation of the risks the technology introduces. Global import and export of foods can still expose the Dutch system to the potential food safety risks of the technology when this is applied abroad. **Therefore, the use of this technology should be coupled to strict rules for potential further application.**

*Interests:*  Sustainable development; Global Perspective; Global equity.

*Irritated by:*  Downplaying the importance of sustainability, irrational behaviour.

*Habits:*  Activistic attitude; no-compromise when it comes to principles.

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| **Factsheet** |
| Cellulose nanofibrils, extracted from wood, can be formed into a paper-like material which is transparent and flexible, and therefore can serve as an alternative to standard silicon-based materials used in the electronic industry. Electrodes, transistors or other electronic components can be integrated on the paper-chips to fabricate biodegradable electronic sensors. Paper-based electronic sensors have only recently been demonstrated and mass fabrication must still be validated.[[5]](#footnote-6) |
| Important elements of life-cycle design are material choice, material use in processing, manufacturing process, transportation of the product, the use of the product, the lifetime of the product, and the end-of-life disposal. |

1. Inspired by Peter Steenekers profile as contact person of the Plantenna project <https://www.tudelft.nl/3me/over/afdelingen/precision-and-microsystems-engineering-pme/people/professors/profdr-pg-peter-steeneken> [↑](#footnote-ref-2)
2. Based on <https://www.rivm.nl/rivm/organisatie/centrum-duurzaamheid-milieu-en-gezondheid> [↑](#footnote-ref-3)
3. High-performance green flexible electronics based on biodegradable cellulose nanofibril paper | Nature Communications [↑](#footnote-ref-4)
4. Based on <https://www.rivm.nl/rivm/organisatie/centrum-duurzaamheid-milieu-en-gezondheid> [↑](#footnote-ref-5)
5. High-performance green flexible electronics based on biodegradable cellulose nanofibril paper | Nature Communications [↑](#footnote-ref-6)