UNIVERSITY OF TWENTE.

Theatrical Technology Assessment

MODERATOR MATERIALS

INTERNET OF PLANTS

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Theatrical Technology Assessment - Moderator Material Internet of Plants

In this document the key elements for moderation of the Theatrical Technology Assessment (TTA) case on “Internet of Plants” are highlighted.

What is TTA?

TTA is a learning activity designed by Klaasjan Visscher (2020) which “aims to enable engineering students to explore and anticipate the socio-technical dynamics of emerging technologies, and to find ways to integrate their insights in nuanced innovation plans” (2020, p.5). The method is based on the concept of Constructive Technology Assessment (CTA) (Rip et al., 1995), which is a research methodology to assess technological developments in society and enable real-world stakeholders to anticipate or influence this development and embedding (Te Kulve, 2011). In the educational setting, the focus is put on understanding new technologies in complex and uncertain situations while developing the competencies to deal with this. The roleplay simulation aspect of it allows the student to get an inside experience of stakeholder positions, including the conflicting and constructive relationships this stakeholder may have (Tjosvold, 2008). The materials of the case should facilitate sufficient information for the actor to play out the stakeholder in a realistic fashion. The method includes improvisational theatre to make actors more confident in their role while interactions are quicker and more interesting. It allows for the construction of the situation during the play because of its “yes-and” nature, which creates a certain path dependency and has room for alternative, new, or unexpected outcomes (Van Bilsen et al., 2013).

Goals of the TTA roleplay “Internet of Plants”:

- Students experience different stakeholder perspectives and get an idea of the interaction between stakeholders in a particular setting
- Students experience the Safe-by-Design process and its principles in general and specifically for a new and emerging technology
- Students understand the impact and potential of disruptive technologies, their global effect, the relation between technology and politics and the role of regulations in the context of innovation

Setting and materials

Number of attendees: 5-25 (advisable to double role descriptions from 15 attendees onwards)

The complete set of material for this case can be found online and consists of the following:

- Moderator Material (this document)
- Moderator Cheat Sheet (Appendix 1 and separate .pdf)
- Technology description (Appendix 2 and separate .docx)
- Role descriptions (Appendix 3 and separate .docx)
- Observer instructions (Appendix 4 and separate .docx)

Organisational aspects

This section covers the organisational aspects needed to execute a TTA roleplay. Make sure to read into the materials before implementing a specific case. We provide bullet points on what to address to make the introduction and moderation of the case easier.

Materials to bring

It is important that the people who will act out as well as the ones who will observe the roleplay are well informed about the context of the play. This can be facilitated by bringing printed materials to class and allowing students a moment to read.

- Moderator Cheat Sheet
- Technology description (x number of persons present)
- Role descriptions (5 or 10, depending on choice to double roles)
- Observer instructions (x number of non-players)
- Blank sheet of sturdy paper for character names (1 for each role + yourself as moderator)
- Markers for writing the character names
- A watch for keeping time

To improve the readiness of those playing and to save time during the lecture, role descriptions can be shared with the actors before the play. This however requires the distribution and assigning of the roles prior to the meeting. Only share the role description with the persons who will play the roles and do so two days in advance latest. Do bring prints of the role descriptions to the lecture, this is often appreciated.

Setting the room

Put all tables to the side to create a large open space. Put chairs in a semi-circle facing the front. At the end of the warming up, make a **V-formation** of two tables facing the audience. Put a chair for the moderator at the closed end and 5 chairs behind the tables. The tables only serve to put up the name of the character. This set-up gives the actors room to play, unobstructed by a table and allows the observers an unobstructed view of the goings-on.

No multimedia equipment is required for the roleplay, unless this is preferred during the introduction or reflection moments.

Timeline of the play

Phase	Duration	Description
Introduction	5 min	·Introduce technology, aim of the meeting, and assign roles.
Preparation	10 min	·Give attendees time to read materials, think of a name, and write this on a paper card.
Warming up (extend in case of more time)	10 min	·Improvisational theatre exercise, make people enthusiastic, enter character.
Session 1 'CTA workshop'	20 min	·Introduction by the moderator, mention the setting, the reason for gathering, and goal of the session. Ask characters to introduce themselves and their perspective on the situation.
Reflection 1	15 min	·Analyse stakeholder dynamics, observed tensions, group formation, and applied strategy. Involve observers, ask about acting.
Break & Preparation of pressure cooker	15 min	·Prepare pressure cooker (5-10 year time jump). Involve observers.
Session 2 'Pressure cooker' (15min)	15 min	·Players are introduced to changed circumstance and presented with a challenge. Moderator can decide to step out and let actors discuss.
Reflection 2, Theory & Reflection assignment (extend in case of more time)	15 min	·In case of large group, involve students with digital platform of choice. Focus on discussion analysis, changes in the discussion compared to first session, and stakeholder influence on outcomes. If applicable, draw links to innovation and Safe-by-Design theories addressed in earlier lectures, link the outcome to the other assignments of the course (VSD).
After the workshop [Suggested]		
Reflection assignment		·Reflect on theory in relation to the role play experience ·Articulation of (new) insights

Facilitating the Play

This section describes how to facilitate the play and provides important tips for the form and decisions during the session. It is good practice to lead the group with 2 persons, one to introduce the technology, stakeholders, and to play the moderator, and one to lead the warming up, pressure cooker, intermediate reflection sessions, and to keep track of the time. Make sure to guard the time well, often more can be discussed than time allows for.

Starting the session

When introducing the session be as clear as possible on the origin of the concept, the outline of the session, and the goals. The introduction and goals can be found at the start of this document and the outline is included under "Timeline of the play".

Then, briefly **introduce the technology**. This should provide an overarching frame for the students to put the technology description and potentially their role in. This overarching frame can be found under "Context of the play". Address the following:

- Who works on the technology – "The Plantenna project works on microchips that can be implanted in any type of plant."
- The aims of the project – "It aims to monitor temperature, plant vitality and optimize water and nutrition application schemes."
- Main functional characteristics of the technology – "To do so, the project depends on advances in nanotechnology related to sensing. The chips form a fine-grained network based on technologies of the Internet of Things."
- The reason for the stakeholder meeting – "A pilot to implement the chips in fruit trees of select farms in the Groningen has been planned. The pilot aims region to combat produce loss because of unexpected frosts in early spring, causing young flower buds to die off."
- The aim of the stakeholder meeting – "The discussion will centre on the design criteria to be taken into account when developing this technology further."

Now, roles have to be assigned to the attendees (if not done before the roleplay). **Assign the roles** based on interest if you have not distributed this beforehand. Try to take into account the (first) impression you have of a person when assigning the roles to align these a little. This makes it easier for the person to play the character. Otherwise let students choose which role they want to play.

After the introduction, give people **time to read** their materials and prepare for their role. Invite actors and observers to read together and discuss a potential strategy of the stakeholder during the discussion, make sure of an even spread of observers among actors. Ask the actors to **think of a name** for their character, write this down on a sheet of paper, and put this in front of them. As a moderator you also think of a name and put this up (see Role description of moderator). Make sure to only refer to the actors by their fictive name during the session.

The **warming up** is next. Depending on the group size this can be done with the complete group, only the actors, or with the group of observers as 'one' role. There are several activities you can choose from:

- *Circle of emotions:* Everyone stands in a circle. You request a regular sentence that an attendee has said during the day ("I want coffee" or "What a beautiful morning" or the like). Additionally, you request an emotion. This makes a pair. One person starts by saying the sentence with the accompanying emotion. This is passed on through the circle and with each repetition, the emotion has to be stronger. After completing the round ask for a new sentence-emotion-pair and repeat. Make sure you have had a positive and a negative emotion. If at the end of the second round the emotion can still grow stronger,

surprise them by announcing another round of the same prompt, while continuing to enlarge the emotion.

- *Walk around:* In the open space, ask everyone (observers pick a role) to walk as their character in silence. Begin this session by showing examples yourself, it is all about body language. During the session, prompts like "Does this person walk around like they are the top dog or more shy", "Are they comfortable looking others in the eye", and "Is this person intimidating towards others or not? [remember no shoving or pushing, can be laughed at]."
- *1 min introductions:* Ask the actors to introduce themselves to the observers in their group as the character they will be playing.
- *Cheerleading:* Ask the actors and observers to psych each other up in groups (already formed), as if they were in a way too enthusiastic start-up environment. Sentences like "You/we can do this!" and "Go get 'em!" are well suited. Ask them to do this in a circle of emotions style, several rounds of repeating the sentence each time with more hype. Mention that this can be completely over the top.
- *Clapping:* Go round the circle clapping with eye contact, amp up the game by the possibility of going back with double clap. Pointing a clap to someone skips the circle. You can also try make two claps go around the circle.
- *Cluedo:* Have all but one participant leave the room, the location and murder weapon are told to the first person. One by one come in, location is portrayed without words, just sounds until the person knows and shakes their hand, then the weapon is portrayed, hand is given and then this person acts it out to the next one.

People will be nervous about playing, so make sure to **exert enthusiasm** towards the group from the introduction onwards. In the end, you are also playing a role and enthusiasm is contagious.

After the warming up, request the actors to enter the stage as their character (think of the way they walk, talk or sit), introduce themselves to each other, and make some small talk (the journey, building, lunch, etc.). As a moderator you play along with this. This enables the actors to step into the character role and activate the improvisational aspect of the play.

Starting the play

When everyone is seated at the table the moderator starts the play with a welcome and short introduction. The following points can guide this introduction

- Name the setting (The Hague, Ministry or City Hall), introduce yourself in character
- Mention who initiated the meeting and the reason for meeting
- Mention the goal of the meeting "to agree on a set of design criteria for the product and pilot"
- Mention some of the clear tensions present, for example:
    - The safety of the technology and involved processes
    - Possible impact on the environment
    - Unknown risks that might come up during the pilot and how to deal with this
- Give the word to the actors at the table
- "I believe not everyone knows each other at the table, so let's start with a round of introductions, and please elaborate on what you think of the technology"
- [After introductions] As soon as the discussion picks up, leave it to the actors. If this does not happen, ask one stakeholder to elaborate their perspective on the situation.
- [In the second half of the first round] Help the discussion to work towards the intended outcome

How to design the pressure cooker

During the break, you as a moderator will have to design the prompt for the pressure cooker. The design has to **build forth** on the outcomes and decisions made in the first CTA session. **Imagine** a situation that is five to ten years into the future. Try to centre the design on two considerations:

- Have tensions remained unaddressed that would be interesting to highlight?
- Have stakeholders been in the background, formed strong alliances, or any other consolidated position that should be shaken up?

Involve the observers in this process. Make use of the designed tensions and underlying theoretical concepts described further on in this document. These might help when you have to design a pressure cooker in a limited time span. Make sure to write down the key points of the pressure cooker prompt before starting the second session to increase the clarity of your story. Ensure to create a sense of **urgency** in the pressure cooker.

Starting the pressure cooker

After the break and designing the pressure cooker, the stakeholders will come back to the table. In the case that 2 actors are assigned to each role, make sure the other person is at the table. As a moderator you can choose to do another brief warming up exercise in character, like meeting the others in a hotel lobby. Make sure to address this in the introduction.

- Start the pressure cooker by introducing the time setting (5 years later) and the reason to convene (often the request of a relevant Minister)
- [When having new actors] Make sure everyone introduces themselves again
- Make sure any papers with information are withdrawn (such as role description) are removed from the table. This will help the actors act more freely.
- An overview of what has happened, the pressure cooker prompt
- An element to create a sense of urgency
- The request for a timely response
- [Depending on how comfortable actors are playing] Moderator leaves upon the prompt of another important meeting or call
- [Three quarters into pressure cooker] Moderator drops in to push for concrete outcomes, can decide to keep moderating

Intermissions and ending of the session

During the session there are two moments of reflection with the actors and observers on the roleplay and a break, one after the first discussion round and one after the pressure cooker. The moderator, or preferably a well-informed colleague, leads the reflection. During the break, the moderator is responsible for deciding on the prompt for the pressure cooker, together with the observers of the session.

How to reflect during session

Begin the reflection on what happened between the stakeholders during the play. Allow all people present to contribute to this. When possible, already make a link between underlying theories and observations. Some examples:

- Which tensions or conflicts did you observe during the discussion?
- How were the stakeholder positions distributed (dominant vs weak stakeholder positions, neutral vs engaged)? Who formed alliances, who were opponents?
- [To the actors] Why did you follow this particular strategy to defend your position during the discussion? Are you satisfied with the result of the discussion? How can you feed it back to your peers / colleagues?

Do not start off with the question of how it was to play, while it may be natural to do so. The discussion on the contents of the play will be difficult to start up afterwards. Also, this is a question that can be best left for the second reflection or feedback in a digital survey after the session.

During the **second reflection** round, try to **draw out contrasts with the first session** and reasons why this may have occurred. Especially a reflection on what the group of the first session could have done differently in the first session can be of interest.

Reflection assignment

The stakeholder roleplay can be combined with a reflection assignment to deepen the experience, e.g.:

- Describe the stakeholder dynamics you observed during the discussion. How did these change during the pressure cooker and why?
- Which Safe-by-Design elements did you observe in the roleplay? How could these elements impact the development of the technology?
- Which aspects could have been taken into account already in the first round of the discussion to overcome challenges and tensions present in the pressure cooker?
- Which conclusions do you draw from the roleplay for developing technologies in general?
- What other underlying theoretical concepts regarding stakeholder discussions are applicable to the roleplay?

The Play

This section provides an introduction to the play, your own role during the roleplay, an overview of the actors present, and the designed tensions in the discussion.

Context of the play

In the Plantenna research project microchips are developed that help to monitor the health status of a plant by measuring the surrounding temperature, humidity and the nutrition level of the plant. Microchips are attached to the plants of an orchard and linked to a network of sensors – the internet of plants. The development of the chips is at an early stage. In order to already take safety issues, environmental impact and implementation challenges into account, the researchers of the project, together with the municipality of Groningen, invited various stakeholders to discuss this issue. The researchers, municipality and farmer have agreed on conducting a pilot. The meeting aims to establish the design criteria for the product system.

Role description of moderator

As a civil servant to the municipality of Groningen, you know the alderman of Groningen on agriculture. They have asked you to chair the stakeholder meeting because of your extensive experience with chairing meetings and stakeholder discussions.

The stakeholder discussion is at the initiative of the project leader of the Plantenna project. They have asked the municipality to help facilitate this, which is the reason you are leading this meeting and why the discussion takes place at the city hall of Groningen.

Your aim is to enable all stakeholders present to put forward their perspective in full. In the beginning of the discussion, you love to solely intervene when the discussion comes to a halt. When this happens, you do not shy away from pointing out conflicting opinion or topics that are brushed over and giving this person the word. While it is up to the researchers to draw up the design requirements for the product, you try to ensure that this goal is satisfied towards the end of the discussion.

Overview of actors

Professor, Project Lead Plantenna

Enactor, strong focus on innovation, is precaution sensitive

The professor is strongly focused on the development of the chips and the underlying design choices. The professor believes that the sensor network can help increase worldwide production to meet requirements posed by an increasing population under the challenging circumstances of climate change.

Currently the chips are fabricated from silicon-based materials and metals. There is the possibility for the microchips to be developed in a biodegradable manner. The possible effects on the produce and environment when the chip breaks or degrades is unknown.

The scope of this character is limited to the product and its development. Implementational, contextual and regulatory considerations are brought in by the other actors.

RIVM

Selector, holds precautionary focus

The RIVM brings in the regulatory and product life-cycle perspective to the meeting. The RIVM wishes to avoid introduction of toxic- and rare earth materials into the environment, tries to ensure the safety of people involved in the full cycle, and prioritizes the safety of the produce.

The RIVM is faced with the pacing problem of regulation. It therefore wishes for the professor and farmer to make policy suggestions and have a pro-active stance. An outcome that applies to the process of the pilot in which relevant stakeholders are involved is an aim of the RIVM.

Farmer

Enactor of implementation, Selector of design, holds innovation focus

The farmer brings the implementational and business perspective to the discussion. The farmer prioritizes the safety of their fruit orchard, the ability to improve harvest and sell more produce, and the feasibility, reliability, and understandability of the sensor network and its data analysis.

The farmer wishes to maintain its autonomy and would rather not involve too many people in the process of monitoring.

Alderman of Groningen

Selector, Precaution focus

The alderman brings the (local) societal perspective, debate, and responsibility to the meeting. Their focus lies most on the concern raised by the municipal council: informing the consumers about how the crop was modified and potential hacks impacting the yield. Another concern raised by small-scale farmers concerns equal competition among farmers and avoiding richer farmers to outcompete smaller farmers. The required infrastructure for the network is another question the alderman needs to answer

The alderman steers for an agreement that accounts for unknown risks and problems that may arise during the pilot.

Director of ResSus Institute

Selector, Precaution focus

The director of the ResSus institute brings a global perspective on the development of the product including a discussion on equity in the context of the Global South and doubles the product life-cycle perspective of the RIVM. This stakeholder emphasizes environmental sustainability.

The possible reintroduction of harm by the product in your own ecosystem because of widespread use and regulatory differences in different nations is introduced by this stakeholder (think of shipments of crops in which the chips are still present or no checks on broken chips). This stakeholder could suggest a committee to aid adequate response to unexpected risks and enable effective policy development.

Designed tensions

Via the role descriptions of the characters, several tensions are implemented in the roleplay. Use this during the session to bring out topics and controversies that have to be discussed. Additionally, you can use this when designing the pressure cooker to identify tensions that have not been addressed but you would like to see emphasized.

Environmental and Food Safety concerns

Relates to the suggestions of design choices and requirements of the complete sensor system.

- Biocompatibility of the microchip in the context of material design.
    - Researcher has the option to shift to cellulose, biodegradable material. This brings durability and degradation concerns
    - RIVM wishes to avoid permanent or temporary deposition of toxic- and rare-earth materials

    - ResSus requires biodegradability of microchip in context of unforeseen circumstances
- Worker and environmental safety in life cycle of system (sourcing, processing, transport, use of product, lifetime of product, and end-of-life disposal)
    - RIVM draws on local scope and requires certainty regarding the safety of the people involved in the process and the environment in which the system is introduced.
    - Farmers wish as little external requirements as possible.
    - ResSus draws this to global scope, emphasize the enormous number of chips used and wish for its minimisation
- Cyber- and health safety
    - RIVM emphasizes the safety of the consumer, outlaws health hazards
    - Alderman minimising risk and pushes for informing consumer. Brings in a concern for hacks of the system, emphasizes need for secure networks.
    - Farmer does not want to scare customer and sell its produce. Wants to maintain simple and functional system.

Technology push

The technology can be seen as an inherent solution to the problem or scrutinised.

- Researcher believes that the technology is the best solution for this application.
- Farmer is keen on business case that it provides, improving revenue and scaling up of production at low cost.
- RIVM remarks that solutions introduce costs, invites a systemic perspective.
- ResSus is more sceptical (related to equity discussion)

Regulatory and implementational requirements

The requirements that are put to the use of the system can be debated.

- The RIVM looks at the farmer and the researcher to take up a pro-active stance regarding the policy required for the responsible implementation of the technology since current regulations do not apply
- ResSus introduces the possibility of reintroducing harm into your own system when the technology is spread over the world into different policy paradigms. Proposes restriction.
- Farmer wishes to maintain a system that is the least complex.

Alternative Uses

The technology brings opportunities that go beyond its initially intended use. Stakeholders can discuss how to deal with this.

- RIVM prefers to limit the uncertainty involved by restraining other implementations from the start. The focus should remain on the pilot for now.
- Farmer has big ideas regarding the business advantages they can gain. It could be used to monitor transport or help the flower industry achieve better outcomes.
- ResSus is involved in the alternative use discussion with the reintroduction of the above-mentioned harm argument.

Equity

The introduction of a new technology has the potential to shift around economical competition. This plays on local level between farmers in the region and on a global level related to the Global South.

- Alderman brings the concerns of small-scale farmers in the region who wish to avoid dominance of the biggest farmers in the region.
- ResSus presents perspective of the Global South needing to profit from these solutions as well. It fears enabling of remote farming and compromising autonomy of famers in Africa.

Inherent Uncertainty

This concerns how to deal with unknown unknowns during the pilot. Often relates to process-oriented solutions.

- Researcher reduces the uncertainty to the design choices made
- RIVM prefers on-the-ground check-ups on the pilot
- Farmer wants to remain in control themself, possibly downplays importance or assumes responsibility
- Alderman wishes to avoid controversy and minimise risk
- ResSus has the proposal to establish an oversight committee to respond to risks and develop policy in time.

Pressure cooker examples

Tech overdrive (amps up responsibility and regulation discussion)

- The technology is picked up really well and it now has multiple different uses
    - Annual crops are now also tagged (inflation of chips produced)
    - Transport of crops are monitored by applying sensors to the products to monitor moisture, temperature, contact with pesticides to ensure quality of the product
    - Flower industry also started using the sensors to optimise their production
- The many different countries involved complicate regulation of the technology => use of chip also in Global South countries with less strict or no regulation regarding the use of microchips => microchips were deposited in the environment or remained on the fruits => who is responsible for the environmental and health effects?
- [Urgency] Recently it was discovered that it regularly happens that the microchip tags are not removed before sale. People ate the microchips, and this has caused widespread public concern. They demand to stop the use of microchips on arable crops.

Taste control (amps up equity discussion)

- Farmers have been developing methods to control the taste of the final product of the crops using the microchips and the thereby enabled precision farming methods.
- Farmers who give taste guarantee have been consistently outcompeting farmers who are unable to provide taste guarantee.
- Different categories have been developed for the guarantee and unguaranteed products, price differentiation has been made.
- Farmers from the Northern hemisphere have thereby been dominating global food markets
- [Urgency] Farmers from the Global South have raised alarm that they are unable to sustain themselves and risk being brought up by large corporations against their will.

Underlying theoretical concepts

Safe-by-Design approach

Goal: Bringing science and engineering in accordance with societal needs and public values, considering safety aspects already at an early stage of development

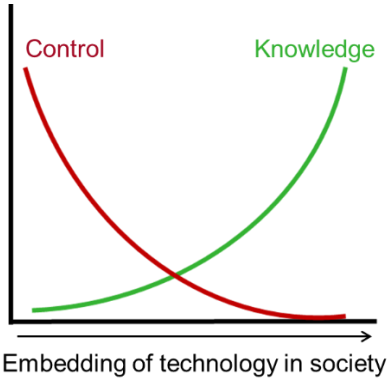
Mantra: Preventing harm is better than curing its consequences

Important Safe-by-Design values related to the roleplay (van Gelder et al., 2021):

- Safety (design choices, systemic aspects, and the normative perspective on safety and risk)
  - Material choice sensors with a focus on biodegradability / biocompatibility
  - A life-cycle / systemic view on safety issues
  - Consumer health
  - Environment surrounding the field
  - Addressing unknown unknowns, addressing unforeseen use, addressing normative ambiguity
- Wellbeing of developers, farmers, citizens, environment
- (Environmental) Safety and Sustainability / Planetary boundaries
  - Limit the use of Rare Earth Materials, if possible, look for alternatives
  - Restoring nitrogen cycle: excessive use of fertilisers which cannot be taken up by plants => excess nitrogen and phosphorous ends up in rivers / lakes and stress ecosystems => more precise and directed use of fertilisers would help
  - More sustainable use of farmland to restore biodiversity, overexploitation of freshwater use
  - Lifecycle assessment / circular design: Introduction of new entities, plastics, pesticides, pharmaceuticals, antibiotics and hazardous chemicals from industry and consumer products to the earth ecosystem has exceeded a boundary => need for circular approach to reuse and recycle products
- Equity among farmers in relation to competition, among people in relation to food scarcity, among countries (higher yield for lower prices presses the prices others can ask)
- Regulation involved, pacing problem: technological change outpaces political change, policy cannot take responsibility for the safety of the innovations
- Governance/policy of the implementation (safety culture, stakeholders involved, decision making processes)
- Responsibility: Example of roman bridge engineer standing under bridge upon crossing of first carriages => build something you sure is safe

Collingridge dilemma

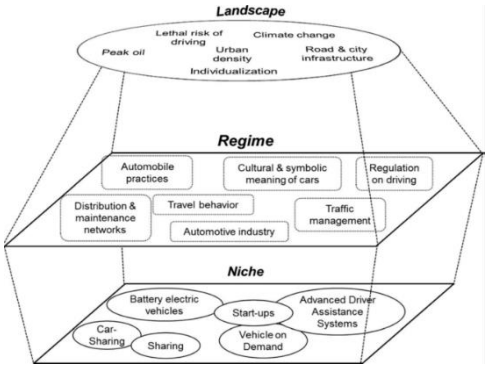
- The further the technology is developed, the more specifics are known about the technology, its design and foreseen implementation and use
- The further the technology is developed, the smaller the room to induce changes in the technology design or application
- Proposed solution to cope with this dilemma (Collingridge, 1982): accompany the development and design process with regular societal assessments of the technology to be able to adapt the technology accordingly towards a societally desirable technology



Role play: many uncertainties regarding technological design and implementation create (known and unknown) unknowns

Responsible Research and Innovation

- Responsible Research and Innovation (RRI) is an umbrella concept of different policy agendas and approaches to anticipate and assess societal implications and expectations of research and innovation
- The goal of RRI is to create an inclusive, collaborative, and sustainable research and innovation process which aligns with the needs and expectations of society
- 4 dimensions of RRI have been proposed by Owen et al. (2013): anticipation, reflexivity, inclusion and responsiveness
- **4 dimensions in the role play:** *anticipating* use and application to develop a safe technology, *inclusion* of relevant stakeholders early in the development process, *reflexive* evaluation of current work practises in the project, and according adaptation of the design process (*responsiveness*)



Multi-level perspective (Fraedrich, Beiker & Lenz, 2015)

- The regime level describes the current socio-technical system in which a certain technology or sector is established, with accepted procedures of fabrication, user behaviours, cultural meanings, policies and regulations (see also Geels 2005)
- In the Niche level, new technologies can develop in protected spaces which eventually may or may not replace (part of) the socio-technical system
- The landscape level contains of broader and uncontrollable developments like globalization, climate change, political developments
- **Role play:** The new technology is developed in a niche but might become part of the general socio-technical system of agriculture, favoured through landscape developments such as climate change, increased population or food scarcity

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Appendix 1: Moderator Cheat Sheet

See next page

Plantenna Moderator Cheat Sheet: Preparation

Duration (1h 45m)	Subject
5 min	Introduction
10 min	Reading time
10 min	Warming up
20 min	Session 1 "CTA"
15 min	Reflection 1
15 min	Break and Prep pressure cooker
15 min	Session 2 "Pressure Cooker"
15 min	Reflection 2, Theory, & Reflection assignment

Setting the scene

Introduction

- Method origin (TTA)
- Outline of today
- Goals of the session
- The technology
- Aim of stakeholder meeting
- Introduce roles and impersonate briefly
- Distribute roles

Goal of Meeting:
Decide on details and success-criteria of pilot in Groningen

Stakeholders:
Professor | RIVM | Farmer | Municipality | ResSus (NGO)

Warming up

- Circle of emotions, sentence + emotion
- Silent walk around in character
- 1 min introduction as character
- Cheerleading, hype each other up
- Clapping, pass a clap around the circle

Tips

- Be enthusiastic
- Provide implicit assurance by acting
- Play your own role
- Fun and laughing allowed!

Checklist
To bring

- [ ] Moderator Cheat Sheet **1x**
- [ ] Technology Description **X** number of attendees
- [ ] Role Descriptions **5 or 10** (double roles)
- [ ] Observer Instuctions **X** number of non-players
- [ ] Sturdy sheets of paper **6 or 11** (double roles)
- [ ] Markers for writing the character names
- [ ] Watch to keep time

Plantenna Moderator Cheat Sheet: The Play

Tensions
In discussion

Environmental safety, Biodegradability of the sensor and introduction of toxic materials
Food Safety, Potential toxins in the produce
Need for regulation, policy lag and uncertainty creates role for innovator
Equity, Impact of large scale implementation of technology on farmer communities
Inherent Uncertainty, dealing with unknown problems during the pilot
Responsibility, for process and consequences

Kick off Session 1
Bring up in introduction

The setting: City hall of Groningen
Reason for meeting: Intended roll-out of the plant-integrated sensor network technology
Goal of the meeting: Decide on details and success-criteria of pilot in Groningen
Initial risks: Safety of the produced foods | Safety of the technology for those who can encounter it | Do we need to collect and dispose of the chips after use | The potential and desirability of wide spread implementation

Pressure cooker design

Start with the outcome of the first session
Imagine a situation 5 to 10 years in the future
Base the scenario on
- Desired changes in stakeholder dynamics
- Tensions that have remained unaddressed

Make it urgent
Examples:
Technology takes off, is used for many crops incl. transport globally. Microchips not removed from produce, eaten
Farmers can **control taste** by manipulating nutrient inflow. Market is disrupted, Global South disadvantaged

Duration (1h 45m)	Subject
5 min	Introduction
10 min	Reading time
10 min	Warming up
20 min	Session 1 "CTA"
15 min	Reflection 1
15 min	Break and Prep pressure cooker
15 min	Session 2 "Pressure Cooker"
15 min	Reflection 2, Theory, & Reflection assignment

Appendix 2: Technology description

Changing weather conditions, floods and droughts, environmental pollution and urbanization are great challenges farmers around the world are faced with. To cope with these problems, the 4TU Plantenna project has the goal to develop sensors to accurately monitor the health status of crops to enable precision farming. The individual sensors can be attached to the stem, leaf or root of a plant and are linked together in an automated network, the 'internet of plants'. The information gained from this network of sensors can be used by the farmers to take the most effective measures to improve their yield and be less dependent on environmental effects under the influence of climate change. Because these sensors form a network, they enable the detailed monitoring of crops in high resolution and real-time. The vitalities of individual plants can be measured and the surrounding humidity can be assessed – a new approach called 'precision farming'. This enables the farmer to optimize the use of plant fertilizer and water, enhance drought protection, and support decision making to improve environmental protection schemes and climate resilience.

Currently, the sensors are fabricated by standard, well-established cleanroom techniques using silicon-based materials and metals. The full functionality of the chip has been confirmed by recent prototypes. How long the sensors can be used depends on the type of crop, varying from various seasons for perennial plants like fruit trees to one cycle for annual plants like tomato plants. What happens to the sensors afterwards is not yet fully clear, whether they can be re-collected or will remain in the soil. Also, the best material for making the microchip for the final pilot is still explored within the project.

Aside from monitoring vitality of plants and humidity, the sensors can also measure the temperature in an orchard close to the plant itself. Because of this feature, the farmers can avoid the loss of young fruit buds due to frost in early spring nights. This is particularly useful for some local farmers in the Groningen region who have struggled with this problem for a long time.

Scene 1

The Dutch province Groningen has the highest area of land used for arable farming in the Netherlands (~840 km^2) and accommodates a variety of orchard types, including apple, pear, plum and berries. In discussion with the municipality of Groningen and local farmers, the researchers of the Plantenna project are planning to run the first field tests of a sensor network measuring the temperature in the orchards of this province. Because the sensors will be attached to the stem of the fruit trees, the ecological safety of the device is important and the system needs to comply to environmental, food safety, and privacy regulations. Especially since the crop produced during the pilot is intended to be sold to regular supermarket customers. Additionally, feasibility of the implementation must be considered. If the trial is successful, the researchers hope that the sensors can move towards the next phase of production to become a real product. Therefore, the researchers have asked the municipality of Groningen to organize a meeting with several stakeholders. Next to the researchers themselves, a representative of the municipality of Groningen, a local farmer, and environmental- and regulatory authorities are invited. The goal of the meeting is to work out the details of the pilot and define its success-criteria. The focus lies on the safe design and secure implementation of this technology and on potential environmental and economic risks that this technology can introduce.

Appendix 3: Role descriptions

Professor and project leader of Plantenna

Enactor, strong focus on innovation/precaution-sensitive

As chairperson of the Plantenna research project[1] 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).

Factsheet
For the pilot only one chip per apple tree is needed, for more dense crops you expect to need at least five per m^2. 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.

[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

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], 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.

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.**

[2] Based on https://www.rivm.nl/rivm/organisatie/centrum-duurzaamheid-milieu-en-gezondheid

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.

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*

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.

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]
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.

[3] High-performance green flexible electronics based on biodegradable cellulose nanofibril paper | Nature Communications

Appendix 4: 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).

Factsheet
For the pilot only one chip per apple tree is needed, for more dense crops you expect to need at least five per m^2. 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], 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.

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.**

[4] Based on https://www.rivm.nl/rivm/organisatie/centrum-duurzaamheid-milieu-en-gezondheid

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.

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.*

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.

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]
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.

[5] High-performance green flexible electronics based on biodegradable cellulose nanofibril paper | Nature Communications

Appendix 5: Observer description

Your task is to carefully observe the discussion, identify the dynamics and conflicts between the different stakeholders, and find important tensions relevant for the development of the technology. You can take notes during the discussion of interesting behavior you see. The following questions might help you during your observation:

- Which stakeholder is dominant in the discussion and who is rather weak?
- Which conflicts and tensions come up during the discussion? How do the stakeholders react upon these issues?
- Who formed alliances? Who oppose each other?
- Which tensions, concerns or risks of the technology become visible during the discussion? How do the stakeholders react to this?

After the first discussion round we move to the 'pressure cooker' – a scene in the future in which the same stakeholders need to discuss action points for the technology. To help design this focus on these questions:

- From the earlier discussion, which points would be interesting to follow up on?
- Where do you see tensions in the future?
- Which event could be a gamechanger for the technology or for the stakeholders involved?

During the second discussion round you focus on these questions:

- What does the outcome of the discussion mean for the development of the technology?
- Which design adaptations could be made in the technology / implementation in order to prevent some of the discussed problems?
- How do the proceedings of the first session affect the current discussion?

Enschede, 2022

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