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Science, Technology & Innovation for Sustainability: Towards transformative change

KVAB THINKERS' REPORT

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Glossary

Word or abbreviation:	Definition:
Constructive technology assessment:	A form of technology assessment that integrates a concern for social and ecological consequences early into the design of technology development, and encourages to include a broad range of perspectives and societal actors.
Deep transition:	A fundamental change of society that spans across multiple coupled socio-technical systems and seeks to influence underlying rule-sets such as linear production (instead of circular) and carbonization (instead of de-carbonization) that drive socio-technical system change.
Directionality:	Socio-technical change is always optimizing in specific ways, for example it terms of labour productivity, or resource use. These specific ways provide technological change with a direction.
Frame 1:	An STI policy framework aimed at ameliorating knowledge production and R&D investments for progress and economic growth.
Frame 2:	An STI policy framework aimed at ameliorating "National systems of innovation" by building absorptive capacity and stimulating entrepreneurship in order to enhance national competitiveness and economic growth.
Frame 3:	An STI policy framework that takes addressing environmental and social challenges as its central aim through questioning assumptions about the directionality of technological innovation processes and by taking an aspiration towards sustainable socio-technical system change or transformation as a starting point.
Food value chain	A food value chain, according to FAO, consists of all the stakeholders who participate in the coordinated production and value-adding activities that are needed to make food products.
Food system	A food system, according to FAO, encompasses the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products. Food systems comprise all food products that originate from crop and livestock production, forestry, fisheries and aquaculture, as well as the broader economic, societal and natural environments in which these diverse production systems are embedded.
Incremental innovation:	Small improvements to existing products or services.
Niche:	A protected environment (can be a proto-market or a small market) where novel technologies and rules can develop and mature as they are not exposed to the strong competition present within the regime.

Parliamentary technology assessment(PTA):	A form of technology assessment that aims to inform democratic decision making on the potential unintended negative consequences of STI on society.
Radical innovation:	Innovation that destroys or supplants existing business models.
Regime:	The set of rules, actors and systems characteristics that provision a basic need in a society, such as mobility, energy, food etc.
Responsible research and innovation:	A term used to describe scientific research and technological development processes that take into account effects and potential impacts on the environment and society.
Rules:	Rules constitute the heuristics that actors use to structure their thoughts, decision-making and actions. They are embedded in values, beliefs and normative and legal sanctions. Rules both shape and are shaped by socio-technical developments. Consequently, socio-technical systems should be seen as expressions of underlying rules.
Social innovation:	(e.g. the development of new business models, new cultural perceptions, user preferences and new types of policies)
Societal embedding:	A technology or service becoming embedded within existing markets, infrastructures and legal & regulatory frameworks.
Socio-technical system:	A set knowledges, technologies, policies, markets and cultural practices that are aligned and interact in order to provide a specific service to society.
System optimisation:	Optimising current practices and processes (or dominant directionalities) within a given system.
System change/ System transformation:	A radical change of the system as a whole, encompassing significant changes in rules & routines, and directionality.
Technology assessment(TA):	The early identification and assessment of eventual impacts of technological change and applications.
Transformative Innovation Policy (TIP):	See “Frame 3”
Unsaturated oils	Unsaturated oils are plant-based fats that are liquid at room temperature. It excludes hard plant fats, like coconut oil and palm oil.

Introduction

Science, technology and innovation (STI) play a crucial role in shaping society as we know it. Innovations such as the combustion engine, electronics and the internet have led to a continuously transforming society that is radically different from that of even a few decades ago. Although STI has always been one of the main drivers of growth, development and wellbeing, it also serves as the root cause of some of society's 'grand challenges' such as climate change, growing inequality and pollution. Since the invention of the combustion engine, greenhouse gas emissions resulting from human activities have likely caused roughly 1°C of global surface temperature increase[1]. Similarly, developments in material sciences have led to persistent organic pollutants now being found in the blood serum of nearly everyone above the age of 12[2]. Technology and innovation are implicated in many of the complex global challenges the current world is facing. As the urgency of these challenges rises, the necessity of governmental STI policy as a means for mitigating and solving current and future challenges becomes increasingly apparent.

In light of these developments, the Thinkers' Programme Sustainable Innovation of the Royal Flemish Academy of Belgium for Science and the Arts (KVAB) set out to address the following question within the Flemish context: Is novel STI policy needed in order to promote sustainable development, in particular to mitigate or solve global challenges? Sustainability has become a prevalent theme in public discourse among politicians, scientists and the general public[3]. Collective goals, Sustainable Development Goals (SDGs) have been set to solve these global, societal challenges[4]. Consequently, several recent STI funding programs such as Europe's 'Horizon Europe' and Sweden's Challenge Driven Innovation programs emphasise sustainable development with the aim of tackling societal challenges. In order to understand how STI policy can contribute towards solving societal challenges and promote sustainable development, it is important to first understand the intervention logic behind STI policy. When examining the role of STI policy through history, three distinct framings and accompanying justifications for government intervention can be identified[5,6]. The first framing emerged after WWII and stems from the notion that, following a linear model of innovation, increased investment in R&D will automatically lead to an increase in innovation activities and consequently stimulate development, economic growth and welfare. Economists argued that market conditions insufficiently incentivised investment in R&D up to the desired level of 3% of gross domestic product (GDP), according to the OECD and EU, thus justifying STI policy as a means to fix this *market failure*. Within this framing there is a recognition that innovation may lead to unintended negative consequences such as pollution, but that these can be mitigated with more science, technology and if necessary, regulation. The second framing arose in the 1980s when differences in the innovative capacity of countries indicated the importance of appreciation and application of knowledge and technology by industry (absorptive capacity) within "National Systems of Innovation". In framing 2, innovation is seen as the product of interactions and collaborations between science, industry, government and societal actors within an innovation system. In the instances of lacking infrastructures, institutions, interactions and capabilities to support innovation, government intervention is justified as a means to alleviate *system failure*[7].

Within framing 2, the method of technology assessment is recognised as an important tool to detect potential unintended negative consequences during the innovation process and in the implementation in society. This allows for facilitating the development of mitigation strategies and remedies at an earlier stage. The third framing is called "Transformative Innovation Policy" and has gained popularity in the past decade, originating from the conviction that addressing societal challenges requires rigorous transformation of socio-technical systems such as our energy, mobility and food systems[8]. Within framing 3, technological innovation is considered to be inherently value driven (and thus not neutral) as it shapes both the challenges and solutions that characterise our society. At the same time, frame 3 recognises that innovation and society in interaction will define the innovation pathway. Framing 3 states that STI policy should provide directionality, thereby facilitating transformations of socio-technical systems through technological and social innovations, thus alleviating a third type of systemic failure: *transformational system failure*. Within framing 3, technology assessment plays a critical role since it makes up the starting point of STI policy, providing the foresight, second-order learning[9] and reflexivity needed to address complex societal challenges.

For the KVAB Thinkers' Programme 2021 cycle, the Steering group (see app. 2 for members Steering group) invited two recognised international experts to discuss the theme of STI policy for sustainable innovation within the context of Flanders: Melanie Peters, former director of the Rathenau Institute and Johan Schot, professor at Utrecht University Centre for Global Challenges. After the untimely passing of Melanie Peters in August 2021, Petra Verhoef, theme coordinator *Maakbare Levens* (Making Perfect Lives) of the Rathenau Instituut was found to be a suitable replacement to continue her duties as a Thinker. Both Johan Schot and Petra Verhoef have an extensive knowledge base and experience when it comes to the interface of Sustainable Innovation, STI policy and Society (see app. 1 for their CV's). Supported by the Steering group and Vincent Baarslag (researcher in the area of STI policy and Society at Rathenau Instituut), the Thinkers developed their ideas through presenting a position paper (see app. 3), desk research, engaging in two roundtable discussions and interviews with key experts and stakeholders, as well as presenting their preliminary findings and discussing them with expert panels and members of the audience during a symposium hosted by the KVAB. Subthemes during these discussions included but were not limited to: the role of STI policy in addressing societal challenges; governance of STI policy; the societal implications of STI policy; transition policy; responsible research & innovation; constructive technology assessment; design, implementation & evaluation of responsible STI policy and so forth. 'Sustainable agriculture and nutrition' was a specific case in the programme.

Following the initial dialogue with the Steering group, the Thinkers presented a position paper (see app. 3). The three aforementioned framings were outlined in more detail within this, after which several concluding remarks regarding the design and implementation of STI policy were made:

- Currently, three frames co-exist in STI policies, and each of them fulfils an important role. More emphasis on framing 3 is required for innovation to play a prominent role in finding solutions to complex global challenges such as those detailed in the SDGs.

- There are no best and optimal approaches to complex problems. It is therefore important to allow for societal experimentation and consulting, a structured learning process informed by evidence and experience to explore potential transformation paths and their consequences.
- The subsequent large-scale implementation will require a process of niche construction, as well as de-stabilization of the dominant system. Eventually the niche may become a new system: actors supporting the dominant system need to open up for change, and become promotors of the niche for this to be able to happen.
- Investing in this process of experimentation and niche construction requires new forms of evaluating the innovation process and the impact thereof. It means engaging with the evaluation process itself, inducing second order learning and reflexivity. This type of formative evaluation differs from traditional evaluations of public policies, since they are participatory, and seek to assess and stretch the level of transformation in the experiment.
- Impact assessment becomes impact construction. Technology assessment becomes Constructive Technology Assessment[10], and innovation turns into sustainable innovation because impacts are integrated into the design and implementation of innovation practices in a participatory manner and aimed to help solve societal challenges.

These conclusions served as the starting point of two roundtable discussions, during which participants were asked to debate the conclusions from the position paper within the local Flemish context. The Thinkers were able to familiarise themselves with local perspectives on STI (policy) as a result of this.

Roundtable discussion 1 with key experts and stakeholders regarding general STI policy:

- Participants:
    - Hans Willems, FWO
    - Willy Verstraete, KVAB, FWO
    - Danielle Raspoet, VARIO
    - Dirk Van Dyck, KVAB, VARIO
    - Mark Andries, VLAIO
    - Anton Muyldermans, Cabinet, Staatssecretaris Relance en Strategische investeringen,
    - Steven De Pauw, GO!
    - Marc Van Montagu, KVAB, UGent
    - Erik Paredis, UGent
- Thinkers and Steering group members:
    - Petra Verhoef, Thinker, Rathenau Instituut
    - Johan Schot, Thinker, Universiteit Utrecht
    - Dominique Van Der Straeten, coordinator Thinkers' cycle, KVAB, UGent
    - Guy Marin, KVAB, UGent
    - Bart Verschaffel, KVAB, UGent

- Freddy Dumortier, KVAB, UHasselt
- Vincent Baarslag, Rathenau Instituut

Roundtable discussion 2 with key experts and stakeholders regarding STI policy within the context of the Flemish food system:

- Participants:
  - Karin Op de Beeck, Vlaanderen Circulair
  - Louis De Jaeger, Commensalist
  - Stefaan De Smet, UGent, CUSTOMEAT project Food2Know
  - Lieven Thorrez, KU Leuven, CUSTOMEAT project Food2Know
  - Kurt Sannen, Voedsel Anders
  - Heleen De Smet, Bond Beter Leefmilieu
  - Jan Wyckaert, Rikolto
  - Joris Relaes, ILVO
- Thinkers and Steering group members:
  - Petra Verhoef, Thinker, Rathenau Instituut
  - Johan Schot, Thinker, Universiteit Utrecht
  - Dominique Van Der Straeten, coordinator Thinkers' cycle, KVAB, UGent
  - Guy Marin, KVAB, UGent
  - Bart Verschaffel, KVAB, UGent
  - Freddy Dumortier, KVAB, UHasselt
  - Vincent Baarslag, Rathenau Instituut
  - Inez Dua, KVAB staff

In order to gain more in-depth insights regarding Flanders' general STI policy and specific STI policy for the agro-food sector, Vincent Baarslag conducted three follow-up interviews with Mark Andries (VLAIO), Joris Relaes (ILVO) and Kurt Sannen (Voedsel Anders). The Thinkers used the findings of the roundtable discussions and interviews along with desk research to gain an understanding of current STI policy and practice within the local Flemish context. The Thinkers then formulated their preliminary findings and presented them during the final symposium in the Paleis der Academiën on the 23rd November 2021.

Programme of Final Symposium:

Part 1: Plenary sessions

09:30-10:00 Registration and welcome

10.00-10.15 Official opening by Elisabeth Monard, chair of the KVAB,

Foreword by minister Crevits

10.15-11.15 Presentation by Johan Schot

Panel discussion including: Dirk van Dyck, Robby Berloznik, Anton Muyldermans

11.15-11.45 Break

11.45-12.45 Presentation by Petra Verhoef

Panel discussion including: Joris Relaes, Inge Arents, Kurt Sannen

12.45-13.00 Introduction of group sessions

Part 2: Group sessions

14.00-14.15 General introduction and Q&A

14.15-16.00 Workshops on Flemish STI policy (within the food sector)

Part 3: Plenary session

16.00-17.00 Final session

17.00-18.00 Reception

This Thinkers' report on Science, Technology and Innovation for Sustainability consists of two essays written by the Thinkers. The essays were written separately, based on the knowledge and expertise of the individual Thinker, but are both rooted in the same findings from the aforementioned roundtable discussions, follow-up interviews and desk research, as well as the panel discussions and workshops that took place during the final symposium. The first essay was written by Johan Schot, and describes the current STI policy landscape, highlighting its strengths in fostering excellent science, increasing R&D expenditures and stimulating knowledge valorisation as well as its lack of focus on system change. The second essay was written by Petra Verhoef and examines STI policy for sustainability within the context of the Flemish food sector. She concludes that Flanders has a broad vision for its food system, but that this vision has yet to be translated into STI policy that supports it. Following the essays, a few conclusions and recommendations are provided.

References

[1] IPCC (2021). Climate Change 2021: The Physical Science Basis. available from https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report_smaller.pdf

[2] Kato, K. Wong, L.Y. Jia, L.T. Kuklenyik, Z. Calafat, A.M. (2011). Trends in exposure to polyfluoroalkyl chemicals in the U.S. Population: 1999-2008. Environ. Sci. Technol., 45(19), pp. 8037-8045.

[3] United Nations Development Programme. (2021). The Peoples' Climate Vote. available from https://www.undp.org/publications/peoples-climate-vote

[4] UN General Assembly. (2015). Transforming our world: the 2030 Agenda for Sustainable Development, A/RES/70/1. available from undocs.org/en/ A/RES/70/1

[5] Schot, J.W. Steinmueller, W.E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. Res. Policy, 47(9), pp. 1554–1567.

[6] Weber, K.M. Rohracher, H. (2012): Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive 'failures' framework. Res. Policy, 41(6), pp. 1037-1047.

[7] Klein Woolthuis, R., Lankhuizen, M., & Gilsing, V. (2005). A system failure framework for innovation policy design. Technovation, 25(6), 609–619.

[8] Schot, J., & Steinmueller, W. E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. Res. Policy.

[9] Observing our own processes of evaluation and the impact they have on our behavior or outcomes of innovation.

[10] Later on, in the Essay of Petra Verhoef we will learn that there is also Parliamentary Technology Assessment which, among other, aims to inform democratic decision making on the potential unintended negative consequences of STI on society.

Empowering transformative change by science, technology and innovation policy

An essay for the Thinkers' Program Sustainable Innovation of the Royal Flemish Academy of Belgium for Science and the Arts (KVAB)

Johan Schot, Utrecht University Centre for Global Challenges

March 24, 2022

Setting the scene

The world is facing a number of huge environmental and social challenges. Together they represent a perfect storm and contain unprecedented risks. The disastrous effects of climate change, floods, fires, famine, droughts, extreme heat, threaten our very existence. The species extinction rate is now 10-100 times higher than at any other point in the past 10 million years, leading to irreversible biodiversity loss. By 2050 there could be more plastic in the sea than fish. Next to these very clear environmental warning signs, we see growing poverty and inequalities, enhanced by the current COVID-19 pandemic, growing geopolitical tensions that has resulted in a war at the heart of Europe and a rapid increase in non-State conflicts. The international order built after the Second World War is no longer particularly effective. On the national level, social protection schemes are faltering, and the trust people have in the state is eroding. Because of this complex of political developments and global challenges many commentators have argued we are at a turning point in history, humanity is facing a stark and urgent choice: a breakdown or a breakthrough as it recently stated in the 2021 United Nations (UN) report of the Secretary-General *Our Common Future*. We are at an inflection point in history.[1]

Already in 2015 the UN published Agenda 2030 detailing 17 Sustainable Development Goals (SDGs) with an underlying message that addressing these SDGs implies transforming our world.[2] Transformation is about technical change, but not in isolation. It needs to connect to fundamental changes in consumption and production patterns, to reduction in poverty and inequalities, the reformulation of needs, and the development of new more sustainable practices, behaviours and aspirations such as not owning a car and a plant-based diet. When all of these changes become aligned in a new architecture system change is happening. This idea of system change is central to this report. How to define it then? In 2015 the OECD published a report on system innovation, defining it as "a radical innovation in socio-technical systems which fulfil societal functions, entailing changes in both the components and the architecture of the systems".[3] Below there is a more elaborate discussion on socio-technical system change, here I want to stress that it is neither about technological solutions nor behavioural solutions. It encompasses both including the connection between them.

Until now the dominant response is to target and regulate high emitting sectors or specific issues and focus on reductions through technological solutions that do not need substantial

behavioural change. Often simply because politicians, policymakers and many companies understand that major collective behavioural change is very difficult to achieve, it is often not popular with voters and mainstream consumers, needs a long-term strategy facing radical uncertainties, and may lead to failure. The approach to avoid behavioural change and focus on technological fixes can lead to results. The ozone layer depletion problem has been addressed with this approach in the past for instance. Another example of such a solution is the introduction of biofuels for airplanes, a solution that would not invite to change our travelling behaviour but may help reduce CO2 emissions. In this case however it is clear that such a solution will not take away climate threats. We need to consider the development of alternative mobility solutions combining the use of airplane and trains in a new mobility service package. This tendency to focus on technological solutions that do not demand considerable behavioural change from voters and consumers is also present in the trend of substituting current gasoline cars by electric vehicles. This is not a full-on system change because the aspiration to own a car is yet further stimulated while many consumers may never be able to buy such a car. Yet the electric vehicle may be a steppingstone towards system change, and thus one could say that it is an example of partial system redesign. On the one hand, if the energy used by electric vehicles is green, they do contribute to solving the climate crisis. Moreover, this substitution process impacts the system as it demands changes in industry strategy of car manufacturers, and changes in infrastructure, transport and tax policy. Full system change would tie electrification of cars to car sharing and reduction of car use. Consumers would no longer desire to own a car. Only then we are generating a breakthrough that involves consumer behaviour, as well as addressing the transformation ambition of the UN sustainable development goals, which do call for changing consumption patterns as well as reducing inequalities (see Figure 1).

System changes or breakthroughs are needed for many other systems and areas, not just for mobility. For example actors in the agri-food system may focus on developing precision agriculture, reducing the use of pesticides and other inputs, and on improvements in food products (using less sugar or salt for example). These types of changes are important and make a contribution to achieving the SDGs, yet also in these cases it is clear that actors in this system should aim for deeper changes rebuilding the agricultural and food system into more regenerative and ecological directions and refocusing on quality instead of quantity as is discussed by my fellow Thinker Petra Verhoef in her contribution to this report. Actors should aim to no longer use many and huge amounts of external inputs (fertilisers, pesticides), and making larger changes to our diets, producing and consuming substantial more plant based foods and drinks.

The 2021 UN Report Our Common Future is very clear, it calls for system change, not just system optimization because only the former change process will generate the type of impact we need. In fact there is widespread international recognition that addressing SDGs requires system change.[4] On top of that it is clear that system change needs to happen not just in one system, but in many systems that sustain our world: from mobility, to energy, communication, food and agriculture, water and healthcare.[5]

Thus at this moment in time two directions are on offer: system optimization and system change. Many actors are focusing on the former option, taking more steps to reduce emissions, while other actors work on the latter. For example the energy sector is transforming in a more fundamental way through the massive introduction of wind and solar energy. However, even for the energy system the rate of change is too slow, many possible solutions are not scaling quickly enough and investments are still flowing to fossil fuel solutions including coal. In many recent scientific reports therefore, calls for action focus on system change at a required

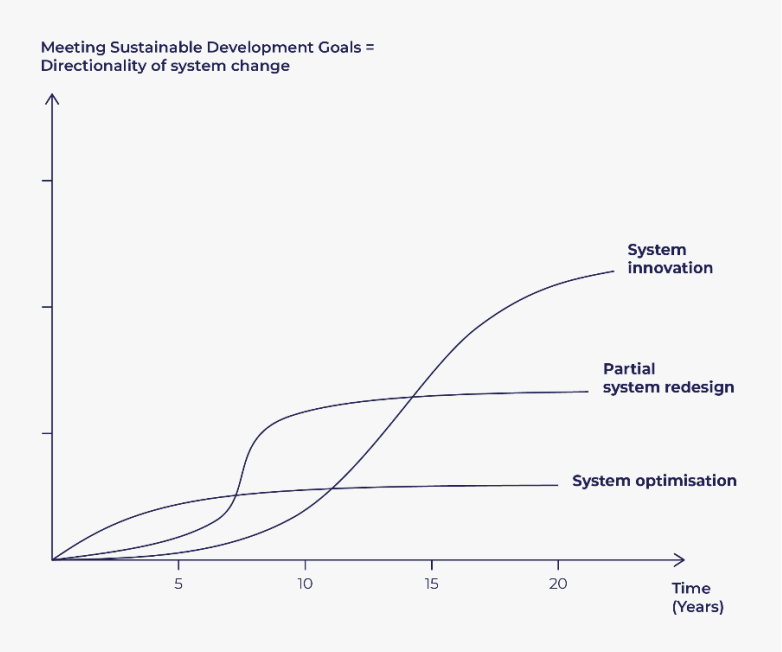

Figure 1: The difference between system optimisation, redesign and system change (innovation) in terms of lead time and impact. The figure shows that system innovation takes more time, impact may come later, yet they will change the directionality of prevailing systems more radically generating much more encompassing impact in terms of meeting the Sustainable Development Goals. Source: adapted from Weterings et al, 1997).[6]

speed or scale, arguing that otherwise humanity is threatening long term stability and prosperity. If the appropriate action is not taken, future generations will have to pay high economic and social costs (such as having to adapt to a new climate, massive loss of biodiversity, a more polluted world and a range of new inequalities that will come with this). The message is: winter is coming, expect shocks, the world needs to take a transformation pathway before it is too late. Simply focusing on adaptation and building up resilience for climate and other shocks is not sufficient. Mitigation strategies focused on transformation may be the most apt way for creating resilience.[7] This call for an unambiguous focus on system change does not exclude certain type of system optimizations. It invites to look at system optimization as a steppingstone for system change. For example precision agriculture may make farmers much more aware of the need to use much less chemical substances, and this awareness may lead to a willingness to accept more long term changes. Similarly for the energy transition, it has been argued that we need gas as a transition fuel, accepting it will be phased out but later.[8] This line of thinking and action has its own risks since system

optimization may create a lock-in into pathways that do not sufficiently address the deep problems the world faces, and may prolong the life of options that are part of the problem.

Even if the need for system change is accepted by various actors, including consumers, it is still difficult to accomplish, even in the face of clear signals that we are heading towards catastrophes. Why is this the case? One answer is that there are many factors at play, and for each solution and system we can identify a range of economic, political, social and cultural barriers and enabling conditions. System change needs collective action from and coordination of many actors across the economy, and across ministries. A second more fundamental answer is that system change challenges routines, aspirations, beliefs and values of many actors as well as their underlying assumptions about their role in and contributions to the problems and solutions. In the transition literature these routines are called rules that guide and shape actor behaviour.[9]

Rule change has happened in the past, hence it is possible. For example rules that stress individual consumption have replaced rules that prefer collective consumption. During the interwar years in the twentieth century fierce competition developed between the visions of a mobility system where cars or public transport would be dominant. The former won, and shaped post-war mobility developments. Another example is the development of the housing system where individual cooking and washing replaced interwar collective practices in these areas. A further example is the rule demanding scaling and industrialization, instead of craft based and smaller production options. The argument is not that we should return to rules of the past (although we should not refrain from reflecting on our history and use it for inspiration and learning purposes); instead the argument is that we need a Second Deep Transition with new type of rules at the heart of the transition process.[10]

To achieve such a Second Deep Transitions focusing on educating individuals to behave in a more sustainable way is not sufficient; even if they were to try, they would still be producing and consuming in systems that invite unsustainable behaviours. The system will beat individual choices. Many consumers who may want to consider not owning nor even driving a car will not be able to act on this in an environment in which cars are clearly the cheapest and more efficient means to travel from A to B. Cars are also an expression of consumer identity and status. In such a situation, some consumers may be willing to give up owning a car, and even more may develop an ambivalence towards owning and driving a car and optimise their behaviour (driving less), but the overall effect on the system will be minimal; it will not create radical change, nor will SDG targets be met. Similarly changing the pricing of consumer goods (such as cars, energy or food) will not be sufficient, it may achieve any given level emission abatement at a lower overall cost than regulation, thus making the current systems more efficient, yet as a tool for achieving system change it will fail because producers and consumer will be willing to pay the price, if they have not developed an aspiration to change their routines. Higher prices may in fact lead to greater inequality because access to mobility will be more limited, energy poverty will proliferate and sustainable food will be enjoyed by a small segment of the market. The argument is not that educating and pricing policies are unimportant, it is that they need to be embedded in broader policy focused on system change.[11]

System change is a society wide process, it involves producers, consumers, regulators, civil society and knowledge-producing actors. It will therefore need a whole of society and a whole of government approach. How then can system change be accomplished? Is it even possible? The answer is yes because our own history shows it has been done. In 1950 for example the mobility system in Europe was not dominated by cars. In the Netherlands people travelled longer distances by foot and bicycle than by car which changed completely in the 1960s. Mixed farming dominated in agriculture and supermarkets hardly existed as a distribution channel. Energy provision was more localised and dominated by coal. Oil and gas were developing in niches, but their steep rise in use and the rapid decline of coal as the main energy carrier was not predicted by energy experts. The European economy was still a frugal one, in which consumers were focused on repair and recycle. This then again all changed in the 1960s within a single decade; producers learned how to produce in mass and consumers learned how to consume. Energy, mobility and food systems changed dramatically. This all led to economic growth, the build-up of a welfare state in many countries in the Global North, unleashing a so-called Golden Age, as well as the so-called Great Acceleration.[12] These are not changes which came out of the blue, they had been prepared and developed in niches during the first half of the twentieth century. From a longer-term historical perspective, they were the result of the Industrial Revolution or what I will call below the First Deep Transition. A main driving force of this First Deep Transition has been the development of a desire and longing for modernization and industrialization by almost the entire population.

The upshot of my argument is that the main question we should ask is not whether certain interventions and developments lead to less emissions, pollution or reduce inequalities. Instead public policy should focus on asking the question whether a specific set of interventions will accelerate a system change or a transition in a more sustainable direction. If successful these systems will then (almost automatically) support optimising sustainable behaviour since this type of behaviour is invited by the rule-sets driving system development. In other words public policy thus needs a system change or transition framing in order to address the SDGs.

While many or even all public policies are implicated in system changes, I would like to argue that science, technology and innovation (STI) policy can become an important driver of the process. This is the case because system change cannot occur without innovation and needs a knowledge base. While recognising the importance of innovation and knowledge production, it is of crucial importance to note that innovation is not just technological innovation, and often not science driven. So called low-tech solutions may be very important, as well as social innovations including the development of new business models, new cultural perceptions, user preferences and new types of policies. In fact sustainability transitions literature argues for the combination and alignment of all these type of innovations, and for this reason uses the notion of socio-technical system change. In addition, it is important to recognise that innovation does not only stem from knowledge institutions and firms, other groups are crucially important, such as policy-makers, users and citizens. System change is a multi-dimensional and multi-actor process.[13]

Whilst I would like to put STI policy at the heart of the system change process, I would also like to argue that our current framing and practice of this type of policy is not fit for purpose. Governments need to rethink the design and implementation of STI policy, which is the focus of my essay. The main question addressed is: how to unlock the transformative potential of STI policy for addressing urgent social and environmental challenges, as for example expressed in the SDGs?

This essay contains three sections: the first focuses on a further elaboration of system change and what is involved, section two on a description of STI policy frames and in a third section a diagnosis of the current STI policy in Flanders is presented based on information collected by desk research, interviews, two workshops and a conference (for more information on these activities see introduction to this report). In a second essay included in this report this diagnosis is substantiated for a case-study of the food system.

Understanding and governing socio-technical system change

Socio-technical systems are built by numerous actors, a process that may take decades. Drawing on a new field of sustainability transitions studies, we define these systems as a set of aligned technologies, knowledge, infrastructure, markets (user preferences), governance and regulations, culture, and industry structures that interact, mutually re-enforce and co-evolve. These systems are built and maintained by actors guided by specific rules defined as humanly devised constraints and enablers that structure human action.[14] Rules come in a variety of forms - informal or formal, unsanctioned or sanctioned, yet all these forms will leave traces that can be identified in one way or another. Rules are embedded in values, beliefs and normative and legal sanctions (see figure 2). Changing rules thus imply a change of these values, beliefs and sanctions. Rules touch upon underlying assumptions of actors for example on ownership of cars, the need for travel by flight, the availability of provision of energy through a grid and the preference for meat. System change or transformations require the opening up of these assumptions for deliberation and change, and the development of new rules that guide actor behaviour into sustainable directions. Adoption of these new rules will lead to the build-up of an original, new set of socio-technical systems for provisioning of basic needs in energy, food, water, mobility and communication areas. Socio-technical systems should thus be seen as expressions of underlying rules.[15]

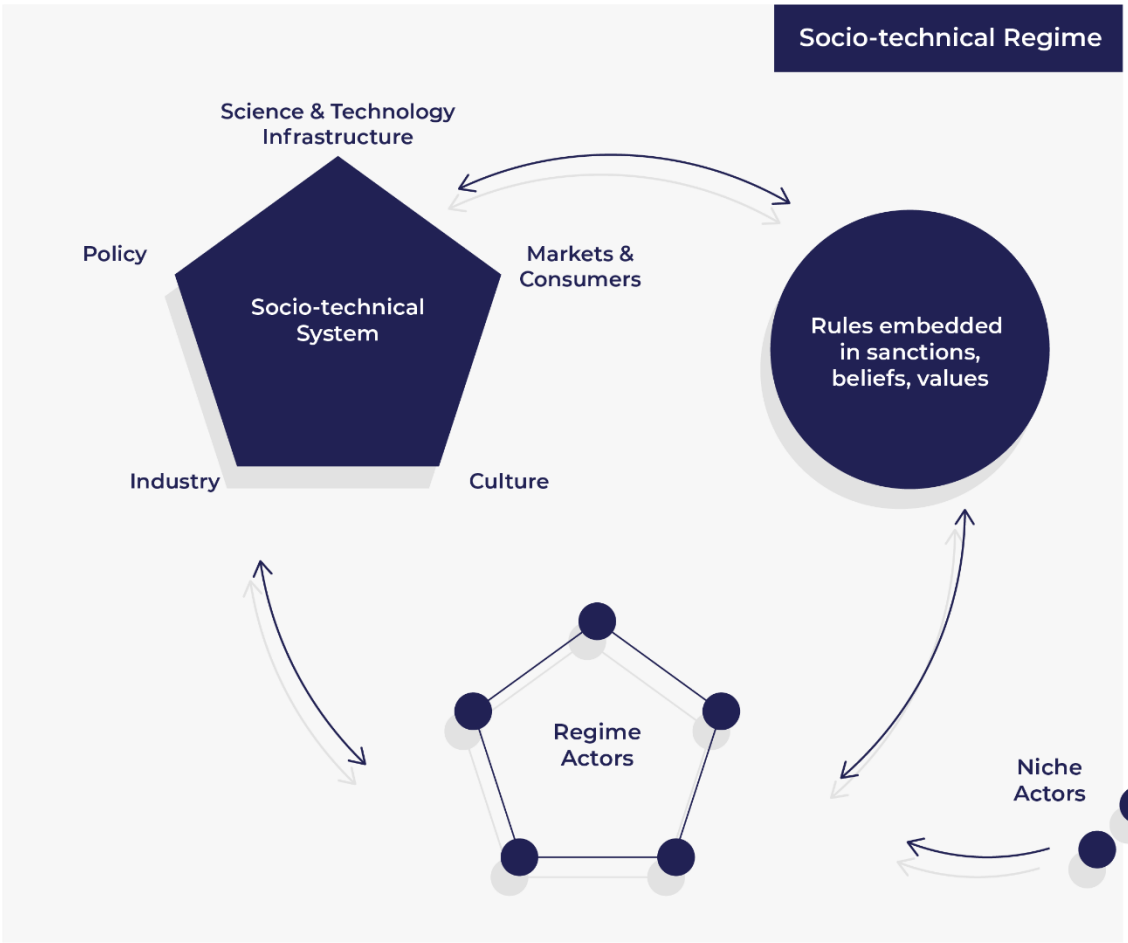

Figure 2: A socio-technical regime consisting of rules, regime actors and systems, and niche actors challenging the regime. Creative Commons License

Rules tend to cluster and cover all system dimensions. They answer questions such as how to innovate and on which technologies to focus, which industry strategies and business models to follow, which user-needs to address, how to perceive systems, which identities and symbols to use that reinforce sustainable behaviours, and finally how to govern systems: how to distribute roles across actors. Together they form rule-sets or regimes, and if shared across multiple systems, they can be called meta-regimes. Examples of such meta-regimes are carbonization (instead of low-carbon or net zero), linear production (instead of circular production and consumption), mass production (instead of serving individual needs) globalization (instead of localization), exploiting nature for human needs (instead of respecting nature, not reducing biodiversity) and externalization of environmental and social costs (instead of internalization, and a focus on a Just Transition).

From this discussion on what is involved in system change, it is important to note that STI policy aiming for enabling system change should not be pictured as a value-neutral process. On the contrary, it is a deeply political process, because it centralises questions on values,

beliefs, user needs, cultural perceptions, industrial strategies and policies, and how these elements relate and align with specific scientific and technological choices. A society focused on local production and consumption, respect for nature and a just transition will prefer to develop other types of technologies compared to a society based on opposite meta-rules. Technological choices involve social choices, and it is important to bring these choices to the surface. For this reason it is also important to recognise that STI policy aiming for system change should involve deliberations among many actors, not only because such a policy will then be more effective, but also because it will be more democratic. Here we refer not so much to the principles of representative democracy (although they are of great importance), but to the idea of participatory democracy, which stipulates that people who are impacted by certain developments should have a voice.[16]

Following insights from the sustainability transitions studies literature, in particular the Multi-Level Perspective (MLP) we can argue that system change comes about through four processes (that can also be seen as leverage or intervention points): construction of new niches by niche actors; expansion of these niches, de-stabilising of a regime and actors supporting and maintaining this regime for change, and development of exogeneous trends and shocks that put pressure on niche and regime actors to act, and open up windows of opportunity for doing so.[17] In case of shocks, the impact on niche and regime actors may be stronger, because the impact of a shock leads to traumatic experiences that may not leave substantial margin for business as usual. Shocks then imprint new behaviours, leading to a rule change. It becomes impossible to go back to prior behaviours.[18]

The most important insight from the MLP is that these processes need to become linked, only then system change will happen. It is not sufficient to construct alternative practices in niches, such as niche markets for electric vehicles, renewable energy and plant-based diets; these niches need to scale. In reality pilot projects funded by the government and co-funded by companies often remain small, and do not lead to the development of a market niche. They do not pass what has been referred to as the valley of death. Even if they do they may still not challenge the dominant regime, but simply become part of the offering by the dominant regime, as has happened to organic food for example. For a transition to occur, regime actors who support the dominant system and practice need to begin to question the system and underlying rule, and become open to change. The typical pattern is that regime actors resist the need for change through denial and/or putting in place lobbying strategies to protect the system.[19] They may also respond through innovation, optimising the performance of the existing system (sailing ship effect), car manufacturers strategy to focus on producing clean engines can be seen as such a response. Car manufacturers were for a long time unwilling to respond to the climate crisis by introducing electric vehicles, instead they were focusing on building more fuel efficient motors that would reduce various emissions. Only when an outside competitor (Tesla) managed to construct a niche and scale it up, in addition to the climate crisis worsening and denial becoming very difficult, did other car manufacturers decide to change their strategy.

While MLP focuses on single system change, the Deep Transition theory focuses on change in multiple systems. Ultimately single system change will not be sufficient, and one may even

argue will not happen if other systems do not change. For example a scaling of the electric vehicle niche will need a change of energy system. Similarly a change of the food systems towards organic food will deeply shape the petrochemical system based on fossil fuels due to the sharp reduction in the required inputs (fertilisers, pesticides). Systems are coupled in value chains, through infrastructures (such as fuel service stations) and through narratives and discourses that sustain the need for these couplings for the future. Deep Transition theory thus brings a fifth change process (or leverage point) on top of the ones identified by MLP: the couplings across systems need to reinforce sustainable behaviour.

The upshot of the MLP and DT frameworks for STI policy is that it should not only focus on funding of research and innovation (pilot projects) that may lead to niche construction, but also consider how to expand and scale niches, how to de-stabilise regimes, manage couplings and finally how to prepare for new trends and shocks. Eventually this may imply a change of mandate for STI related ministries, research councils and innovation agencies: they need to be able to coordinate across the government, but also become strategic actors, who do not focus only on funding research and innovation with an open call using a number of criteria and/or KPIs, even if these would put more emphasis on impact, next to scientific excellence and innovative potential. Before discussing in more detail how to frame an STI policy focused on enabling system change, it is important to explore the history of dominant STI policy frames.

STI policy frames

Looking at the development of STI policy it is possible to make a distinction between three frames (see figure 3).[20] Frame 1 or "R&D for Growth" emerged in the post-war period, stressing the benefits of science and technological change to the economy. Policy makers became concerned about the role of the public sector in supporting science and technology because in the language of economists they constitute a public good, suffering from market failures. The inadequacy of the market to support their development at the level desired, required state intervention, and investment in R&D up to a level of 3% of GDP (according EU Lisbon agreement). Instruments preferred within this frame are investments in higher education, universities and other knowledge producing institutions, subsidies (grants) for specific research projects and programs, adequate protection of intellectual property rights and science for society programs that explain and educate people why tax money needs to be spent on R&D. Mission oriented policies were also installed, including specific technology driven ones such as putting a Man on the Moon. Finally two other instruments were also used: foresight in order to help select a specific technology domain on which to focus, and in the 1970s technology assessment emerged as a tool to predict negative social and ecological consequences of specific technological options, for example for the emerging field of biotechnology, but there was also an interest in looking at employment and quality of job consequences of the Information, Communication Technologies (ICT). These institutions were linked to Parliaments in order to empower them in assessing the consequences of technologies, and helping them to propose regulatory action to protect citizens. These TA

institutions fitted frame 1 R&D for Growth because a clear separation between promotion of science and technology on the one hand, and regulating consequences on the other hand.[21]

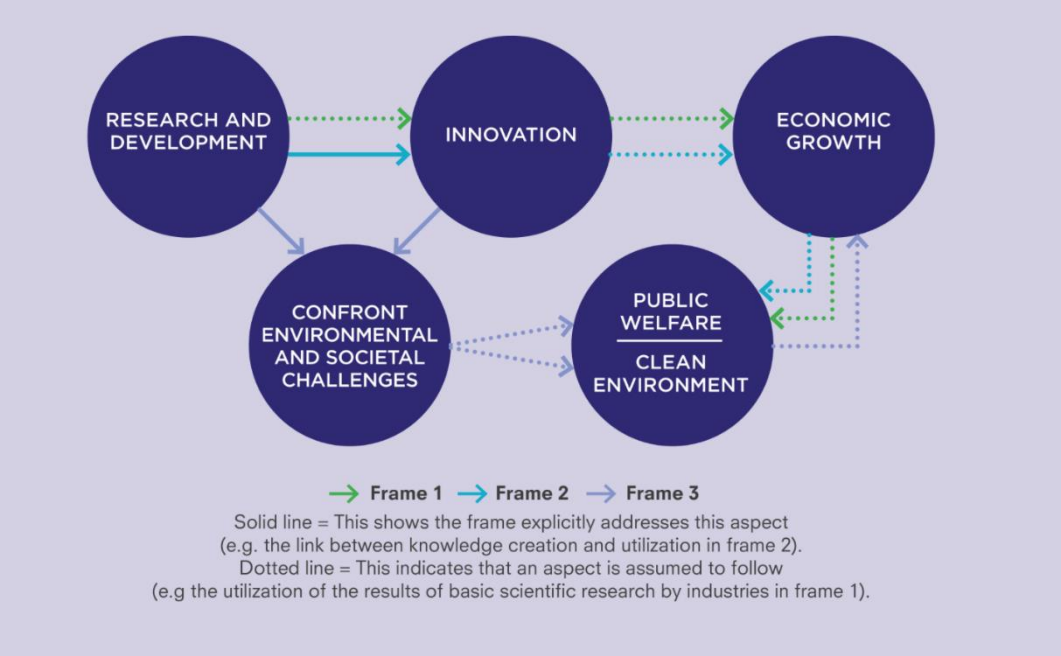

Figure 3: Three frames that have been guiding science, technology and innovation policy, and how they relate to the economic growth imperative, Creative Commons License.

This frame is supported by the linear model of innovation which focuses on building an excellent knowledge basis (including higher education institutions) that will then almost automatically lead to innovation, and rapid economic growth. The role of the state is to stimulate excellent science. This idea was supported by research of a group of economists who argued that the contribution of labour and capital growth cannot sufficiently explain growth in economic output, leaving a large residual which was attributed to technological change.[22]

Within this frame there is a recognition that innovation may lead to unintended consequences such as pollution, inequality and climate change, but that these impacts can and should be dealt with by means of more science and technological development, and if necessary regulation in order to generate a level playing field for companies stimulating them to address impacts through innovation. Since these innovations would only be developed after the impacts have become visible, they often led to cleaning-up (bans, waste management) and add-on technologies (such as the catalytic convertor for a car, clean engines, bans on certain substances, or higher chimneys and use of filters for the chemical industry). The conviction is that economic growth is necessary in order to pay for the costs of environmental and for social measures too, for example loss of jobs due to technical change, and social benefits necessary to provide people with a decent standard of living (at a minimum level). In this frame, if economic growth falters or is reduced, the welfare state will be hollowed out, the economy may stagnate and loose legitimacy since it would not be in a position anymore to promote the wellbeing of its people. Within this frame the notion of structural transformation

was used, it refers to a process of replacing agricultural production with manufacturing and ultimately with a service driven economy. Each country had to go through the same process and catch-up with the USA and to a lesser extent Europe. Development aid was focused on technology transfer from successful countries (mainly in the Global North) to less successful countries (mainly in the Global South).

Frame 2, or "National Systems of Innovation", emerged in a context of growing international competition, marked by economic shocks, such as the 1970s oil crisis, but it only took off in the 1980s and 1990s. Analysts started to recognise that producing knowledge and investing in R&D is not sufficient. Actors need to be able to absorb the knowledge and use it for productive purposes. Following the successful emergence of Japan, Taiwan, Singapore, and South Korea into high growth knowledge economies, this new frame brought attention to the different paths that countries and regions followed in the constitution of innovation systems, characterised by systems and institutions that support learning, skill and capacity building and entrepreneurship. These type of elements enhance the absorptive capacity of an economy. The role of the state became defined as enhancing absorptive capacity by building up national (and later regional, and sectoral) systems of innovation, and stimulating entrepreneurship. The task of the state was overcoming system failure in terms of relationships among actors.

Research by economists such as Freeman and Lundvall assisted in shaping this frame.[23] They argued that the catching up success of countries such as Japan and South-Korea related to a set of important organizational innovation in the generation and utilization of technological knowledge which explained their success in manufacturing performance in sectors focused on producing automobiles and televisions. In this frame the idea emerged that STI policy should enhance national competitiveness, in addition to economic growth. The role of the state is advancing the ability of firms to compete on domestic and international markets, not only by drawing on their science and technology knowledge production, but also through building strong links between industry and knowledge production in universities, and with government agencies supported these links. One other distinguishing feature of this frame is the greater role ascribed to entrepreneurship because they are seen as central actors for commercialising innovation. A related line of research is using the notion of Triple Helix focused on the importance of the increasingly intertwined nature of government, industry and university research efforts, and the need for universities to become more entrepreneurial, fostering spin-offs and licensing technology produced by university researchers.[24]

This frame did not replace the R&D for Economic Growth frame, since economic growth was still perceived the main goal, and R&D investments continued to be an important concern. Frame 2 should be seen as an addition to frame 1. It brought a specific focus on a new set of instruments for government action: building links across actors. Governments became involved in building technology platforms, developing programs for entrepreneurship, and government funding became more dependent on the availability of matching and large-scale consortia that bring together a range of actors. The conviction is that these instruments will make R&D investment more effective. This frame was inspired by a move away from a linear view of innovation to a more systemic one in which innovation is the result of interactions

across many actors: universities, firms and entrepreneurs, governments, workers (they need to have skills) and even civil society. The role of STI policy is not only to provide for knowledge production, but also for learning by interacting, including the building up of workers skills to participate in the learning process followed by a focus on ensuring education puts enough emphasis on so called Science Technology Engineering and Math (STEM) and entrepreneurial skills, and attract more woman who want to learn these skills.

Within this frame, there is a recognition of the importance of technology assessment. In other words, the need to assess the potential negative consequences of innovation, in order to be able to address them early on, and provide regulatory or other remedies. These assessments should be inserted into the learning by interacting process, and this could be done by dedicated technology assessment actors, or other institutions. In this frame societal impacts should thus be integrated in this interaction process, and be addressed because some actors (workers, civil society, firms) articulate a demand for it.

Frame 3 is what we call "Transformative Innovation Policy". This frame takes addressing environmental and social challenges as the central aim of STI policy, questioning assumptions about the directionality of technological innovation processes. It starts from the conviction that the current socio-technical systems that fulfil basic needs for energy, mobility, food, water, security and communications provision need to go through a fundamental shift in order to become truly sustainable. This is different from what constitutes a mere system optimization, it calls for a transition policy focused on bringing about socio-technical regime change in order to address the climate and biodiversity crisis as well as rising inequalities. This change is about changing rules, systems and regime actors (see figure 2). In this frame, the central role of STI policy is not to overcome market failure (frame 1) or overcoming failures in terms of commercialisation of innovation (often called system failure, because this lack of commercialisation is attributed to a lack of interactions in the national system of innovation). Instead the role of STI policy is to overcome transformational failure.[25] Many initiatives by firms and knowledge institutions fail to lead to a needed sustainability transition. Public policy should assist actors in developing a focus on transformation in order to address environmental and social challenges. The legitimation for this focus of STI policy can be found in the signing up of many international agreements that demand such a focus (for example the UN Agenda 2030 and also the Paris Climate Agreements). On top of this one may even argue that not acting on these challenges in an appropriate way will lead to high adaptation costs in the future, as well as may threaten the life of many people, including the citizens of any country across the world (although one should acknowledge that some countries and citizens will be more affected than others).

This frame is close to a mission-oriented innovation policy called for by many governments and the EU, if a mission is seen as one of the instruments to enable system change.[26] It is also close to Responsible Research and Innovation practices aiming for articulating political choices and impacts of science early on in the process.[27] In this third frame technology assessment is not just an additional instrument called upon to insert attention for impacts, but an important ingredient of any STI policy, since it focuses on addressing societal and environmental challenges head-on. This does not imply that this type of policy will not lead

to economic growth, since investments in sustainable innovation will also bring jobs and new economic activities. One may argue that through the focus on sustainability, economic growth and development may be a by-product, even so this frame calls for policies that are not focused on economic growth. Recognising that transitions will also bring negative consequences, for example for workers operating in sectors that may be phased out or will have high transition costs, such as in agriculture, it is important to put in place compensations and opportunities for new developments in order to avoid growing inequalities. This is the principle of a Just Transition which should provide a social floor in order to preclude huge negative social impacts.[28]

This type of STI policy is not new. Over the last decades, several governments have been experimenting with transition policies, putting in place transition arenas to agree on the direction of change and measures to implement agreed objectives. In addition governments have begun to experiment with this type of policy. For example the Swedish innovation agents VINNOVA, Business Finland, the Research Council of Norway, the South African Ministry of Science and Innovation, and the Colombian Ministry of Science are working together in the Transformative Innovation Policy Consortium (TIPC) to identify transformative ways of working.[29] Together with Climate-KIC of the European Institute of Innovation & Technology TIPC has developed a handbook for how enhance the transformative potential of STI projects, programs and policies.[30] Through these and other experiences, it has become clear that this type of STI policy calls for a whole of government approach since energy, food, transport and so forth are issues addressed by other government departments. STI policy needs to leave its own comfort zone and become coordinated across government.

STI policy in Flanders

When examining STI policy and infrastructures in Flanders, its emphasis on fostering excellent science, increasing R&D expenditures and stimulating knowledge valorisation becomes readily apparent. With this strong focus on frames 1 and 2, implemented STI policy has culminated in a robust national system of innovation including a high level of R&D investment. Belgium's, and particularly Flanders' R&D expenditure as a percentage of GDP ranks exceptionally high among European countries and regions, with Belgium's R&D expenditure vastly exceeding the EU Lisbon agreement at 3,56%.[31] Following frame 1 and 2, the Research Foundation - Flanders (FWO) and the agency for innovation and entrepreneurship (VLAIO) have prioritised stimulating knowledge production & diffusion and have stimulated collaborations between universities and businesses in the form of Strategic Research Centres, Spearhead Clusters, Research Institutions and Inter-university Consortia. Furthermore, Frame 1 and 2 perspectives are prevalent when it comes to dealing with unintended consequences of innovation; funding of technologies (for example by VLAIO) and, if necessary, regulations are used as the primary means to mitigate negative externalities. In order to alleviate the economic consequences of regulation, businesses are financially supported in meeting regulatory requirements (REF). One aspect of frame 1 and 2 are underdeveloped: foresight and technology assessment are marginally employed, and no designated actor or institution for assessing broader impacts of technologies exists. There is strong opposition against

putting in place a new technology assessment actor to inform the political decision making or the public debate on STI and society, since this would lead to even more fragmentation in the STI policy area. This fragmentation, having too many institutions and ministries involved without sufficient coordination is already seen as a problem that needs to be addressed. TA thus needs to be done by existing actors, however it is not clear which one would take it up in a systematic manner.

In our discussions about frame 3 policies, actors point at a few initiatives that have been put in place to encourage system change. Examples are the Moonshot program, and the Flemish recovery package Vlaamse Veerkracht where a strong focus on sustainability is clearly articulated, but without a clear preference for system change.[32] In addition the FWO and VLAIO are considering putting more emphasis on societal impact as a general criteria for funding. Using impact related KPIs are seen as a more suitable and effective instrument compared with thematic funding coupled directly to ecological and social targets. Many STI actors want to reserve a balance between funding schemes aimed at fundamental research (building excellent knowledge base) and those aimed at applied research for societal impact. Implicitly this is also a balance between economic and sustainability goals. They are not convinced of the value of a stronger focus on frame 3 type policies. Many actors express the value of a technological optimistic view, and put trust in science and technology actors who will come up with appropriate solutions in time. There is little attention for and willingness to also focus on changing consumer behaviour for sustainability.

A conclusion must be that STI agents in Flanders do not see a need for bigger changes in existing STI system. On the contrary they believe the current policy is fit for purpose: it is supporting economic growth, competitiveness and also has incorporated a number of smaller initiatives for supporting sustainable development. These initiatives may have to be strengthened but not too much at the expense of economic goals that have served very well the Belgian and Flemish economy. Knowledge producing institutions and universities are also not pushing for system change, they accept system optimisation. At the same time universities and research institutes are in a position to enact system change projects, and get funding for this through the traditional funding channels, and through EU Horizon programs. This is happening but in an ad-hoc way, subject to a bottom-up process of responding to funding calls. The overall effect is, however, that a transition focused frame 3 policy and research system is not emerging in Flanders.

To some extent this is surprising since the Flanders government has articulated an overall long term strategy with an explicit focus on a transition to a more sustainable society and economy called Vision 2050 which was published in 2018.[33] This strategy calls for system change, defines transition priorities attached to a specific governance model with high level support by a range of ministries. Question can be raised whether this vision has been implemented successfully. Belgium, like many other European countries, is not on track to meet the SDGs.[34] Clearly the Vision 2050 strategy has not been implemented and absorbed sufficiently in STI policy realm. STI policy remains underutilised as a means to turn innovation into a driver of socio-technical systems change.

Introducing more explicitly frame 3 STI policies with a strong focus on addressing social and ecological concerns does not imply frame 1 and 2 policies are not relevant anymore. On the contrary, a strong R&D capacity and innovation system is important. However, Frame 3 policies would give frame 1 and 2 instruments a new orientation. These instruments would become more strongly focused on delivering on the SDGs, and should be used for enabling system change. This type of change will take time, and the best way forward would be to experiment with existing programs stretching them in new transformative directions. This has been the approach of TIPC, and Flanders could consider adopting some of the methods used. Doing this would require the build-up of human capability of managing frame 3 type transformative innovation policies, the development of some kind of temporary platform for articulating a transformative STI vision that aligns with Vision 2050, and the sharing of experiences with implementing the vision. The coming decade will be crucially important for the world, and for Flanders to use the transformative capacity of STI policy to address the climate and biodiversity crises and the deepening inequalities. It is not sufficient just to add sustainable development flavour to current STI projects, programs and policies. A redirection is needed, building upon the current strengths yet recognising that business as usual will not work. STI policy makers have a choice to make between working towards system optimization or accept the challenge to identify ways for enabling system change. The Flanders STI infrastructure and STI policy system is strong enough to take up the latter, if the actors are prepared to take Vision 2050 as their anchor point, and work together to facilitate a sustainability revolution is Flanders.

References

[1] United Nations, Our Common Agenda – Report of the Secretary General, New York. 2021.

[2] United Nations, Transforming our World: The 2030 Agenda for Sustainable Development, New York, 2015.

[3] OECD, System Innovation: Synthesis Report, Paris, 2015. Quotation at p. 15.

[4] European Environmental Agency (EEA), The European Environment: State and Outlook, 2020: Knowledge for Transition to a Sustainable Europe, Copenhagen, 2019; Intergovernmental Panel on Climate Change; (IPCC) Climate Change 2022: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the IPCC Sixth Assessment Report; Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem; Services (IPBES), Global Assessment Report on Biodiversity and Ecosystem Services, 2019; Mark Swilling, The Age of Sustainability. Just Transitions in a Complex World, Routledge: New York, 2020.

[5] J. Schot, and L. Kanger, L., Deep Transitions: Emergence, Acceleration, Stabilization and Directionality, Research Policy 47 (2018), 1045-1059.

[6] R. Weterings, J. Kuijper, E.Smeets, and G.J. Smeets, G.J. Annokkée and B. Minne, 81 mogelijkheden technologie voor duurzame ontwikkeling. Eindrapport van de milieugerichte technologieverkenning, De Haag: VROM, 1997.

[7] Stockholm Resilience Centre, Transformation is feasible. How to achieve the Sustainable Development Goals within Planetary Boundaries, A report to the Club of Rome, for its 50 years anniversary 17 October 2018.

[8] European Commission endorses fossil gas as 'transition' fuel for private investment (climatechangenews.com).

[9] F.W. Geels and J. Schot, J., The Dynamics of Socio-technical Transitions: A Socio-technical Perspective. In J. Grin, J. Rotmans, J. Schot in collaboration with F. W. Geels, D. Loorbach, Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change, Routledge, 2010, 11-101.

[10] For historical examples, see J. Schot, H. Lintsen, A. Rip (eds.), Technology and the Making of the Netherlands. The Age of Contested Modernization, 1890-1970. MIT Press, 2010. For argument about rules, see Schot and Kanger, Deep Transitions, 2019

[11] On economic incentives, in relation to system change see M. Grub, Planetary Economics. Energy, Climate Change and the Three Domains of Sustainable Development, Routledge, 2014; see also D. Rosenbloom, J. Markard, F.W. Geels, and L. Fuenfschilling, Why carbon pricing is not sufficient —and how a "sustainability transition policy" can help mitigate climate change, Proceedings of the National Academy of Sciences, 117(2020), 8664-8668.

[12] W. Steffen, W. Broadgate, L. Deutsch, O. Gaffney, and C. Ludwig, The Trajectory of the Antropocene: the Great Acceleration. The Anthropocene Review, 2 2015, 81-98

[13] J. Grin, J. Rotmans, J. Schot in collaboration with F. W. Geels, D. Loorbach, Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change, Routledge, 2010; see also J. Markard, R. Raven, B. Truffer, Sustainability Transitions: an Emerging Field of Research and its Prospects, Research Policy 41 (2012) 955-967, and D. Loorbach, N. Frantzeskaki and F. Avelino, Sustainability Transitions Research: Transforming Science and Practice for Societal Change, Annual Review of Environment and Resources, 42 (2017), 599-626.

[14] A. Giddens, The Constitution of Society: An Outline of a Theory of Structuration, Polity Press in association with Basil Blackwell, 1984. W.H. Sewell Jr. A Theory of Structure: Duality, Agency and Transformation, The American Journal of Sociology, 98 (1992) 1-29.

[15] J. Schot, J., and L. Kanger, Deep Transitions: Emergence, Acceleration, Stabilization and Directionality. Research Policy 47(2018), 1045-1059; L. Kanger, and J. Schot, Deep Transitions: Theorizing the long-term patterns of socio-technical change. Environmental Innovation & Societal Transitions 32 (2019) 7-21.

[16] F. N. Laird, Participatory Analysis, Democracy and Technological Decision-making, Science, Technology and Human Values, 18 (1993) 341–361; see also R.E. Sclove, Democracy and Technology, Guilford Press, 1995.

[17] F.W. Geels and J. Schot, J., The Dynamics of Socio-technical Transitions: A Socio-technical Perspective. In J. Grin, J. Rotmans, J. Schot in collaboration with F. W. Geels, D. Loorbach, Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change, Routledge, 2010, 11-101; B. Ghosh, P. Kivimaa, M. Ramirez, J. Schot, J. Torrens, Transformative Outcomes: Assessing and Reorienting Experimentation with Transformative Innovation Policy, Science and Public Policy, 48 (2021) 739-756.

[18] P. Johnstone, C. McLeish, C., World Wars and Sociotechnical Change in Energy, Food, and Transport: A Deep Transitions Perspective, Technological Forecasting and Social Change, 174 (2022), 121206.

[19] B. Turnheim, B.K. Sovacool, Forever Stuck in Old Ways? Pluralising Incumbencies in Sustainability Transitions, Environmental Innovation and Societal Transitions, 35 (2020) 180-184; B. Turnheim, Destabilisation, Decline, and Phase-out in Transitions Research: Elements of a Research Agenda: in Z. Koretsky, P. Stegmaier, B. Turnheim, H. van Lente (eds), Technologies in Decline: Socio-Technical Approaches to Discontinuation and Destabilisation, Routledge 2022.

[20] J. Schot, W.E. Steinmueller, Three Frames for Innovation Policy: R&D, Systems of Innovation and Transformative Change, Research Policy, 47 (2018) 1554-1567; see also F. Steward, Transformative Innovation Policy to Meet the Challenge of Climate Change: Sociotechnical Networks aligned with Consumption and End-use as New Transition Arenas for a Low-carbon Society or Green Economy, Technology Analysis & Strategic Management, 24(2008) 331-343; K. M.Weber, H. Rohracher, H., Legitimizing Research, Technology and Innovation Policies for Transformative Change: Combining Insights from Innovation Systems and Multi-level Perspective in a Comprehensive 'Failures' Framework, Research Policy, 41(2012) 1037-1047.

[21] For the history of TA N.J. Vig & H. Paschen, Parliaments and Technology. The Development of Technology Assessment in Europe, State University of New York Press, 2000.
[22] R.M. Solow, Technical Change the Aggregate Production Function, Review of Economics and Statistics, 39 (1957) 312-320.
[23] C. Freeman, Japan: a New National System of Innovation, in: G. Dosi, C. Freeman, R.R. Nelson, G. Silverberg, L. Soete (eds.), Technical Change and Economic Theory, Pinter Publishers: London, 1988, 330-448. B-A. Lundvall, National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning, Pinter Publisher, London 1992.
[24] H. Etzkowitz, The Triple Helix: University-Industry-Government Innovation in Action, Routledge, 2008.
[25] For this notion of transformation failure see K.M. Weber, H. Rohracher, Legitimizing Research, Technology and Innovation Policies for Transformative Change: Combining Insights from Innovation Systems and Multi-level Perspective in a Comprehensive 'Failures' Framework, Research Policy, 41(2012), 1037-1047.
[26] M. Mazzucato, Mission-Oriented Research & Innovation in the European Union: A Problem-Solving Approach to Fuel Innovation-Led Growth, Brussels, 2018.
[27] J. Stilgoe, R. Owen, P. Macnaghten, Developing a Framework for Responsible Innovation, Research Policy, 42 (2013) 1568-1580.
[28] M. Swilling, E. Annecke, Just Transition: Explorations of Sustainability in an Unfair World, United Nations University Press 2012; see also The Just Transition Mechanism: making sure no one is left behind | European Commission (europa.eu)
[29] See www.tipconsortium.net
30 C. Alvial-Palavicino, C. Matti, & J. Witte, (eds.), MOTION Handbook: Developing a Transformative Theory of Change. Brighton: Transformative Innovation Policy Consortium, 2021.
[31] Eurostat, available at https://ec.europa.eu/eurostat/databrowser/view/rd_e_gerdtot/default/table?lang=en
[32] Vlaamse Veerkracht (fdfa.be); Moonshot: Vlaanderen CO2-arm in 2050 | Agentschap Innoveren en Ondernemen (vlaio.be)
[33] Vision 2050 (vlaanderen.be)
[34] OECD, available at https://www.oecd.org/belgium/oecd-environmental-performance-reviews-belgium-2021-738553c5-en.htm

Food System Transformation: how can society, policy makers and innovators head in the same direction?

An essay for the Thinkers' Program Sustainable Innovation of the Royal Flemish Academy of Belgium for Science and the Arts (KVAB)

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March 25, 2022

Introduction

Good food is central to life. An adequate diet is a necessity for women to bare healthy babies, for children to grow, learn, play and develop into healthy adults, and for adults to stay in good health, up to –hopefully– high age. Food also has an important function in cultural habits: to celebrate, to build relationships and to give expression to religious traditions. Despite being a source of joy, bonding and health, food is also linked to death and disease. Terrible wars have been, and still are, fought over food shortages. War in itself is a threat to food security, as the recent war in Ukraine has made painfully clear. And the bad quality of diets of people around the world is a major cause of death and disease. In low-income and middle-income countries undernutrition is estimated to be responsible for 45% of deaths among children[1] . In high-income countries – and more and more in low-income and middle-income countries as well – diets high in animal fat and low in fibre and essential nutrients are a major cause of deaths due to cardiovascular disease, diabetes and cancer[2].

So the food people consume can literally make the difference between life and death. On top of that, it also affects the health of our planet. "Food systems have the potential to nurture human health and support environmental sustainability; however, they are currently threatening both" is the pivotal first sentence of the summarising paper of the EAT Lancet Commission on healthy diets from sustainable food systems[3]. This commission set out to answer a central, burning question: can we feed a future population of ten billion people a healthy diet within planetary boundaries? They concluded that the answer to that question is yes, but not without transforming eating habits, improving food production and reducing food waste; an enormous change in the global food system. Their paper describes a universal healthy reference diet – an alternative to standard current diets – "that largely consists of vegetables, fruits, whole grains, legumes, nuts, and unsaturated oils, includes a low to moderate amount of seafood and poultry, and includes no or a low quantity of red meat, processed meat, added sugar, refined grains, and starchy vegetables." This reference diet is referred to as a 'win-win diet', meeting the health standards for both people and planet.

What a rigorous shift in dietary habits that is, hard to imagine in the current dietary culture of the Netherlands or Flanders. Even traditional diets would not meet the high standards: 'Vlaamse kost' (Flemish fare) and 'Hollandse pot' (Dutch fare) are known for starchy vegetables (potatoes, carrots and turnips), bread, dairy, meat and animal fat. The authors of

the Lancet paper acknowledge that it requires a complete set of food system changes, based on actions and commitment by various stakeholders, ranging from individual consumers, actors in the food system and policy makers. They call it "nothing less than a Great Food Transformation". Many governments – also in the Netherlands[4] and Flanders[5] – acknowledge that they want to take part in this Great Food Transformation. Or even in a more 'modest', national or regional, transformation towards a more sustainable food system than the current one. Governments realise that even if consumers would like to eat in a more healthy and sustainable way, they would still be facing a food system that does not encourage that win-win dietary behaviour. What options do governments have to accelerate a food system towards a more sustainable direction, thereby optimising dietary behaviour? For starters, what would it mean for their science, technology and innovation (STI) policies? This essay will explore answers to that question, using insights gained during my professional career and the Thinkers' Program.

Expertise coming together in the Thinkers' Program Sustainable Innovation

The vision of food systems operating within boundaries for planetary as well as human health is very appealing to me. Having worked for 25 years as a researcher in nutrition and health in academia, the food industry and a technological top institute centred around public-private partnerships in the food system (Top Institute Food & Nutrition, TiFN), I know the challenges of getting there. In my epidemiological research I have so often found that unhealthy dietary behaviour is common in populations, and causing diseases and death, among the young and the old. And while working at TiFN, I came to realise how much joint effort it takes from knowledge institutes and companies to implement scientific insights into food systems, for better health or sustainability. Also, for a bit more than ten years, I have been engaged in a corporate aspiration to make the food supply chain of a large, global company (Unilever) – from sourcing raw materials and ingredients to preparation by the consumer at home – more sustainable, with respect to health of humans and the earth. Challenging as this all turned out to be, I can hardly imagine how food systems could change in order to stimulate switching people's current diets, still largely based on refined carbohydrates, low-nutrient snacks, dairy and meat, to some kind of 'win-win diet' as the one referred to in the Lancet paper (or even to a less strict version of that diet). How can governments accelerate food systems towards becoming more sustainable?

All of this came to mind when I was invited by the Royal Flemish Academy of Belgium for Science and the Arts (KVAB) to take the place of Melanie Peters as Thinker in the Thinkers' Program Sustainable Innovation. We Thinkers, Johan Schot of the Utrecht University Centre for Global Challenges and myself, with the help of the KVAB, had several discussions with stakeholders to collectively respond to the question of whether current STI policy in Flanders is fit to meet urgent societal challenges such as climate change. 'Sustainable agriculture and nutrition' was chosen as a specific case in the programme for exploring general conclusions about STI policy. It was clear from the onset that the Thinkers' task was to include 'societal aspects' in the discussion. Clearly, for food – being a primary necessity and closely related to life, health, landscape, joy and celebration – it is evident to do so.

We Thinkers agreed that a focus on societal aspects meant following the principles of Transformative Innovation Policy (TIP), as explained in the essay by Johan Schot in this report, as well as exploring the roles of Technology Assessment (TA) in such a policy. TA includes and relates to various practices. For example responsible research and innovation [RRI], Constructive Technology Assessment (CTA) and Parliamentary TA (PTA). In RRI, research and innovation are shaped from the perspective of social ambitions and public values, meaning that science and technology is a means to solving a societal challenge and that societal attitudes and knowledge should guide innovations. One could even say that RRI brings together CTA, with a focus on a wide range of actors incorporating societal aspects, and PTA, that focuses on informing Parliaments about opportunities and potential negative consequences of new technological options[6]. Taking into account my personal professional journey and my work for the Rathenau Instituut, the Dutch institute for TA, it was agreed that I would take 'reaching a more sustainable food system in Flanders' as a starting point and explore answers to the question: "Is current STI policy in Flanders fit enough to enable transformative solutions for reaching a more sustainable food system in Flanders, and what role could TA have in this?"

Beyond policy actors, I will pay particular attention to the role of companies, farmers, stakeholder representatives and citizens in defining and implementing the STI policy. And of course, I acknowledge that there are other relevant policies for reaching a more sustainable food system than STI policy, i.e. agricultural policy, industry policy and transition policy.

Build-up of the essay

This essay is divided into four sections. First of all, it will describe what a food system entails, based on a framework published by Food and Agricultural Organization of the United Nations[7] that includes not only the core food value chain largely driven by economic incentives, but also societal and environmental elements. In the description of a food system, the interconnection with the STI system and policies will be mentioned. Transformative Innovation Policy (TIP) will be introduced as a new framing that focuses on system change. The second section will discuss the role of political decision making in defining and re-arranging food systems, in particular when it comes to STI policies related to the food system and regulation on biotechnology. This section will start by briefly describing the role of TA in political decision making and the various ways to include society in defining STI policies, the actual processes of STI or the evaluation thereof. Dutch and other European examples studied by the Rathenau Instituut and others will be shared to illustrate this and to consider a few key factors for successful STI policy for reaching sustainable food systems.

Subsequently, the essay will take a look at the situation in Flanders. This third section describes the relevant (STI) policies in agriculture and bio-based industry. Then, based on the KVAB discussions around 'Food system-related innovation policy in Flanders' between the two Thinkers and stakeholders, section four will give my perception of current policies in Flanders that exist for investing in knowledge and technological innovations in order to reach sustainable food systems, my observations from the stakeholder discussions and some suggestions for future policy options in Flanders. Throughout the essay, where deemed helpful, I used the case of the Netherlands as an example, be it good or bad.

Food systems and their link to STI systems and policies

Food systems are complex socio-technical systems with important economic interests

Though interconnected, food systems vary around the globe, and in my opinion there is no such thing as a universal 'global food system'. However, for sure there are enormous challenges to safely feed the ever growing population of our globe, while protecting nature. Scientist and policymakers agree that the way we tend to feed the world is having a major impact on our planet[8]. Many agricultural practices disrupt ecosystems and leave soils eroded, deprived of nutrients, rendering them unable to support plant life. Agriculture, but also industrial food processing and preparation, use up freshwater sources. Agriculture interferes with global nitrogen and phosphorus cycles. Furthermore, industrial food processing and transport of fodder, chemical inputs and foodstuff contribute to CO2 emissions. Hence, across the globe, the various food systems cause detrimental changes to the environment and are a major cause of climate change. In addition, agriculture and food industry employ half of the global workforce and form the largest economic sector. Ending poverty also means changing food systems[8].

Worldwide, there is an interwoven network of national and international markets for food production. The large economic interests plus the fact that provision of safe and healthy food to citizens is a primary task of governments explains why national governments historically strongly control the agricultural sector and invest in it with public money. These are investments not only in the infrastructure and regulations to ensure a reliable, safe food system, but also in STI to make food systems economically be of more relevance and resilient to drought, massive rainfall, pests and shortage of labour and other inputs.

What does it take for a governmental STI policy to actively steer towards a more sustainable food system? In other words, where in a food system are the levers to meaningfully transform it towards a more sustainable system by STI policy?

To answer this question, it helps to understand a food system better. Obviously, a food system is much more complex than getting 'from farm to fork'. The FAO refers to a food system as follows: "Food systems encompass the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products. Food systems comprise all food products that originate from crop and livestock production, forestry, fisheries and aquaculture, as well as the broader economic, societal and natural environments in which these diverse production systems are embedded"[7].

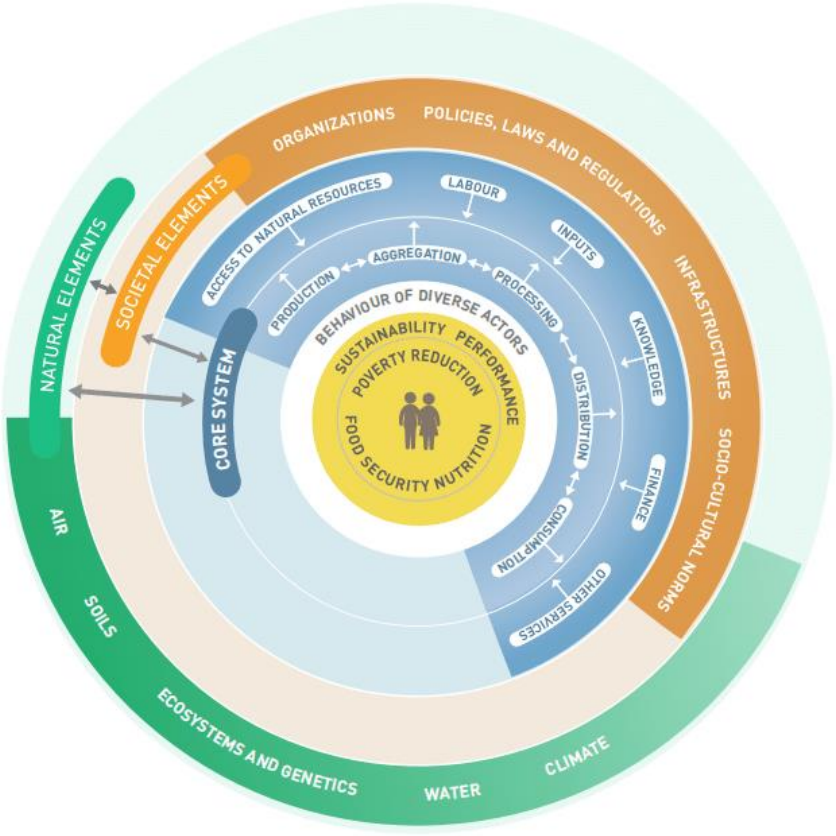

Figure 4: Food system wheel, according to FAO

This is broader than a food value chain which, according to FAO, consists of the stakeholders who participate in the coordinated production and value-adding activities that are needed to make food products. The FAO introduced the so-called FAO food system wheel (Figure 4) which depicts the three different layers of the food system (a core system [the food value chain] and the societal and natural elements surrounding it) and the interactions between the various three layers. In the very middle are the overall global goals of FAO for sustainable food systems: "to reduce poverty and ensure food security and nutrition for all, in such a way that does not compromise the capacity of the economic, societal and natural environments"[9]. That latter condition is summarised in the (yellow) layer 'sustainability performance', which is determined by the 'behaviour of diverse actors'. This refers to all the actors in the layers towards the outer spheres of this wheel. The 'core system' in the food system wheel shows the **core food value chain (**production, aggregation, processing, distribution and consumption) and the **extended food value chain**: various inputs and services which support (or limit) the flow of goods through the core value chain. These include access to natural resources and labour, key food ingredients or packaging materials, scientific knowledge and technology, finance and other services. This is where small and medium enterprises (SMEs), large industry, farmers, banks and insurance companies come in. In the context of transitioning towards a more sustainable food system, one could imagine inputs and services like innovative technology for agriculture (e.g. precision farming), low-carbon transport of food products, and financing of innovative farming systems and start-ups. The food value chain is embedded in a societal and a natural environment. These two environments influence the food value chain, but also define the playing field for STI as a means for changing the

current food system towards a more sustainable food system. And hence the playing field for STI policies in that respect.

The societal environment consists of elements like organizations (including research and educational organizations, ministries, unions, human rights organizations, representative organizations for citizens and nature), policies, law and regulations, infrastructure (broadly defined; this could also include science and technology infrastructure) and sociocultural norms– the ideas, customs, and social behaviour of society related to agriculture, food and nutrition. But also norms related to the interaction between STI and society.

In this societal environment, the basis is laid down for the STI policy, including the funding strategy and structures for collaboration (knowledge and innovation ecosystems), e.g. between private and public partners, or co-design and co-creation (involving society in designing and implementing STI policies). The norms and values present within society make up the basis of the laws and regulations in food systems regarding agricultural practices, implementation of technologies et cetera. These norms and values are rooted in moral beliefs like: “foodstuff should be safe”, “farmers should earn a fair price for the food they produce”, “land-based agricultural should fit into the landscape”, “food companies should be transparent on food processing methods and ingredients” or “farm animals should be slaughtered in a humane manner”, but also in cultural beliefs, such as the notion that insects are perfectly fine as a source of protein, or in certain attitudes, like the idea that genetically modifying food crops should be avoided as it is not natural. The societal environment also has interconnections with the **natural elements**, including air, soils, water, ecosystems and genetics, water and climate. Relevant societal elements ‘interacting’ with the natural environment are public perceptions of climate change or specific national or regional plans to mitigate climate change or adapt to it. Hence, the natural resources and the societal management thereof also determine the chances of successfully developing sustainable food systems.

The societal and natural environment together form a **national (or regional) enabling environment** which defines how sustainably the food value chain performs. Of course, there is also a **global enabling environment** (including agreements like the European Farm to Fork Strategy[10] and the global Paris Agreement[11].

Food systems interact with other systems, like health systems, energy systems and transport systems. Political systems and choices, e.g. on the importance of building a strong bioeconomy, are crucial to reaching sustainable food systems, as I will discuss later in this essay.

A food system can be regarded as a **socio-technical system,** defined as a set of aligned Science & Technology infrastructures, markets & consumers, cultural perceptions, industry structures and (government) policies that interact and co-evolve (see essay by Johan Schot)). Each food system, similar to other systems, has a **regime**: a set of rules that guide a prevailing set of key organizations (so called regime actors) in their behaviour. Rules reflect values, beliefs, such as the ones mentioned above: foodstuff should be safe et cetera. The system expresses these rules. The so-called ‘regime actors’ can belong to the core system (i.e. the food value chain)

itself or the societal and natural environments that were described above. The arrangement and power distribution in the regime are hence strongly defined (and conserved) by the beliefs and values that prevail in the particular system. The food system regime involves farmers, the manufacturing industry, multinational food concerns like FrieslandCampina and Unilever, chains of supermarkets, science and technology institutes and funding structures, and also citizens, in their roles as consumer and otherwise.

Some regime actors may have come to the conclusion that solving the sustainability challenge for the food sector and the need for system change means that they need to make fundamental choices and change the rules, beliefs and values that guide their behaviour. As a result they may have begun to invest in alternatives practices of non-regime actors in what is called a 'niche' in sustainability transition research. Such a niche is then nurtured by these niche players, who have to expand the niche and transform the regime in order to be successful. The 'Vegetarische Slager' (Vegetarian Butcher), now owned by Unilever, is an example[12]. Niche players building alternative practices are active in Flanders, for example Those Vegan Cowboys[13], Peace of Meat[14] and the Voedselbos (food forestry)[15]. A focus on niche players does not imply that regime actors are not important for a sustainability transition. On the contrary, the system optimization strategies they implement may become building blocks for system change, and eventually transitions need productive niche-regime actor interactions allowing regime actors to open up for more fundamental change[16].

Food system transition asks for Transformative Innovation Policy

Current food systems are not sustainable. Accommodation or optimization of current food systems along the lines of dominant rules will not suffice. For a food system to become (more) sustainable one needs to have a **fundamental shift** in that system and its underlying regime, called a sustainability **transition**[16]. What does this mean for the related *STI-policy*, let's say in the Netherlands or Flanders?

As explained by Johan Schot in his essay in this report, a recently emerged, new type of innovation policy is needed for a fundamental system shift: **Transformative Innovation Policy (TIP)**. Schot and Steinmueller introduced this term and also refer to it as 'Frame 3 innovation policy'[17]. Frame 1 and 2 are explained in detail in the essay of Johan Schot. Others came up with similar concepts, yet different terms for frame 3 innovation policy or TIP. Stefan Kuhlmann and Arie Rip discuss 3rd generation innovation policy as a means to tackle Grand Challenges[18]. The economist Mariana Mazzucato talks about mission-oriented innovation policy, because of the use of missions as a central policy instrument[19]. The Rathenau Instituut[20] consciously chose for the broader term of 'challenge-driven' (*opgavegericht* in Dutch) innovation policy. The institute even calls it "a new generation of transformative innovation policy". In the view of the authors of that report, in transition pathways the solutions and the route thereof are not or only partly known. Missions do only make sense if there is a general agreement on the direction of the route to solutions. Formulating missions may be a powerful instrument in transitions, but the complexity and versatility of societal challenges, such as transforming an unsustainable food system to a sustainable one, require yet another policy approach. In their view, missions are only one part of a policy mix with which governments can tackle societal challenges.

As said, this challenge-driven innovation policy is very close to TIP, which takes societal challenges as a starting point ("funding with a focus on impact" or "innovation with a purpose" as Johan Schot calls it). It 'provides directionality', which is different from 'directing large, existing companies towards promising technology, for benefit of their business *and* the planet'. TIP also takes into account uncertainty, complexity and the controversies that often surround transitions.

Further details on the key characteristics and conditions of TIP will be given later in this essay (Table 1), but first you will find a brief **intermezzo on the transition of the Dutch food system, in relation to its STI-policy**. The aim of this intermezzo is inspire thinking about the Flemish situation. I do not aim for a systematic comparison.

It is impossible to describe the entirety of the current food system regime in the Netherlands and to what extent the STI policy is aimed at its transformation, but I will give a synopsis based on recent political debates, the coalition agreement and some insights from the Rathenau Instituut on the hurdles 'food change makers' in the food system transition encounter[20].

INTERMEZZO: STI AND CHANGING FOOD SYSTEM IN THE NETHERLANDS

Political parties in the Netherlands agree that a thorough revision of the Dutch food system is inevitable[21], but how this system should look like yet has to be answered[22]. The focus so far is largely on primary production, in particular cattle breeding. When nitrogen emissions were far higher than rights in 2019, thousands of construction projects were paused. An MP of the social liberal party Democraten 66 (D66), Tjeerd de Groot, called for halving the entire Dutch livestock population[23], to free up emission space. This led to a national outrage among Dutch farmers[24]. The recently installed government has stated that the livestock population should be decreased by 30% in about 10 years[25]. This is linked to the coalition agreement[26] aiming to reduce nitrogen emissions, informed by a recent report[27]. The largest part of a budget of in total 30 billion euro for reducing nitrogen emissions will be used for reducing the livestock population and nature restoration. In this coalition agreement, the government states that an area-oriented approach ('gebiedsgerichte aanpak' in Dutch) will be used: creating a balance by combining sustainable agricultural practices with 'robust nature'. The area-oriented approach is based on extensification, shifting farms and use of innovation to speed up sustainability in agriculture. This approach is not only focusing on reducing nitrogen, but also on meeting the (European) norms and goals of water quality, soil, climate and biodiversity. A differentiated approach will be taken, which is likely to lead to large adaptations in certain rural areas. Circular agriculture is at the centre of the strategy, aiming for good business models for farmers and expecting "a non-optional contribution of banks, suppliers, manufacturing industry and retail".

Clearly, as observed in research of the Rathenau Instituut[20], innovation does not automatically lead to a structural change of the food system in a sustainable direction. Overall, among the ministry of Agriculture, among politicians, some farmers and entrepreneurs there is hope and faith that research and innovation will be part of path towards such a structural change and thus enable a sustainability transitions of the food system. Some even believe that technological solutions will sooth it all. In an interview, the CEO of FrieslandCampina deemed

a reduction in the number of cows of 10% sufficient to lower nitrogen emissions. The paper wrote that he expects that innovation in stables[28] and higher milk production per cow will increase milk production with lower negative effects[29] Some find this somewhat naïve, to say the least[30]. The main point is that a sustainability transition leading to a new food system cannot be achieved by a focus on one of the problems such as lowering the nitrogen emissions. It needs a more encompassing approach with a stronger focus on achieving a sustainability transition. Such a focus is also still lacking in the Netherlands

Yet, a general awareness is rising in The Netherlands that a broader food system change is needed, which encompasses all the elements described in Figure 4, although the system as such or its parts (core value chain, societal, environmental elements) are not made explicit per se in the discussions. As made clear before, research and innovation– and involved research systems, finance structures, collaborations – are part of the food system.

The report of the Rathenau Instituut[20] mentioned two challenges that STI policymakers face: 1) how to properly position the STI programme within the debate on the transition of the food system; and 2) how to include new actors in stimulating innovation.

Ad 1. Researchers and companies who want to contribute to the transition to a sustainable food system notice that they ***become part of the normative discussions*** *surrounding this transition. Values and beliefs as expressed in rules are implicated, and the debate cannot be reduced to a number of separate technical issues. The battle around the transition to a sustainable food system resonates in the discussion on what type of research is needed, who decides on that and who can join in the research and innovation activities.*

Some 'food system change makers' even fear that investing in research and innovation is a deliberate strategy of policymakers to avoid or delay any rigorous changes in the food system. And even when the government (~STI policymakers), knowledge institutes and companies agree on the relevance of research and innovation for the transition, they can very much disagree in the views on the direction of innovation. For example, those who plea for using new technological insights will stand directly opposite to farmers in the societal debate who favour nature-inclusive experimental agriculture. This is called the 'technologists versus the ecologists discussion'[31].

For challenge-oriented research and innovation programmes this means that STI policy makers and STI programme coordinators cannot deny their partly normative character. On the contrary; they should embrace it. A key challenge for this kind of programmes is to be ***transparent*** *and most of all* ***reflexive*** *on how the approach within the programme relates to the broader transition in the food system, and the regime (rules, values, beliefs) guiding actor behaviour.*

Ad 2. For a sustainability transitions all parties that are needed to establish concrete changes in the food system, should be involved in the design and conducting of the research and innovation programme through a process of ***co-design and co-creation****. However, niche players may have difficulty entering the process. Research of the Rathenau Institute has concluded that 'new parties' or niche players – such as (innovative) farmers or societal organizations– cannot easily participate in existing programmes, because they are not seen as a relevant knowledge partner or are not eligible to certain kinds of financial support. This is problematic, because niche parties from 'food system practice' should be able to contribute*

if the goal is to move towards system change. Similar conclusions were drawn from a debate that the Rathenau Institute organised in 2019[32], on the way in which knowledge can contribute to transitions in the agricultural sector: bridging is needed between established and new parties in various areas from research, to education, to farmers' practice, industry and governmental policy. The report with various suggestions for adjustments that could be made with regard to the organization of research and development programs, in order to better involve societal parties with varying knowledge, in order to better anticipate on the ***societal*** *embedding of an innovation[33].*

Clearly there are many different opinions of the best route to take towards a (food) system change. This is reflected in the landscape of research and innovation: from scientific programmes aiming at technological innovations[34], to societal partners experimenting with small-scale area-oriented approaches[35], and multinationals like Unilever who, within their own ranks, invest in all kinds of innovations because they want to contribute to a fundamental transformation of the (global) food system[36].

It is a positive sign that very diverse parties and research and innovation programmes and projects are actively trying to achieve the food system transition. Step by step the various parties involved (farmers, researchers, companies, policy makers) must learn what a good approach for the food system transition is. This ***learning process*** *is important but may not be focused enough on system change. Hence, efforts may not become aligned. This is a typical role that government policy may take up.*

To avoid fragmentation and directionless actions, several parties, including the Transition Coalition Food (Transitiecoalitie Voedsel in Dutch)[37], have stressed the importance of having a ***clear problem analysis*** *at an early stage and a* ***shared vision*** *on how the various projects fit together and complement each other. Such shared vision should include niche players, regime players and actors with different visions. Transitions will always bring controversy and conflict, it is better to embrace this, and work towards an inclusive new vision as an end product.*

The intermezzo above has given an indication of the dynamics that actors in research and innovation encounter if they want to play a role in speeding up the transition of the Dutch food system. This is likely to be similar in the Flemish food system. It brings some starting points for STI policies that should stimulate transformative innovation for food system sustainability. I will discuss these below.

Key aspects and characteristics of Transformative Innovation Policy

The above analysis of the debate in the Netherlands on the necessary food system change (although mostly focused on changes in primary production) and the associated STI policies, paves the way for describing aspects of challenge-driven policy or TIP.

As said before, the societal challenge is the starting point. A broad transdisciplinary approach, allowing all kinds of knowledge to be brought in, is preferred. Embedding should be anticipated with regards to regulatory, infrastructural, societal and financial aspects. There should be a programmatic approach, guaranteeing coherence and continuity among projects and all relevant departments and a broad range of societal stakeholders should be involved. Governments should take a guiding and directing role, have a reflexive attitude, experiment

with new policy instruments and organise a learning process to improve their own approach. Citizens and their interests must be involved during the entire research and development trajectory. Obviously, this requires additional capacity and the building of new transformative competencies. Table 1 below describes all these characteristics of TIP.

Table 1: Key aspects of Transformative Innovation Policy (TIP) and specific characteristics

	Aspects of transformative innovation policy	**Characteristics**
1	Oriented towards societal challenges	Societal challenge is **starting point**. Focused on societal **embedding** of innovation, paying attention to: a. Societal aspects of innovation; b. input of different sorts of knowledge; c. ecosystem perspective on knowledge and innovation; and d. the role of innovation in societal changes and transitions.
2	Policy approach	**Programmatic** approach, taking into account: a. Coherence of projects; and b. Continuity. **Multi-actor**- and **multi-level** approach, including: a. All relevant policy departments; b. Various policy levels (EU, nationaal, regionaal, lokaal); and c. Societal parties (public and private). d. Explore options to work more with private investors More **guidance and direction** from the government to mobilise knowledge and innovation for societal challenges. **Experimenting**, **flexible** and **reflexive** approach ("learning approach") involving research and policy.
3	Relationship with citizens	Involvement **of citizens and their interests during the entire** research and development trajectory.

Note: Table 1 is derived and translated from 'De belofte van opgavegericht innovatiebeleid'[38].

Politics and policy for food system transition need to be informed based on technology assessment

Democratic policy making

The decisions that politicians make, be it at the international, national or (in the case of Flanders) regional level, affect the direction of the transition of the food system. These decisions range from decisions on (limiting or re-directing) primary production, STI policy and the extent of investments therein, and regulation on the use of certain technologies, be it novel or existing.

Hence, transitions of food systems, or the future of our food systems, in the end depends on several **political decisions**. The political choice to clearly articulate that the food system needs to transform into a more sustainable system is a first bold one, as it is likely to touch the interest of regime actors. Some of them closely intertwined with political interests and the national economy. Then immediately several other political questions follow. How to transform the food system? How will research and innovation contribute to this? How much STI budget should be allocated to research and innovation for changing the food system and other societal challenges? How much public funding will be made available and what contributions does the government expect from private partners? And can we in hindsight say which kind of STI investments were most impactful when it comes to sustainability?

But let me be clear: transformative innovation policy is about more than just investments in STI. It should also cover regulation, in particular for achieving food system change. For example political decisions on regulations for new biotechnologies, e.g. genetic modification of crops or of microbes, are important.

In the case of democratic policy making, these political decisions can be informed by TA (CTA and PTA, see earlier in this essay). In addition, they can be informed by the outcomes of societal dialogue on new, potentially controversial technologies, which help define the conditions of implementing technology in society. A societal dialogue entails opinion forming in a process of mutual learning between scientists and various other societal stakeholders in order to collectively anticipate on the broad consequences of technology for individuals, society and humanity. The activities of TA could have a mediating function between the spheres of parliament, government, science and technology, and society.

In 1986 the Dutch government founded a TA institute that was entrusted with the specific task to research these kind of questions. This institute was then called the Nederlandse Organisatie voor Technologisch Aspectenonderzoek (NOTA), now called the Rathenau Instituut. The research of the Rathenau Instituut informs politics - the Upper and Lower House and the European Parliament. The Rathenau Institute is managed under the auspices of the Royal Netherlands Academy of Arts and Sciences. Just like universities, the institute is independent of the national government, even though it finances the majority of the work[39]. Worldwide there are at least 22 other institutes that advise parliament and citizens on the possible societal consequences of technological developments. In the European Parliamentary Technology Assessment network (EPTA) they cooperate and learn from each

other[40]. Of course, the work of these institutes is also relevant to wider society, in particular citizens and other knowledge institutes.

The **level of political support for having such institute** varies among countries. Former Thinker and colleague Rinie van Est explains that it depends on whether the TA is performed by members of parliament (MPs) or by TA experts, and to what extent MPs are allowed to play a role in the scientific process or the organization of societal dialogues. This influences the relationship between the outcomes (often policy options) of TA and democratic policy making. Van Est stresses the importance of having TA for democratic policy making, particularly "in the current political climate that is regularly portrayed as a 'post-truth era' and influenced by the rise of radical right populism"[41].

Until 2012, Flanders had a PTA institute called Institute of Society and Technology (IST, in Dutch: Instituut Samenleving en Technologie). It was also part of the EPTA network. The history and the process of decision taking around its ceasing to exist and landing of (part of) its activities can be read on the EPTA website[42]. From the discussion Johan Schot and I had with the various stakeholders in Flanders, it is my conclusion that there is not enough support for recreating a TA institute in Flanders. Yet it is deemed important to organise the mediating function (i.e. between society, STI and politics) such institutes have, leaving Flanders with the question how to do this.

Well, let's turn back on political decisions on regulation surrounding biotechnology. So far, quite some attention in this essay has been on agricultural production, i.e. the primary production process in the food value chain. However, it is important to also include biotechnology in the discussion on transition of food systems for its relevance to more sustainable primary production and advancements in the bioeconomy, which forms a pivotal part in the strategy of Flanders towards a more sustainable food system (see section 3).

Biotechnology, sustainability and bioeconomy: need for a societal dialogue

Biotechnology often entails gene-editing techniques, which are seen as controversial by part of society, not only the general public, but also scientists or policy makers. Gene editing can for example be used for crops to be made more pest-resistant or for microbes to become 'cell factories' for production of special food proteins or edible oils. First of all, aspects of risk and uncertainty surrounding gene editing[43] are a concern for members of society. In addition, gene editing is considered unnatural by several members of society for various reasons[44]. These attitudes influence the use of the gene-editing technologies in the food system, considering that they serve as important sources of information for political decision taking. That these attitudes vary over time and differ per country or region is exemplified by the case of Golden rice (rice that is genetically-modified to contain beta-carotene, the precursor of vitamin A): in 2021, The Philippines was the first country to approve Golden rice, more than 20 years after the first successful scientific developments[45].

The introduction of CRISPR-Cas9, a breakthrough genome-editing technique, was a catalyst for renewing the societal debate on gene-editing of crops. Because there is no introduction of foreign DNA in the gene-edited organism, several stakeholders advocated to exempt CRISPR-Cas9 crops from the European GMO Directive regulation and hence give room to

innovation. In a report of 2019, the Rathenau Instituut[46] described three negatives of this policy: 1. Monitoring of safety of application of new genome-editing techniques in crops is still warranted; 2. Being GMO-exempt also means being exempt of labelling, leaving no freedom of choice to the consumer; 3. This policy option gives no space for weighing ecological, cultural or ethical aspects. The Rathenau Instituut in that report describes a differentiated approach, a policy option that takes into account the level of risk involved as well as broader societal and ethical aspects. The strictness and speed of risk assessment procedure in our view depend on presumed risks. Besides, this third option gives systematic attention to concerns of citizens as well as to the contribution of GMO crops to solving societal challenges.

Also agricultural stakeholders acknowledge these as important criteria for admissibility of cultivation of GMO crops in the Netherlands, the Rathenau Institute found in interviews and dialogues with stakeholders[47]. Based on the 2019 report[46] the Panel for the Future of Science and Technology (STOA) organised stakeholder dialogues which can further inform the political debate[48].

Trust in biotechnology can only be gained if scientists, government, societal organizations and commercial parties take their responsibility and a wider risk-benefit assessment is done.

The role of politicians is to have the debate and weigh chances and risks for economy, sustainability and wellbeing (see Table 2).

Table 2: Guidelines for democratic policy making for modern biotechnology, such as gene editing

	Guidelines	Rationale
1	Engage in societal dialogue	In dialogue, all stakeholders should discuss the goals and conditions for applications of gene editing or other forms of modern biotechnology.
2	Assess risk and benefits	In the debate, the following issues should minimally be addressed: • **Power & control**: NGOs worry about patents in gene editing and other forms of modern biotechnology, because of the chance of monopolising of knowledge by large companies. This can cause resistance and suspicion in society. • **Benefits, including sustainability**: For the bioeconomy, biomass should be used much smarter and more efficiently. This requires new and radical forms of modification and manufacturability of plants and micro-organisms. The value of 'sustainability' clashes with that of 'naturalness' **Risks and regulation**: Trust defines societal support. Existing regulation should be evaluated for current and future suitability for assessing safety risk. Risks of mis-use should be identified early on. The precautionary principle can guide.
1.	Active role of government	2. Governmental policy cannot define the exact path of innovation, but can influence both the development and implementation phase. 3. Stimulation of responsible innovation [RI] in development. 4. Give clarity on accountability and ensure that parties take responsibility and show responsiveness.

Footnote to Table 2: In preparation of a political debate on Biotechnology in February 2017, the Rathenau Institute gave policy options that are still relevant today, based on the report: Moderne biotechnologie in Nederland | Rathenau Instituut[49].

So the question is: How to organise this in Flanders, given there is no TA institution that could independently organise such societal dialogues? Considering what it takes to have democratic decision taking on controversial technology, like some biotechnology, there is value in having such an institution. Let's move to the next section of this essay, to Flanders' (STI) policy on economy, innovation and the food system, and how society is involved in that.

Flanders' policy on Economy, Innovation and Agriculture

In the previous sections I have explained what a food system entails, that Transformative Innovation Policy (TIP) is needed to reach a transition of a food system (or any system for that matter), what the prerequisites are for TIP and what the relevance is of TA and societal dialogue for informing politicians and policy makers on STI policy for the food transition. Let's turn back to the question that minister Crevits asked us to answer in her video message at the final symposium: "Is the STI policy and STI landscape in Flanders enabling solutions to the societal challenge of reaching a more sustainable food system in Flanders?"

Giving a proper answer to this question would require in-depth research, not just of the STI system, but also of the food system in Flanders. I have done neither of the two, as it would go beyond the scope of the task of a Thinker-in-Residence. What this essay *can* do is give suggestions for STI policy to the Flanders' government that will help the transition of the Flemish food system. These suggestions are the result of the three KVAB discussions between the two Thinkers-in-Residence and stakeholders from both the food system and the STI policy system as well as follow-up interviews with a few of the aforementioned stakeholders.

For those who are unfamiliar with it, I would like to start with a sketch of the Flanders' food system and its policy, including the link to STI policy, based on desk research and the discussions. The Flanders system of agriculture and fishery is nationally and internationally well known. Agricultural business makes up 70% of all businesses in Flanders. The food industry provides 65% of total revenues, makes most investments (58%), creates most added value (62%) and is the largest employer (49%). The agricultural distributive and collecting trade and other sectors like suppliers of ingredients and other materials take in the remaining percentages[50].

As in many small regions or countries in Europe, the food system has various challenges: lack of space, a farmers population that is ageing and the problem of high nitrogen concentrations. The key elements in the agriculture and fishery policy are collaboration, sharing and using knowledge, and innovation and supporting of agricultural business in a joint "evolution" to an agricultural system that is **in balance with the carrying capacity of the environment** and that **increases the resilience of the businesses**[50]. The Flanders government wants to engage in an "intense collaboration" across all policy domains and levels, in order to reach an "integrated, coherent Flanders' food policy embedded in a circular economy". This circular economy is translated to practice, since the Flanders' government has installed Circular Flanders[51], "…the hub and the inspiration for the Flemish circular economy. It is a partnership of governments, companies, civil society, and the knowledge community that will take action together." Regime players are dominant in Circular Flanders. This appears the most important, if not only, example of where a vision of the Government is translated into a concrete transition government and policy practice[52].

The policy brief on Agriculture and Fishery states: "Healthy, sustainable, sufficient and safe food for a fair price for each chain of the food value chain are central to the food policy." It continues explaining that in such a policy, primary production forms the basis and hence the agricultural businesses are given a pioneering role in the further process of reaching a more

sustainable food system, in collaboration with the core value chain and in close connection with the consumers. “Together with the sector we make a switch **from a production model to a sustainable business model**. We provide the policy instruments to achieve such a transition over time and support initiatives that contribute to it. Communication and engaging stakeholders to realise widely-supported behavioural changes are important focal points in this strategy”, the policy brief explains. Clearly, transitioning to resilient, innovative, sustainable agricultural business models is quadruple central in this policy[50]. It should be noted that the word ‘sustainable’ is not equal to ‘(agro)-ecologically sustainable’. It is primarily about ‘ensuring a stable income for farmers and economy’.

This **tight interconnection between economic progression, science and innovation, and agriculture** is very obvious in Flanders. The “integrated, coherent Flanders food policy embedded in a circular economy” provides a clear focus. It defines the policy and landscape for STI related to the food system. The Flemish cabinet, which kicked off in October 2019, has made close connections between the policy domain Economy, Science and Innovation (EWI) and the domain of Agriculture and Fishery.

The policy brief 2019-2024 takes “an honest contextual analysis of the strengths and weaknesses of our economy and innovation-ecosystem” and “**mission-oriented policy**” as important starting points. The brief states that the **bioeconomy is crucial to reach a circular economy**. The Flanders policy plan ‘Bioeconomy’ specifically formulates the strategy to support the Flanders bioeconomy, by a series of actions ranging from stimulating research and development, guiding new **collaborations between industry and agriculture**, and flanking policies[53].

This Flanders bioeconomy policy is based on and **aligned with the European policy on bioeconomy**[54]. This document states: “Bioeconomy the European way: The bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services. To be successful, the European bioeconomy needs to have sustainability and circularity at its heart. This will drive the renewal of our industries, the modernisation of our primary production systems, the protection of the environment and will enhance biodiversity.”

Hence, the Flanders’ strategy for economy, science and innovation –pivoting around circular economy and specifically bioeconomy– leans on optimal use of European programmes and actively influencing European policy making for STI and industry policies. Cross-regional and international alliances are expected to strengthen Flanders’ economical position. The ministry and also VARIO are in favour of the so-called ‘quadruple helix’, characterised as an innovation model that will help solve societal challenges. This means that not only industry and scientists are involved in collaboration, but also citizens and SMEs get an active role. Excellent fundamental research remains the basis for innovations and company R&D for guaranteeing competitiveness of business. “Sensibilisation of wider society about innovative

entrepreneurship, a transparent and accessible science communication and **methods to collaborate [co-create] with citizens**" are strongly emphasised in this 'quadruple helix' model "to contribute to larger societal and economic impact." Besides that, the foreword of this policy document stresses that citizens should have a **better understanding of and trust in new technology and in the solutions it can bring to societal challenges**. "Bringing technology and innovation closer to citizens will create broad societal consensus on its application", the minister states.

According to the Beleidsnota 2019-2024, Flanders has unique assets that make it stand out internationally in further building a strong bioeconomy: its many research centres, pilot installations, and universities specialised in fundamental and applied research that form the basis for an innovative bioeconomy and can stand the competition internationally. Also, there is large involvement of industry in the bioeconomy. The Flanders 'specialised clusters programme' (Spearhead clusters) supports innovation in bioeconomy[55]. The clusters involve networks of businesses, knowledge institutes and governments, to some extent comparable to the Dutch Top Sectors[56]. **Flanders' FOOD** – Agro-food has a budget 40 million euros.

The NOTA continues that the primary sector has pioneering, innovative entrepreneurs who collaborate with local partners to set up new technologies or value chains. And: "the transition towards a bioeconomy has the potential to make the local economy more resilient, particularly by supporting SMEs in the agricultural and agro-food domain." However, when taking a closer look at the scheme of the bioeconomy, it is obvious that it entails 'flow and economization of biomass', but lacks the levels of societal elements and environmental elements shown in the Food System Wheel. I would argue that for transitioning to a more sustainable food system it would help to not reside purely on a strong bioeconomy in which agriculture and industry interact. There is space for more sustainable business models in the strategies, but no specific invitation to niche actors, as far as I can see.

Finally, the elements explained above (collaboration in the food value chain, innovative and knowledge-driven, communication, resilient business models) are also echoed in the Flanders Food Strategy (5), Vlaamse Kost, which has four strategic goals: 1) All in on a resilient food economy, 2) Food unites farmer and citizen, 3) Circular and sustainable venturing for the future and 4) Healthy and sustainable food for everyone. There are possibly some elements of TIP (frame 3) here, for example "dissemination of good practices" and "power of social entrepreneurship". **The Flanders Food Strategy might offer building blocks for TIP.**

The Food Strategy acknowledges that environmental targets are bounding (climate, water, biodiversity). Protein diversification is seen as an important element to sustainability, but it is closely tied to economic benefits gained from this innovation. Food is expected to be produced close to home for a fair price ("Vlaamse kost"), food poverty must be reduced and food consumption patterns must be both healthy and sustainable. Like in the 'EAT Lancet paper' and aligned with the Sustainable Development Goals[57].

In 2022, the Flemish government will organise a Flanders "food summit" together with the 'demand side' (consumers) and 'supply side' (agro-food value chain) of the market. This is the endpoint of a trajectory in which everyone is invited to collaborate and come with ideas. It

should lead to a final, practice-oriented approach for reaching a sustainable food system. In the summer of 2021 the Go4Food call[58] invited 'food change makers' to come forward with a promising idea for 'food for the future'. Out of 79 initiatives the five most promising were selected[59]. The change makers will be supported by a broad food coalition offering their facilities, network and expertise. At the food summit in 2022, the leveraging initiatives will be joined with the launching of *the* Flanders' Food Strategy. The broad food coalition will make the translation to the necessary policy approach. The question is whether enough actors from outside the current food system regime are included.

Also the Netherlands knows 'food change makers': Food100[60]. The 'regime actors' Rabobank, Foodvalley NL[61] and World Food Center[62] make it possible. And like in Flanders there is food coalition called Transition Coalition Food[63]. This coalition was truly a bottom-up approach which already came up in 2016 unlike the top-down invitation to gather a coalition by the Flanders' government.

Interestingly the transition of the food system is nowhere to be found in the Vision 2050, a long-term strategy for specific transitions[64]. So far for a rough analysis of relevant policy documents that give a sense of the STI policy intent in Flanders. But what are the observations from the stakeholder discussions?

Conclusions from the stakeholder roundtable discussions

Is Flanders' STI policy fit to shift the Flanders' food system to a more sustainable system? That was the questions that I started this essay with. The Thinkers-in-Residence held basically three discussions on transition of the Flanders' food system with actors from the food system and from the STI policy system. On October 11, 2021, in a roundtable discussion, several actors of the Flanders' food coalition joined. On November 23, there was a session in a conference on this topic, and a workshop, focusing on including society in the food system change. In this last section of the essay, I will summarise the analysis on the various policy documents and innovation strategy, and use the discussions as illustration, confirmation or elaboration of the analysis. Per observation, I will provide some suggestions for the Flemish Government that in my view are needed to make progress in the food system transition.

Observation 1: Economic growth is still central to the Flemish food strategy

Summarising, the Flanders government expects that a successful food policy for healthy, sustainable, sufficient and safe food for a fair price should be embedded in the bioeconomy, brought forward by a tandem of entrepreneurial businesses in agriculture and industry. In the various policy briefs, the Flanders' food system (probably better defines as 'food value chain', since it is nowhere in policy documents described as holistically as the FAO food system wheel) is intended to shift from a production model to a sustainable business model. Economic growth and welfare of the primary sector and the biotechnology sector remains central. The Flanders government in her policy shows **some directionality**: it favours a 'sustainable business model' which of course is not necessarily the same as 'a sustainable food system'. In the end, economic growth, combined with "do no harm", appears to be the

driver. I found no articulated, agreed vision of how STI policy can accelerate a true transitioning of the food system.

This was confirmed by stakeholders, in particular niche actors. “There is no consensus and no open debate about the future of our agricultural system. Many are stuck in their own vision and beliefs. There is little basis for support of a real change, but that does not mean the government should sit back and relax.” One stakeholder commented that it is needed to “reset the economic rules of the game” in order to stimulate and reward a sustainable food system.

Suggestion 1: Articulate a strategy of how STI policy can accelerate a true transition of the food system in Flanders, using the FAO Food System Wheel as a basis.

Observation 2: Regime actors in the Flemish food system are still put in the lead

From the discussions I concluded that the shift towards a ‘sustainable’ business model in agriculture, preferably embedded in the bioeconomy, is left to the farmers and the other (dominant) actors in the current food system and the science and innovation system, such as the renowned universities and technology institutes. As currently the regime actors in the food system benefit from high throughput and high-efficiency production, it is questionable how exactly the ‘sustainable’ business model will be reached. Too often, *optimization* of the current food system (mitigation / adaptation) is seen as the way forward for sustainable innovation. This ‘frame 2 approach’ can of course be useful, and might even ignite the transition process, but is not sufficient to ensure transition of the food system. New technology, based on digitization (precision technology) or biotechnology, is expected to lead to desired results (“technological optimism”), and the current regime actors are kept in the lead For example Flanders Food, based on a strong bioeconomy, relies on the current, wealthy regime actors from the agro-food complex and collaboration in a public-private construction. Only on a smaller scale, within universities and knowledge institutes, e.g. at ILVO, research is done on **system change**. Also a few researchers within universities, e.g. at KU Leuven and University of Ghent (Centre for Sustainable Development), study system changes. In provincial research centres, farmers are involved in research processes towards sustainable farm systems. Bringing in experiences and interests of farmers instead of big agro-food players is a necessary step towards a sustainable food system. So these activities show elements of ‘**transdisciplinary learning**’.

From the stakeholders in the discussions we heard that it is particularly difficult to organise finances for agro-innovation from Belgium or Flanders. Much more often, EU-funding is leveraged. At the same time, some stakeholders argue that EU legislation is hindering innovation, e.g. on gene-editing of crops or micro-organisms. Stakeholders comment that so-called incremental innovation (system optimization) more easily gets funding than radical (system) innovation. The current, dominant funding structures of public-private partnerships are deemed responsible. European STI policy supports involvement of and collaboration with niche players and transdisciplinarity better than e.g. the policy of FWO. Based on research of the Rathenau Instituut, I can confirm the fact that the European STI policy is ahead when it comes to TIP[38,65]. According to an STI policy stakeholder, the multi-actor approach of

European Commission is in fact partly inspired by the policy of VLAIO. The stakeholder explained that within Flanders' subsidy systems for financing research, **co-financing by private partners** is needed. It turns out that attitudes of regime partners and current subsidy conditions, both in EU as well as Flemish innovation projects, are not conducive to using the funding for "stakeholder interaction" or "field experimentation", e.g. by farmers or niche players. Instead, the regime actors want it to be spent on 'hard' research, e.g. investment in laboratory research. Hence, income insurance of farmers that engage in a high-risk, high-benefit field experimenting by farmers are not reimbursed. This is a clear example of the fact that the behaviour and attitude of the current dominant system actors has to change towards a more open, engaging one that allows transdisciplinary learning. This would mean for example that also in-kind investments by niche players would be valued or a fixed percentage of subsidies should be earmarked for niche players.

Finally, looking at the Flanders' food strategy there is some notion of niche construction with the Go4Food call, but **as of yet no destabilization of the dominant system**.

Suggestion 2: Reconsider (and if needed: redesign) the current Flanders' funding schemes for food and agriculture STI, in particular their conditions on co-funding and suitability for transdisciplinary learning.

Observation 3: Flanders' food strategy is seen as old wine in new bottles

In general I sensed a certain reservation towards the trajectory of the Flanders food strategy, in particularly on how it will pan out in practice. Among many stakeholders there is a fear of "old wine in new bottles", a situation in which the well-known regime actors are asked to participate in the Flanders' food coalition and will be involved in defining the strategy. This is likely to limit the (modest) transformative character that is has. The fact that the Flemish government has invited the civil society, i.e. private organizations representing groups and interests, it seen by some as a worrisome approach. Among the partners in the food coalition, great power imbalances exist which reflect the current power distribution in the Flanders agro-food system. The Flanders Farmers Union apparently "sits at the head of the table", as we heard.

The protein diversification strategy, on the other hand, is a good example of a strategy where STI policy may promote a transition. It involves not only the minister of Agriculture, but also of Environment. Instead of a mitigation approach (e.g. inhibitors of methane production in animal feed) or high-tech approach (i.e. lab-grown meat) the protein diversification strategy in Flanders is open to any other protein source in the diet than meat, dairy and fish. The fact that it is called 'protein diversification' instead of 'protein transition' (like in the Netherlands), explains why the primary sector, food industry and consumers in Flanders are willing to participate. It's not too radical and animal farmers are willing to participate too.

The Spearhead clusters Flanders Food may be successful in coordinating innovation in bioeconomy, but it is likely to be too slow and too much focused on economic growth to lead to true system change. The regime actors keep niche players at an arms' length here.

Suggestion 3: Preparing for the Food Summit in 2022, Flanders' government must find a way to prevent regime actors from dominating the final action plan, and pause if this is not possible.

Observation 4: The government, or some delegated party, is hardly offering transition management.

With transition management, among others, we refer to stimulating system change research and installing democratic processes for the innovation and knowledge-building through transdisciplinary learning. In our stakeholder discussions we raised the possibility that the Flanders' government would proactively lead the transition of the food system, by giving further mandates (e.g. for performing system change research or TA) to certain existing institutes and allowing more space to niche players. We found that the niche players, e.g. farmers experimenting with new business models, were in favour of such an approach as it would give niche players a stronger position. The 'free market' was unlikely to lead to non-incremental system change, stakeholders said. Some STI policy stakeholders deemed the Spearhead clusters to be sufficient to take up the coordinating role, "guided by sustainability indicators". Some stakeholders think that a too directive role of the government will harm the support base of the general public. Also system optimization should keep a firm place, according to some stakeholders.

Suggestion 4: Give a fully independent (existing) institute or committee the mandate to manage the food system transition in Flanders.

Observation 5. Society is included mostly in the food system transition via citizen science and communication

And of particular interest too: are the insights from societal interactions used to build a stronger STI policy and take better political decisions for accelerating towards a food system transition?

Connecting with and communicating to citizens (mostly in their role as consumers) is another key element of the Flemish food policy. Let's take a closer look at how this relates to Transformative Innovation Policy (frame 3). The discussion on what it entails to include society were quite fuzzy among the stakeholders. Including farmers is seen as 'including society' by some stakeholders. ILVO has expressed the ambition to strengthen social innovation within the agricultural sector by performing transdisciplinary research (i.e. involving expertise from farmers and citizens) with an interdisciplinary team of scientists. At the same time, the Landbouw en Visserij Nota gives farmers a pioneering, leading role (on paper at least).

Next to that, citizen science is seen as valuable approach to bring about 'change'. Citizens in Flanders were asked to grow soy plants to get a better understanding of protein diversification and sustainability. Among policy makers, however, I noticed that there is little intention to engage with citizens in societal dialogue to better inform political decision making on biotechnology, such as producing proteins via gene-edited microbes that function as 'cell factories'. In the final workshop on November 23, it was raised as a useful option though. Another option raised at that workshop was to include citizens in funding of innovation for

sustainable food systems (crowdfunding) to allow for the shift towards 'sustainable business modes'. Can this be enabled? Can the government steer this? Others question this idea: is lack of money truly holding back the transition? It's the skewed allocation of money towards actors and projects that seek to optimise rather than change current systems, according to them.

Furthermore, education of school children and consumers of what sustainability entails is deemed important. But some see the role of education as not far-reaching or not effective enough. And as argued before: consumers can only effectively change towards a sustainable diet if the food system invites them to do so. Nudging consumers to change food behaviour will not suffice. In conclusion, one could say that debates on sustainable food systems are taking place within institutions, but not among citizens. This hampers societal support for biotechnology-based solutions.

Suggestion 5: Organise a more formal, independent way of having societal dialogues on food system transition in the broadest sense, and the use of promising technology therein. The outcomes can inform political debates.

Concluding comments on STI policy and food system in Flanders

The STI policy for reaching a more sustainable food system in Flanders shows a broad, horizontal vision, but it is not truly a food system transition policy; the bioeconomy is put central ("farmer meets industry, university enables"), and this is probably where Flanders' strength lies. The actual steps towards a more sustainable food system are left to a food coalition in which regime players are dominant. Niche players do not get enough space. The policy is not actionable enough in my view. Mobilising new actors for sustainability depends on money of regime actors, but they prefer to invest in high-tech incremental innovations instead of more transformative 'field experiments'. Farmers and their switch to a sustainable business model are central in policy briefs; (big) farmers are present in discussions, but not truly involved in innovation and knowledge-building processes through transdisciplinary learning. There should be more room for societal debate on where the food system should be heading, and on weighing benefits and risks of modern biotechnology needed to prepare for a broader base of support within society.

References

[1] Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M, Ezzati M, Grantham-McGregor S, Katz J, Martorell R, Uauy R; Maternal and Child Nutrition Study Group. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet 2013 Aug 3;382(9890):427-451. doi: 10.1016/S0140-6736(13)60937-X. Epub 2013 Jun 6. Erratum in: Lancet. 2013. 2013 Aug 3;382(9890):396. PMID: 23746772.

[2] GBD 2017 Diet Collaborators. Health effects of dietary risks in 195 countries, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 2019:393:1958-27. Health effects of

dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017 - The Lancet

[3] Willett W, Rockström J, Loken B, et al. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. Lancet 2019; 393: 447–92. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems - The Lancet

[4] Ministerie van Landbouw, Natuur en Voedselkwaliteit. Visie Landbouw, Natuur en Voedsel: Waardevol en Verbonden. The Hague, The Netherlands, September, 2018. Visie Landbouw, Natuur en Voedsel: Waardevol en Verbonden | Beleidsnota | Rijksoverheid.nl

[5] Departement Landbouw & Visserij. Voedselstrategie: Vlaamse Kost, Vlaanderen, 2020. Vlaamse kost (voedselstrategie) | Departement Landbouw & Visserij (vlaanderen.be)

[6] Van Est, R. Responsible Innovation as a source of inspiration for Technology Assessment, and vice versa: the common challenge of responsibility, representation, issue identification, and orientation, Journal of Responsible Innovation 2017;2: 268-77. Full article: Responsible Innovation as a source of inspiration for Technology Assessment, and vice versa: the common challenge of responsibility, representation, issue identification, and orientation (tandfonline.com)

[7] FAO 2018. Sustainable food systems: Concept and framework. Sustainable food systems: Concept and framework (fao.org)

[8] Gladek E, Fraser M, Roemers G, Sabag Muñoz O, Kennedy E, Hirsch P. The Global Food System: An Analysis. Report commissioned by WWF, METABOLIC, Amsterdam, 2017. Global Food System: An Analysis - Metabolic

[9] HLPE, 2014. Food losses and waste in the context of sustainable food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome 2014. Food losses and waste in the context of sustainable food systems (fao.org)

[10] Farm to Fork Strategy (europa.eu)

[11] Paris Agreement (europa.eu)

[12] Ons verhaal | The Vegetarian Butcher (devegetarischeslager.nl)

[13] Those Vegan Cowboys

[14] Peace of Meat (peace-of-meat.com)

[15] Het Voedselbos vzw

[16] John Grin, Jan Rotmans, and Johan Schot, Transitions to Sustainable Development. New Directions in the Study of Long Term Transformative Change, New York: Routledge, 2010.

[17] Schot, J. and Steinmueller, W. E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. Research Policy 47: 1554–1567. Microsoft Word - Latest April 2018 3 Frames Paper fro Web Proofed v8RK SENT-Schot-Steinmueller Framings of STI Policy-Secondsubmission.docx (tipconsortium.net)

[18] Kuhlmann, S. and Rip, A. (2018). Next-Generation Innovation Policy and Grand Challenges. Science and Public Policy 45(4): 448–454.

[19] Mazzucato, M. (2018)]. Mission-Oriented Research & Innovation in the European Union: A problem-solving approach to fuel innovation-led growth. European Commission.

[20] Rathenau Instituut (2021). Onderzoeksprogramma's met een missie – Lessen voor opgavegericht innovatiebeleid. Den Haag. Onderzoeksprogramma's met een missie (rathenau.nl)

[21] https://www.agf.nl/article/9289914/noodzaak-transitie-naar-duurzame-landbouw-erkend-in-verkiezingsdebat/

[22] Politieke partijen bakkeleien over grond en innovatiemiljarden - Nieuwe Oogst

[23] D66 – Halveer de veestapel

[24] How a Nitrogen Crisis Turned Dutch Farmers to Rage | ARC2020

[25] https://nos.nl/l/2417566

[26] Coalitieakkoord 'Omzien naar elkaar, vooruitkijken naar de toekomst' | Publicatie | Kabinetsformatie (kabinetsformatie2021.nl)

[27] Quickscan van twee beleidspakketten voor het vervolg van de structurele aanpak stikstof | PBL Planbureau voor de Leefomgeving

[28] Toekomstbestendige stallen melkvee (zlto.nl)

[29] Hooguit 10 procent minder koeien, meer hoeft de veestapel niet te krimpen, zegt de hoogste baas van FrieslandCampina | De Volkskrant

[30] https://www.volkskrant.nl/columns-opinie/de-baas-van-frieslandcampina-zegt-zulke-onnozele-dingen-dat-je-medelijden-met-hem-krijgt~bb5dcc4c/

[31] Weg met het hokjesdenken in de landbouw (volkskrant.nl)

[32] https://www.rathenau.nl/nl/terugblik/maatschappelijke-transitie-alleen-mogelijk-met-circulaire-kennis

[33] Rathenau Instituut (2019). Voorbereid op de Praktijk – Anticiperen op de maatschappelijke inbedding van innovatie bij onderzoeks- & ontwikkelprogramma's. Den Haag, 2019. Voorbereid op de praktijk | Rathenau Instituut

[34] Precisielandbouw - WUR

[35] https://www.staatsbosbeheer.nl/Over-Staatsbosbeheer/Dossiers/natuurinclusieve-landbouw

[36] https://www.unilever.nl/news/overig-nieuws/2019/unilever-opent-nieuw-foods-innovation-centre-in-wageningen.html

[37] https://transitiecoalitievoedsel.nl/wp-content/uploads/2020/05/Voorstellen-missiegedreven-innovatie-van-TcV.pdf

[38] Rathenau Instituut (2020). De belofte van opgavegericht innovatiebeleid – Een analyse van Europees innovatiebeleid voor de Green Deal en kunstmatige intelligentie. Den Haag. De belofte van opgavegericht innovatiebeleid | Rathenau Instituut

[39] Who we are | Rathenau Instituut

[40] EPTA Network - Home

[41] Rinie van Est (2019). Thinking parliamentary technology assessment politically: Exploring the link between democratic policy making and parliamentary TA. Technological Forecasting and Social Change; 139: 48-56. https://doi.org/10.1016/j.techfore.2018.07.003. Thinking parliamentary technology assessment politically: Exploring the link between democratic policy making and parliamentary TA - ScienceDirect.

[42] Flanders (eptanetwork.org)

[43] The precautionary principle and the development of gene drive technology | Rathenau Instituut

[44] COGEM 2022: Final COGEM report - On the nature of nature - A study on the use and meaning of nature and naturalness in the literature on genetic modification

[45] Philippines becomes first country to approve nutrient-enriched "Golden Rice" for planting | International Rice Research Institute (irri.org)

[46] Van Est, Habets 2019: Genome editing in plants and crops | Rathenau Instituut

[47] Afwegingskader nationale teeltbevoegdheid genetisch gemodificeerde gewassen | Rathenau Instituut: Geert Munnichs, Huib de Vriend en Dirk Stemerding, Afwegingskader nationale teeltbevoegdheid gg-gewassen - Verslag van een stakeholderdialoog. Den Haag, Rathenau Instituut, 2016.

[48] STOA 2021: Online stakeholder engagement on controversial subjects: The case of genome editing in crops | Epthinktank | European Parliament.

[49] Virgil Rerimassie, Rinie van Est, Dirk Stemerding, Ira van Keulen, Zoe Robaey, Melanie Peters, Ineke Malsch , Moderne biotechnologie in Nederland - Achtergrondnotitie AO Biotechnologie op 9 november 2016. Den Haag, Rathenau Instituut 2016 Moderne biotechnologie in Nederland | Rathenau Instituut

[50] Beleidsnota Landbouw en Visserij [127 (2019-2020) – Nr. 1 8 november 2019 (2019-2020)].
[51] Circular Flanders - Hub of the Flemish Circular Economy (vlaanderen-circulair.be)
[52] OECD Environmental Performance Reviews: Belgium 2021 | en | OECD
[53] DE VLAAMSE MINISTER VAN ECONOMIE, INNOVATIE, WERK, SOCIALE ECONOMIE EN LANDBOUW. NOTA AAN DE VLAAMSE REGERING. Betreft: Vlaams beleidsplan bio-economie. Brussel, 2020. 5fdb87a305144e000d000845.pdf (ewi-vlaanderen.be)
[54] European Commission, Directorate-General for Research and Innovation, A sustainable bioeconomy for Europe : strengthening the connection between economy, society and the environment : updated bioeconomy strategy, Publications Office, 2018, https://data.europa.eu/doi/10.2777/478385
[55] Brochure_flanders_bioeconomy_2020.pdf (vlaanderen.be)
[56] Topsectoren: van 2011 tot nu | Topsectoren
[57] UN General Assembly. (2015). Transforming our world: the 2030 Agenda for Sustainable Development, A/RES/70/1. available from undocs.org/en/ A/RES/70/1
[58] Go4Food zoekt voedselveranderaars - ILVO Vlaanderen
[59] Vijf voedseltafels krijgen subsidie in aanloop naar de Vlaamse voedseltop | Departement Landbouw & Visserij (vlaanderen.be)
[60] Food100 - Dé voedselveranderaars van Nederland
[61] Foodvalley NL | Shaping the future of food together
[62] World Food Center (WFC) Werken, Wonen, Beleven in Regio Foodvalley
[63] Transitiecoalitie Voedsel – Transitiecoalitie Voedsel
[64] Visie 2050. Langetermijnstrategie | Vlaanderen.be
[65] Rathenau Instituut (2021). EU-missies voor maatschappelijke opgaven – Inspiratie uit Horizon Europe voor opgavegericht innovatiebeleid. Den Haag: Rathenau Instituut. EU-missies voor maatschappelijke opgaven | Rathenau Instituut

Overall conclusions and recommendations

The purpose of this report was to answer the following question for Flanders: is a novel STI policy needed in order to promote sustainable development, in particular to mitigate and address solve global challenges? Additional points for reflection were: how to best engage society in sustainable development, and what role could Technology Assessment (TA) have? These questions have been explored in two essays published in this report. The essay by Johan Schot addresses the questions for STI Policy in general, while Petra Verhoef focuses on the selected case-study of sustainable agriculture and nutrition. In this final section of the report we provide a number of conclusions that apply to both the general policy as well as the case study. In this sense the food case study has confirmed general findings about STI policy. To inform ourselves about current developments in Flanders we have engaged in roundtable discussions, panel discussions and follow-up interviews with experts and stakeholders in the field as well as desk research as is explained in the introduction to the report.

We have one main recommendation for Flemish STI actors: focus more on transformation and system change. The coming decade will be crucially important for the world and Flanders to use the transformative capacity of STI Policy to address ecological and social challenges, such as the climate and biodiversity crises as well as growing inequalities. While Flanders' STI policies rank very high when it comes to fostering excellent science, R&D investment and stimulating knowledge valorisation, a clear focus on mitigating social and ecological challenges through transformation and system change (= a sustainability transition) is missing.

Accordingly, Flanders' STI policy may end up failing to develop and accelerate much needed sustainability transitions in areas such as energy, mobility, food. Such a focus on system change has a number of consequences:

- Social innovation, behavioural change and technological innovation need to go hand in hand. Neither technological nor social fixes will work. STI policy should thus focus on this combination. This can be done by using a system perspective, for example for the food system the FAO Food System Wheel can be used as a basis.
- Marginally adding sustainability or impact criteria to projects, programs and policies does not suffice. Instead meeting social and ecological challenges should become the most important criterium, building upon the current strengths (for example for the food areas the bio-economy) yet recognising that business as usual will not work.
- Incumbents or regime actors should not dominate programs and networks (such as the food coalition) aiming for a sustainability transition. This is also a consequence of co-funding requirements that can be more easily met by these regime actors. It is very important to provide enough space for newcomers or niche actors, and relax co-funding requirements for them. For example for the food system transition is crucially important that the Flemish government should find a way to prevent regime actors from dominating the final action plan of the Food Summit in 2022, and assist niche players in contributing, even if this means a delay in the process.

- Prioritising sustainability transitions requires capacity and capability building for researchers, policy makers as well as private actors, including private investors and civil society. The development of a (temporary) platform for articulating general transformative missions (or visions) for several areas such as food, organising learning, sharing of experiences with implementing the vision, and developing more soft coordination across various STI agents is recommended. This platform should get a long term (10 year) mandate to assist in accelerating sustainability transitions.
- Technology assessment is an underserved function in the Flemish STI policy landscape that has the potential to play crucial role in sustainability transitions, both by assessing the development of sustainability transitions in various areas, as well as by informing decision-making of STI agents. Thus, both constructive technology assessment and parliamentary technology assessment can play a crucial role. In addition, technology assessment can be used to organise a more formal, independent way of having societal dialogues on system transitions in the broadest sense or on specific biotechnology, such as gene modification. The outcomes can inform political debates. Hence we recommend to re-install a technology assessment function and capability either by providing one of the current actors a mandate (and financial means) to perform this task, or by creating a new institution.

From our conversations, interviews and desk research it became clear that many STI actors have doubts about putting social and ecological challenges more front and centre in STI Policy. They want to hold on to a strong focus on supporting economic growth, and competitiveness, and to a belief that science excellence will deliver on economic, social and ecological challenges. They want to keep a balance in place between various aims, and well as free fundamental research and targeted or thematic research. To discuss and explore these doubts and underlying question we suggest to use our report to organize a debate about the main call of this report: STI Policy should focus on system change enabling a sustainability transition.

Appendix 1 - Curriculum Thinkers

Petra is an epidemiologist. She studied Human Nutrition at Wageningen University and was post-doctoral fellow at the Harvard School of Public Health in Boston. She worked 8 years as project leader 'nutrition and ageing disease' at the Top Institute Food & Nutrition in Wageningen. Subsequently she worked almost 12 years at the R&D-department Nutrition and Health of Unilever. She joined the Rathenau Instituut in February 2018 as one of the coordinators.

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Appendix 2 - Members Steering group

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Appendix 3 - Position Paper Thinkers

Assessing societal and environmental impacts of science, technology and innovation

A (brief) position paper for the Thinkers' Program Sustainable Innovation of the Royal Flemish Academy of Belgium for Science and the Arts (KVAB)

Johan Schot, Utrecht University Centre for Global Challenges, and Petra Verhoef, Rathenau Institute

September 2021

Preface

This is a brief position paper written by the two thinkers appointed by the KVAB. The paper aims to introduce three sets of questions to be discussed at round table discussions on October 4 and October 11 organized by the KVAB. During the first session we will focus on general Science, Technology and Innovation Policy (STI) developments, while during the second session we will zoom in on the STI policies for the agriculture and food system. The session aims at gathering information about the situation in Flanders and a first discussion with various stakeholders. A follow-up discussion will happen at a one day symposium on November 23, 2021.

The three questions are:

1. How did STI (agriculture & food) policy develop over time in Flanders (and Belgium)? How did it integrate considerations about negative STI impacts?
2. How to account for and integrate societal impacts into STI (agriculture & food) policy?
3. How to design, implement and evaluate STI (agriculture and food) policy?

Introduction

Science, technology and innovation (STI) has played a central role in the development of the world as we know it today. Especially after WWII, STI policy became a concern for governments as a driver of growth, development and wellbeing. Yet, as we know today, technology and innovation have also become a part of the problem. They are implicated in many of the challenges the current world is facing, including the climate and biodiversity crises and growing inequality. These challenges are expressed in the United Nations Sustainable Development Goals. To understand how STI policy can contribute to addressing these challenges and lead to sustainable innovation, we need to understand the frames or logics behind STI policy.

Three STI policy frames

We distinguish three frames of STI policy[1] [2]. Frame 1 or "Innovation for Growth" emerged in the post-war period, stressing the benefits of science and technological change to the economy. Policy makers became concerned about the role of the public sector in supporting science and technology because in the language of economists they constitute a public good, suffering from market failures. The inadequacy of the market to support their development at the level desired, required state intervention, and investment in R&D up to a level of 3% of GDP (according to the OECD and EU). This idea was supported by the linear model of innovation which focuses on building an excellent knowledge basis (including higher education institutions) that will then – presumably – almost automatically lead to innovation, and rapid economic growth. The role of the state is to secure the presence of excellent science. Within this frame there is a recognition that innovation may lead to unintended consequences such as pollution, inequality and climate change, but these impacts can and should be dealt with by means of more science and technological development and if necessary regulation. This to generate a level playing field for companies stimulating them to address these undesired consequences (impacts) through innovation. Since these innovations would only be developed after the impacts have become visible, they often led to cleaning-up (waste management) and add-on technologies (such as the catalytic convertor for a car, or higher chimneys and use of filters for the chemical industry). The conviction was that economic growth is necessary in order to pay for the costs of environmental and for social measures too, for example loss of jobs due to technical change, and social benefits necessary to provide people with a decent life (at a minimum level).

Frame 2, or "National Systems of Innovation", emerged in a context of growing international competition, marked by economic shocks such as the 1970s oil crisis. Analysts started to recognize that producing knowledge and investing in R&D is not sufficient. Actors need to be able to absorb the knowledge and use it for productive purposes. Following the emergence of Japan and Korea into knowledge economies, this new frame brought attention to the different paths that these countries and regions followed in the constitution of their innovation systems, characterized by systems and institutions that support learning, skill and capacity building and entrepreneurship. These type of elements evidently enhance the absorptive capacity of an economy. This frame led a move away from a linear view of innovation to a more systemic one in which innovation is the result of interactions across many actors: universities, firms and entrepreneurs, governments, workers (they need to have skills), and even civil society. In this frame societal impacts should be integrated in this interaction process, and thus be addressed because some actors (workers, civil society, firms) articulate a demand for it. The role of STI policy is not only to provide for knowledge production, but also for learning by interacting, including the building up of skills to participate in the learning process. Within this frame, there is a recognition of the importance of technology assessment. In other words the need to assess the potential negative consequences of innovation, in order to be able to address them early on, and provide remedies. These assessments should be inserted into the learning by interacting process, and this could be done by dedicated technology assessment actors, or other institutions. Reference 3 gives historic examples for the Netherlands[3].

Frame 3 is what we call “Transformative Innovation Policy”. This frame takes addressing environmental and social challenges as the central aim of STI policy, questioning assumptions about the neutrality of technological innovation. It starts from the conviction that the current socio-technical systems that fulfill basic needs, such as energy, mobility, food, water, security and communications, need to have a fundamental shift (transition) in order to become truly sustainable. This is different from what constitutes a mere system optimization, e.g., improvements in agricultural yields. It calls for a transition policy focused on bringing about system change in order to address the climate and biodiversity crisis as well as rising inequalities. Changes that are needed involve infrastructures, such as food supply systems, and cultural norms and practices, such as what we consider a healthy diet. Sustainable innovation includes social innovation. This frame brings the attention to the direction of innovation, namely the different social and political choices embedded in technological choices made. This frame is close to a mission-oriented innovation policy called for by many governments and the EU, if a mission is not interpreted as a top-down policy but a bottom-up process enabling system change. It is also close to Responsible Research and Innovation practices aiming for articulating political choices and impacts of science and technology early on in the process[4]. In this third frame technology assessment is not just an additional instrument called upon to insert attention for impacts, but a starting point for any STI policy since it focuses on addressing societal and environmental challenges head-on. It also calls for a whole of government approach since energy, food, transport et cetera are issues addressed by various government departments. STI policy needs to leave its own comfort zone and become coordinated across government.

Concluding remarks on design and implementation

Currently, these three frames co-exist in STI policies, and each of them fulfills an important role. Yet, more emphasis on frame 3 is required for innovation to play a prominent role in finding solutions to complex global challenges such as the ones expressed in the SDGs. How to implement frame 3 policies then? A starting point is the acknowledgement that there are no best and optimal approaches to complex problems. Therefore, it is important to allow for societal experimentation, a structured learning process informed by evidence and experience to explore potential transformation paths and their consequences. An experiment can also be seen as a series of practices, methods and objectives used to inform and facilitate system change. It allows to test ideas at small scale and in real contexts (for example in a living lab) before full implementation, without the compromises of large-scale policy intervention. The subsequent large scale implementation will require a process of niche construction, as well as destabilization of the dominant system. A niche in an environment in which the new solutions are nurtured through shielding, networking, learning and visioning and then scaled in a process of replication, circulation, wider adoption and institutionalization. Eventually the niche may become a new system. For this to happen, actors supporting the dominant system need to open up for change, and become promotors of the niche[5]. An example is the development of renewable energy socio-technical system replacing an energy system build

around fossil fuels. This is not just a technological process, but requires new regulations, business models, user preferences, industry strategies and cultural norms. Investing in this process of experimentation and niche construction requires new forms of evaluation which engage with the process itself, inducing second order learning, and reflexivity. This type of formative evaluations differs from traditional evaluations of public policies, since they are participatory, and seek to assess and stretch the level of transformation in the experiment[6]. Impact assessment becomes impact construction. Technology assessment becomes Constructive Technology Assessment[7], and innovation turns into sustainable innovation because impacts are integrated into the design and implementation of innovation practices in a participatory manner.

References

[1] Schot, J.W. Steinmueller, W.E. (2018): Three frames for innovation policy: R&D, systems of innovation and transformative change. In: Research Policy, 47 (9), pp. 1554–1567.

[2] Weber, K.M. Rohracher, H. (2012): Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive 'failures' framework. In: Research Policy, 41 (6), pp. 1037-1047.

[3] Sikma, T., P. Verhoef en J. Deuten (2019): Voorbereid op de praktijk – Anticiperen op de maatschappelijke inbedding van innovatie bij onderzoeks- & ontwikkelprogramma's. Den Haag: Rathenau Instituut (in Dutch).

[4] Stilgoe, J., Owen, R., and Macnaghten, P. (2013) Developing a framework for responsible innovation, In: Research Policy, 42 (9), pp. 1568-1580.

[5] Ghosh, B. Kivimaa, P., Ramirez, M., Schot, J., and Torrens., J. (2021): Transformative outcomes; assessing and reorienting experimentation with transformative innovation policy, In: Science and Public Policy, https://doi.org/10.1093/scipol/scab045

[6] Molas-Gallart, J., Boni, A., Giachi, S., Schot, J. (2021); A formative approach to the evaluation of transformative innovation policies, In: Research Evaluation, https://doi.org/10.1093/reseval/rvab016

[7] Schot, J., and Rip., A. (1997) The past and future of constructive technology assessment, In: Technological Forecasting and Social Change, 54 (2-3), pp. 251-268.