“DEVELOPING A FRAMEWORK FOR RESPONSIBLE SCALING OF AN INNOVATION: OVERCOMING BARRIERS FOR LARGE-SCALE HYBRID PROTEIN APPLICATION.”

Date: 07-01-2026
Date defence: 22-01-2026

Student: Kelly Lans
Student number: 5125545

MSc degree 1: Life Science & Technology (LST)
Faculty 1: Applied Sciences (AS)
Supervisor: Associate Professor Lotte Asveld
Third Examinor: Assistant Professor Britte Bouchaut

MSc degree 2: Management of Technology (MOT)
Faculty 2: Technology, Policy and Management (TPM)
Second Examinor: Professor Roland Ortt

Daily supervision: PhD Juan David López Taborda

TU Delft

Acknowledgement

This thesis marks the completion of my Master Life Science & Technology (faculty of Applied Sciences). This would not have been possible without the support and guidance of many people!

First and foremost, I would like to express my sincere gratitude to my supervisors, professor Roland Ortt and associate professor Lotte Asveld for your valuable feedback, critical insights, and continuous support throughout the research process. But most importantly I would like to thank you for supporting this unique collaboration between the two different faculties, master degrees and research groups. From the start you have believed in this collaboration and have helped me shape this thesis to what it is now. I really believe that the most value has been created by this collaboration.

Secondly, I would like to express my gratitude to my daily supervisor Juan David López Taborda. Thank you for your guidance throughout this process. You have been of great importance in shaping this thesis. I really enjoyed our discussions, which were always very valuable for me.

To Roland, Lotte and Juan David, I enjoyed all of our sessions in which we had open discussions about how to tackle this research. We have been building something that is different from a standard thesis research, so it was a journey for all of us and I am glad we did this together.

Also, I am thankful for the experts and professionals who took the time to participate in interviews and share their knowledge and perspectives on the barrier and responsibilities around alternative protein. These insights were essential for grounding this research in real-world practice and have provided me insight that helped shape the framework.

Furthermore, I would like to thank my fellow students, friends, colleagues, boyfriend and family for the support during this period of one year that it took to complete the two master theses. You have always been very understanding and open for a discussion to help me along.

Completing this thesis would not have been possible without all of you, and I am truly grateful for your support.

Abstract

Research on the development and commercialization of hybrid protein, a combination of cultivated and plant-based protein, in the alternative protein transition has been increasing over the past few decades. This transition is increasingly urgent due to environmental impact and ethical issues around animal protein, as well as issues around food security and health impacts. Hybrid protein is argued to be a promising innovation to accelerate this transition as it helps overcome limitations that both cultivated protein and plant-based protein are facing.

The Netherlands is at the forefront of this development, however, the current regulations have not allowed the selling of hybrid protein yet in the European Union. At this moment, large-scale market introduction is unfeasible due to limited customer acceptance, insufficient knowledge of large-scale production, the high costs, the absence of a network that coordinates regulations and stakeholders and most importantly the absence of the regulations to allow it.

The aim of this master thesis research is to look into how to systematically integrate responsibility in the design of market entry and diffusion strategies for emerging innovations, using hybrid protein as a case study. By combining the meta-responsibility framework by Sonck et al. (2019) with the Technological Innovation System (TIS) framework for large-scale diffusion strategies by Ortt and Kamp (2022), a combined framework called the Responsible Market Development (RMD) framework is developed that serves as a tool to design responsible market entry and diffusion strategies. Where responsibilities of market actors are not incorporated in the TIS framework, a more sustainable framework is designed that does not only look at economic, but also social and environmental sustainability.

By applying the RMD framework, the barriers to market-introduction or large-scale diffusion are identified, strategies to overcome these barriers are proposed, conflicts and synergies between responsibilities are identified and combining these insights results in an output of the framework of responsible market-introduction strategies.

For the case of hybrid protein, the following barriers have been identified: ‘production system’, ‘network formation and coordination’, ‘product price’, ‘customers’ and ‘innovation-specific institutions’. The identified influencing conditions include ‘knowledge and awareness of technology’, ‘knowledge and awareness of application’, ‘macro-economic and strategic aspects’, ‘socio-cultural aspects’ and ‘accidents and events’. Based on these findings, the “top niche strategy”, “subsidized niche strategy”, “redesign niche strategy” and “geographic niche strategy” are proposed as most suitable pathways to market-introduction. Also the “redesign niche strategy” and “demo, experiment and develop strategy” are being applied already.

Results from the RMD proposed framework as well as expert interviews suggest that there is an order to which the strategies can most effective be applied as the barriers have a sequence. Advised is to first start with the “top niche strategy” or the “redesign niche strategy”, followed by the “subsidized niche strategy” if price is still a barrier. These proposed strategies have been adapted in a way that responsibilities are taken into account to make the innovation not only economically viable, but also socially and environmentally sustainable.

Keywords: responsible innovation, market introduction, large-scale diffusion, responsible market introduction strategies, TIS framework, meta-responsibility framework, alternative protein, hybrid protein

Table of Contents

Introduction

Problem description

The global population is growing rapidly and is expected to exceed 9 billion by 2050, resulting in an increase in food demand. Currently, food scarcity is already an issue, with millions of people lacking access to sufficient protein and nutrition and this number will only increase with the predicted trends. One of the reasons animal meat is consumed by human is due to the presence of protein, which is an essential macromolecule in human diet.

However, the traditional meat production is perceived as unsustainable, requiring vast amounts of land, water, and feed to grow the livestock, putting immense pressure on natural resources and taking up land to live on. This industry is also a leading contributor to greenhouse gas emissions, driving climate change and environmental degradation. Approximately 30% of global warming and climate change is originating from the food industry (Ahmad et al., 2022). At the same time, the way animal farming is done raises ethical concerns, as billions of animals are kept in poor conditions and suffer during production of animal meat.

Raising animals as a protein source is common practice. Yet upon closer examination, it becomes evident that it is notably inefficient. Even for chicken, which are the most efficient at converting crops to meat, it still takes 9 calories of food to feed a chicken to get back 1 calorie in form of its animal flesh. Besides, livestock provides only 18% of the calories that humans consume, while it takes up 77% of all global farmland. Not only the production, but also the consumption of animal meat is linked to risks. Overconsumption of meat has been proven to cause health problems, including heart disease, obesity, and antibiotic resistance. Food systems need to change – a protein-rich diet is essential, but conventional meat products will not be sufficient to ensure safety, sustainability and sufficient food supply at global scale (Chen et al., 2021). Over time, the growing world population cannot be fed from animal protein. Combined with the sustainability and inefficiency issues, it can be concluded that animal protein is not future proof. Therefore, multiple alternatives are being developed.

Alternative protein landscape

These alternatives include plant-based protein, fungi-based protein like mycoprotein, and fermentation-derived protein. Also, there are newer innovations, including cultivated protein and hybrid protein products. The hybrid products can be a mix of multiple protein sources, e.g. animal-plant or plant-cultivated protein products. Among these alternative protein sources, the focus in this research is on plant-based protein, cultivated protein and plant-cultivated hybrid products.

Plant-based proteins are derived from crops like soy, wheat and peas, and have already been introduced to mainstream markets. It is present in mainstream supermarkets and it is being sold in restaurants, showing a growth in customer interest and acceptance in alternative protein sources. However, there are still issues related to taste, texture as well as perception that results in plant-based protein not having fully replaced conventional animal protein.

Cultivated proteins are grown in a controlled environment directly from animal cells, but without having to raise and slaughter the animal. It is an innovation that is still in its early stages, but has immense potential as it can provide similar nutritional value as conventional meat without the environmental and ethical impact of conventional meat. The issues revolve around scaling,

production price and regulations, as well as perception and acceptance of this protein with potential customers.

The challenges of plant-based protein lie in taste and texture experience, while the challenge of cultivated protein is focussed on scaling, regulations and acceptance. To bridge that gap, hybrid protein products have been developed that are a mix of both plant-based protein and cultivated protein. The composition can be adapted to the needs, and makes it possible to increase the taste and texture profiles as well as nutritional values and introduce cultivated protein to the market in a more accessible way, while keeping the costs and environmental burden lower.

Large-scale diffusion

Currently, hybrid products have been developed, and the first examples can be found on the market globally. However, in the scope of the Netherlands, hybrid products have not yet had their market introduction.

Ortt and Kamp developed the Technology Innovation System (TIS) framework in 2022 with a company perspective, aimed to formulate a strategy for the introduction of an innovation to the market. It consists of seven building blocks and seven influencing conditions that have been defined to analyse. The absence, incompleteness or incompatibility with the other building blocks can block large-scale diffusion. A specific strategy can be formulated to circumvent the lacking building blocks or to build up those blocks. In fact, this strategy formation can either be a niche strategy that enables the introduction of an innovation in niches, by circumventing the missing building block, or a strategy helps to enable large-scale diffusion later on by building-up the missing building block.

This framework is of interest, as this research is looking at the factors that are keeping this innovation – hybrid protein – from larger scale market introduction. It can help explain what the barriers are that are still present that limit its full potential on the market. And what strategies could be applied to overcome the barriers?

Responsibility within innovation

Innovations are broadly spoken seen as beneficial, usually it is referring to progress or improvement or even to solutions of global challenges. However, in complex societal challenges like food scarcity, health problems and environmental issues, innovations can have serious consequences as well when they are directly affecting public health, well-being and values. It is of uttermost importance to not only question whether to innovate, but also how to do so responsibly.

In response to this challenge, Responsible Research and Innovation (RRI) has emerged. RRI is ‘conceptualized as an endorsement of the relevant public values during the innovation process’ (Taebi et al., 2014). It is a process where societal actors and innovators are mutually responsive regarding different societal values (von Schomberg, 2011b). The aim of this RRI is to enhance the societal embeddedness of innovation, as companies hold various responsibilities in society, one of the key responsibilities of finding solutions for societal challenges. It also includes the involvement of stakeholders in the design stage, as well as throughout the development, making the innovations process more inclusive and adapting the development on the public values and societal expectations. The stakeholders that are included in the responsible innovation, are the ones that are usually not directly involved in the process, but are affected by the innovation. Examples in this field are farmers, local communities, consumers with low incomes and even future generations or the environment.

Despite recognition of the importance of responsible innovation, it is still often neglected in the process. Besides practical incentives and uncertainty of innovation, also the abstract nature of responsibility results in the lack of it in the innovation and decision-making process. Specifically in the process of creating an alternative protein landscape, there is a lack of clarity on what and for whom the responsibilities are, due to the complex dynamics. Additionally, it might result in a more complex decision making and responsibility can form a barrier in the innovation process.

Hybrid protein can on the one hand mitigate the environmental and ethical issues conventional animal protein faces, however, it is currently only accepted by limited range of people and under certain conditions. It is generally perceived as unnatural, not believed to be safe and transparency about what the actual product makes it difficult to market the product. This raises the ethical and responsibility related question, like how decisions need to be made when there are trade-offs between values like cost-efficiency or sustainability and health improvement. Even who is responsible when the outcome of large-scale diffusion of the product is uncertain.

To provide a more structured approach to responsible innovation Sonck, Osseweijer, and Asveld developed the meta-responsibility framework in 2019. This offers a practical tool to allocate responsibilities. The framework provides a structure for relevant actors to see what their roles and obligations are, but also where there is tension between those roles and obligations and trade-offs.

Combination – how responsibility can be integrated with diffusion of innovation

Both the TIS framework and the meta-responsibility framework are interesting frameworks that are created to offer a structured approach to tackle a problem; where the TIS framework is aimed at market-introduction and large-scale diffusion of innovations and identifies barriers and influencing conditions to find an useful strategy to overcome these barriers, the meta-responsibility looks at the responsibilities that actors have regarding innovations and helps identify conflicts between those responsibilities. The latter can be combined with the former, since responsibility is becoming an increasingly important part of innovation. The TIS framework currently does not touch upon responsibility, but the meta-responsibility framework offers a suitable foundation to be added to the analysis. Combining both frameworks is not only ethically interesting, it is a way of ensuring that an innovation is not only technically, economically and market wise viable, it is also socially sustainable. This combination of frameworks is relevant in the academic field as it offers a more complete analysis that helps design responsible innovation, not making it a barrier or constraint, but a strategy for long-term success.

Research questions

The main research question states:

"How can responsible strategies be designed to overcome barriers to market-introduction and large-scale diffusion of hybrid food products that combine cultivated and plant-based proteins?"

To answer this research question, six sub-questions are developed that will be discussed in the designating chapters of this thesis. The sub-question state:

1. "How are hybrid proteins relevant in the alternative protein landscape?"
2. "What are the barriers that are blocking hybrid protein from market introduction and large-scale diffusion?"
3. "What strategies can be applied to overcome those barriers?"
4. "How to systematically identify and classify innovator's responsibilities to support responsible market introduction strategies?"
5. "How to integrate responsible innovation principles into strategies for overcoming market introduction or diffusion barriers?"
6. "What responsible strategies to apply to hybrid protein case?"

Table 1 gives an overview of the six sub-questions, with their methods to answer the question, designated programme and dedicated chapters. The basis of this report is a combined report between the two master degrees. Two separate report have been delivered. All chapters will be part of this report, but the chapters that are designated to the other Master may be shortened in certain parts. The full chapters of the other Master can be found in the MSc Management of Technology report titled "A combined framework for responsible innovation strategies to overcome barriers to market-introduction and large-scale diffusion: a case study on hybrid protein.". Within each of the Chapters, the designated programme is once again noted.

Table 1: Overview of the research sub-questions with the designated methods, programme and chapters.

Sub-questions	**Methods used to answer sub-question**	**Designated programme**	**Dedicated chapter**
"How are hybrid proteins relevant in the alternative protein landscape?"	Literature	MSc Life Science & Technology	1
"What are the barriers blocking hybrid protein from market introduction and large-scale diffusion?"	Literature Interviews	MSc Management of Technology	2
"What strategies can be applied to overcome those barriers?"	Literature	MSc Management of Technology	3
"How to systematically identify and classify innovator's responsibilities to support responsible market introduction strategies?"	Literature Interviews	MSc Life Science & Technology	4
"How to integrate responsible innovation principles into strategies for overcoming market introduction or diffusion barriers?"	Literature Interviews	MSc Life Science & Technology MSc Management of Technology	5
"What responsible strategies to apply to hybrid protein case?"	Designed framework Interviews	MSc Life Science & Technology MSc Management of Technology	6

Methodology

This thesis research has been conducted with a mixed-methods approach, where literature research, secondary data analysis, and qualitative method (interviews) are combined. This ensures a detailed understanding of the research topic and considers multiple sources and perspectives. The general topic of this research is alternative proteins, specifically hybrid protein. This is used as a case study to design a more general framework and guidelines for other innovations, with the aim of including responsibility in the market introduction and large-scale diffusion strategy of an innovation. The scope of this research finding strategies specifically for in the Netherlands, considering the regulations of the European Union and learning from developments worldwide.

Firstly, academic literature, including journal articles and relevant reports have been utilized to lay a foundation for the technical background. This literature review focussed on hybrid protein, plant-based protein, cultivated protein and its conceptions, consumer behaviour, innovation trajectories, market strategies, diffusion of innovations and responsibility, where existing knowledge is analysed, and gaps are identified. Secondary data were complementary sources to the findings of the literature, including institutional reports, case studies, and previously conducted surveys. These sources have been used if they are relevant, reliable and align with the research objective. For more relevant and useful insights, also a qualitative method has been used looking to broaden the perspectives with experts in different fields. Interviews can be useful to gain insights in the perspectives and opinions of stakeholders in the hybrid protein development and market, as well as with professionals or experts in the field of innovation diffusion and responsible innovation for their experience in the field. The interview is a semi-structured comparative interview, using the same set of questions aimed to compare between stakeholders.

The data collected from these interviews before the participants' consent, have been transcribed and analysed trying to identify patterns and key insights. The data from secondary sources have been examined through a descriptive analysis to identify trends.

For all interviews, the ethical guidelines have been followed, ensuring informed consent, confidentiality and professional data usage and storage, which is regulated through the Human Research Ethics Committee (HREC). After approval of the Data Management Plan by the HREC, access to safe storage network was ensured. The ethical standards of the TU Delft have been followed.

Figure 1 gives an visual representation of the different topics, research questions and methodologies used in this thesis.

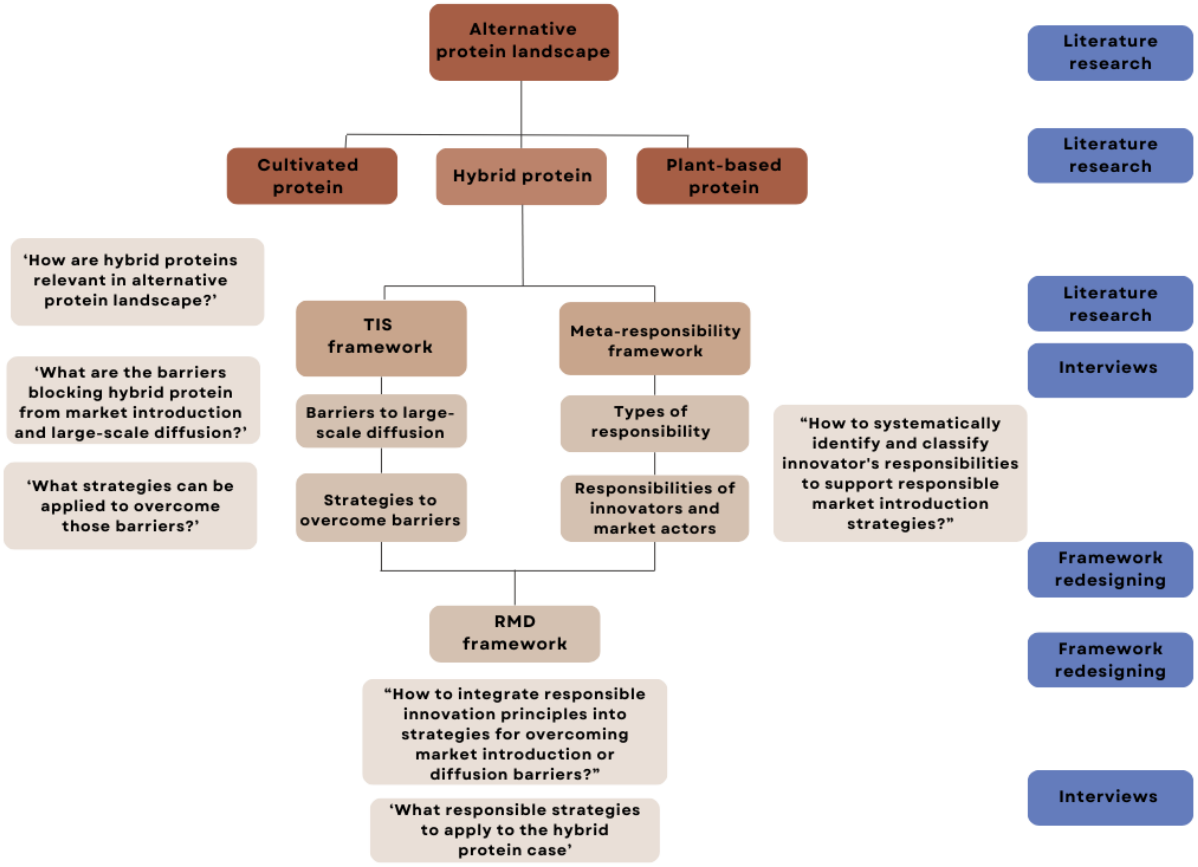

Figure 1: Workflow of thesis including topics, research questions and methods of research.

There are different perspective of how to approach these developments of alternative protein. It can be viewed from a customer perspective or a technological perspective. However, a broader and longer-term perspective is taken here, where also the perspective of actors outside the market and long-term effects are considered. Not only the actors involved in the direct market are to be considered, also the indirect actors that at that moment or on longer-term effected should be considered.

The basis of this thesis was a combined research between two Master degrees, having combined all steps of the thesis as it being one research due to the interlinked research topic. The output of the research is also a combined framework. However, for each of the Master thesis, a separate report has been delivered.

Chapter 1: Hybrid protein in the alternative protein landscape.

"How are hybrid proteins relevant in the alternative protein landscape?"
– MSc Life Science & Technology

Alternative protein landscape

The most commercialised alternative protein source is plant-based protein. Plant-based meat alternatives made its market introduction on the Dutch market in the 1980s and up until now developed and embedded itself into the market. However, it is still a small market sector that has shifted from animal-based protein to plant-based protein for the required protein transition. Cultivated protein have therefore been a promising option to add value in this transition. The concept has been proven to work, and developments are at the stage that it is possible to make cultivated meat alternatives. The downsides and challenges both plant-based and cultivated protein were facing have resulted in the production of hybrid products. First, a deeper look is taken at the two technologies separately, and after that it is shown how that combination can be relevant in the current protein transition.

Plant-based protein

Plant-based protein refers to products made from plants that are alternatives for conventional animal-based protein products. Plant-based protein sources have a history reaching back to approximately 20 centuries with tofu, tempeh and seitan being the first products that were plant-based. These products originate from Buddhism, which prohibits the killing of a person or animal (Finnigan, 2017). As these products were aimed at vegetarian consumers, it means they have not been designed to replicate or replace conventional meat. For that reason, it did not gain popularity in Western societies, as the qualities are different compared to conventional meat (Thavamani et al., 2020). Also, it is often perceived as low-quality and ultra-processed food (Toribio-Mateas et al., 2021). Historically when growing crops, they were used for their oil and starch and optimized for increased yield. For the purpose of alternative protein sources as plant-based meat, the crops should be optimized for protein production. In the plant-based meat production, the starting material used is usually either plant protein concentrate (60%-70% protein) or plant protein isolate (>90%) (Mount, 2023). A simplified schematic overview of the production process of alternative plant-protein products is given in Figure 2.

Recently, environmental, sustainability and food security issues have led to the development of plant-based protein with the aim of replicating conventional meat by mimic or even improving the taste, texture and nutrition. The distinction between plant and animal protein lies in the amino acids sequence and interaction. In contrast to animals, plants can synthesize all EAA themselves. However, in conventional crops, they lack some of them, and besides they are less digestible than animal protein (Toribio-Mateas et al., 2021).

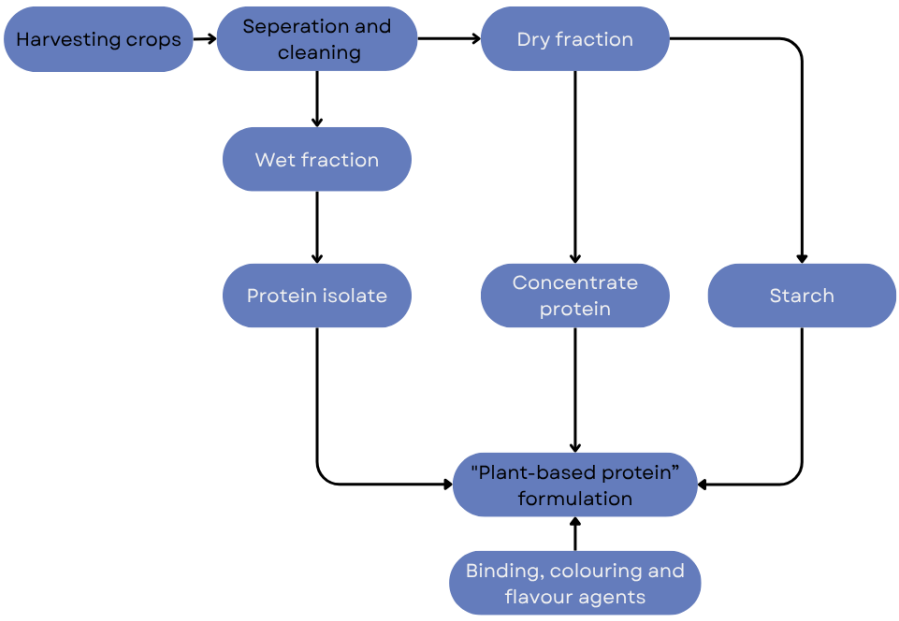

Figure 2: Production process of producing plant-based meat alternatives (Ahmad et al., 2022)

It has been studied that various aspects affect people's consumption of meat alternatives. Consumer valuing the environment, but also gender and educational level have been shown to have an effect on the likeliness to consume meat substitutes. Some of the reasons plant-based meat alternatives have not become the dominant product in the protein products market, is because of some impediments like unfamiliarity, lack of sensory appeal, the taste, affordability and also convenience. Especially the structure and taste of plant-based alternatives, is what differs from conventional meat and is not stimulating the consumer to replace their meat intake. The flavour and taste is what influences the average consumer's preference for meat alternatives (Ahmad et al., 2022).

Cultivated protein

To produce cultivated protein, a starting cell source is required. This is mostly taken from a living animal by taking a muscle biopsy or skin sample. Also taking a sample from a slaughtered animal that is ready for the traditional meat market is an option. This does require tissue that is still viable, making it comply to religious laws like halal or kosher. These samples are used to select cell populations with characteristics suitable for meat production and can be stored in a cell-bank. This storing is an essential step for research and scaling-up of the production (How Is Cultivated Meat Made, 2023).

The extracted cells are either adult or pluripotent stem cells, both able to proliferate and differentiate into the necessary cells for cultured meat. Adult stem cells are more commonly used because they are easier to work with despite dividing more slowly. They are able to differentiate into one or more key mature cell types. In contrast, pluripotent stem cells offer more flexibility in terms of cell they differentiate in, but are harder to develop in livestock and raise ethical issues when sourced from embryos (Reiss et al., 2021) (Swartz, 2024).

Once the starting cell source is retrieved, it will be cultivated in a bioreactor. In two phases, the proliferating and differentiating phase, the cells will grow into the desired cell type. Here it is important that the media is steering them in the right type of cell, and also in a state that the maximum protein production can be reached, or fat cells are produced. The culture conditions influence this process and is therefore an important parameter to optimize. These cells are cued

into the right type of cells and together are prepared into the right structure to make it an actual piece of meat (Post, 2012). A systematic and simplified scheme of the production process is shown in Figure 3.

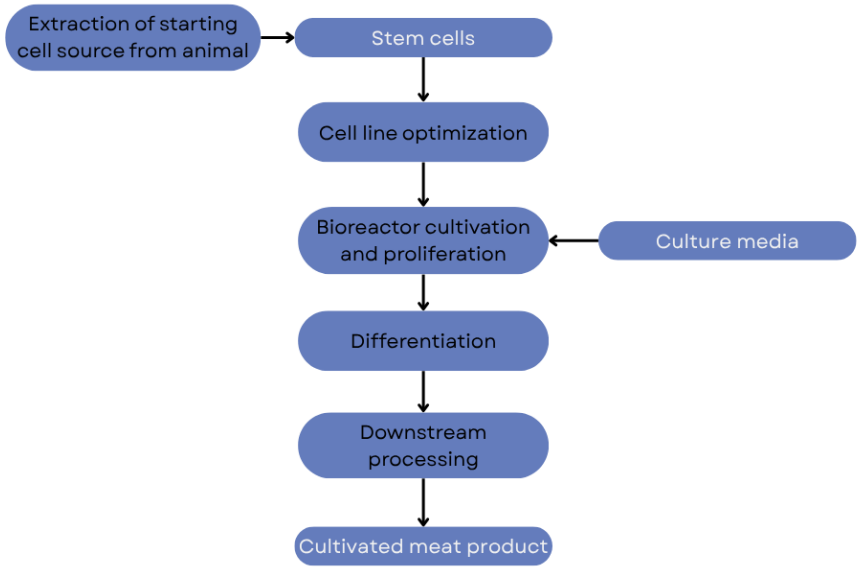

Figure 3: Systematic and simplified process of cultivated meat production.

Where the conventional meat industry requires a lot of natural resources, cultured meat requires much less resources, especially in land usage and feed. Half of the habitable land in the world is used for agriculture in conventional meat production. That can be lowered with the introduction of cultivated meat. It is still difficult to make statements about the environmental impact, some studies comparing cultivated meat and conventional meat show a decrease in energy consumption, greenhouse gas emissions, and land and water use, however other studies looking at individual gas emission indicate potential longer-term impact of cultured meat (Chen et al., 2021). The production cycle is much lower for cultured meat, 5-6 weeks, where conventional animal growing take around 112 weeks (What is cultivated meat, 2023). The production of cultured meat does have the benefit of being able to be decentralized, as it is less dependent on land suitable for animal grazing. Therefore, it reduces the reliance on the import of meat (Chen et al., 2021). As this break-through innovation offers advantages over the current main process, it is a technology that is being researched and developed all around the world. It is fair to mention there are still various barriers that hinder the innovation from becoming a large-scale product, and thus is it is relevant to dive deeper into these barriers.

Hybrid protein

Both alternative protein sources offer healthier and more sustainable ways to meet global protein demand. However, the current cost to produce alternative meat products from cultivated protein is too high as the large-scale production process is still too immature. Also, the consumer acceptance is not yet high for large-scale acceptation of cultivated protein. Additionally plant-based protein do not have the taste up to the standards of the consumers preference, so both products are not ready for large-scale market yet. Considering both challenges but simultaneously the advantages, hybrid options are being developed. This includes hybrid sausages and burger, containing a certain percentage of cultivated meat and the remaining part is plant-based. The first startup from California, Eat Just, that received regulatory approval in Singapore with their cell-cultured meat, composed of 70% cultured meat hybridized

with plant-protein (Ye et al., 2022). This concept of combining both plant-based and cultivated protein, is for now on referred to as hybrid proteins. In the hybrid mix, also cultivated fat can be added which enhances and mimics the conventional meat taste. When cultivating fat, the fat is retained inside the cell, recreating the mouthfeel of animal meat. Also, the fatty acid profile is similar to animal fat, which results in similar melting points and therefore the cooking behaviour remains the same (Alberganti & Zaccarian, 2024).

Compositions

The percentage and composition can be specified per product, which is useful marketing wise to adapt this over time, but it also makes the labelling of these hybrid products difficult; what percentage determines the use of the term 'meat' (Tavan et al., 2025). However, these hybrid products are a means to introduce cultivated protein to the market, while gaining acceptance and optimizing and scaling the production process. The composition of Good Meat's first hybrid product was also lowered to 3% cultivated chicken to reduce the price per product. This is one of the advantages of the hybrid products as these are more flexible in terms of composition and nutritional values. Once the cultivated meat production process is in more mature stages, the prices go down, or regulations are more in favour of this product, the shift to a higher content cultivated protein can be easily made.

Types of hybrid protein

As defined, the hybrid product of this case is a blend of plant-based protein and cultivated protein. However, there are also other possibilities of hybrid protein in terms of the protein sources as well as based on the composition of the blend. The first blends were plant-based protein products, supplemented with animal protein to create the desired taste and texture that resembles animal protein products. Also, a blend of fungi and plant-based protein have been on the market, Quorn introduced those as one of the first blended products on the market in 2002. Now Quorn sells a complete range of products, with the goal of clean eating and being meat free (Quorn, 2025) (Jones, 2022). Plant-based and even blended plant-based products have not been able to convince customers of liking it (Southey, 2023).

Also, meat from cultivated protein is an option, but this is unrealistic to be produced in the pure form and with the desired structure. Currently, it is more challenging to produce composite meat products that require muscle like tissues and structures compared to processed meat (Gursel et al., 2022). Therefore, the first hybrid products are most likely to be in processed forms like hamburgers or sausages, instead of composite steak. Still, this would be an expensive process and difficult to market, and thus hybrid protein sources are becoming investigated more often as an option to get cultured protein to the market. Research in this field is therefore crucial for creating a more responsible and resilient food system. Looking at what barriers are still present before hybrid proteins can get onto the market, will give insights in the steps that need to be taken to make that possible.

Table 2 gives an overview as means of comparison between the four discussed alternative protein sources.

Table 2: Overview as means to compare the different sources of protein; animal, cultivated, plant-based and hybrid, divided into aspects like source, amino acids content, production process, resource usage, environmental impact, health impact, ethical concerns, costs, consumer acceptance and taste and texture.

Aspect	Animal protein	Cultivated protein	Plant-based protein	Hybrid protein
Source	Derived from livestock.	Cells sourced from living animals (muscle biopsies or skin samples).	Derived directly from plants.	Blend of plant-based and cultivated protein.
Amino acids	Provide all essential amino acids in adequate amounts. Animals cannot synthesize all essential amino acids, but they are supplemented by plants in their diet (Galili et al., 2016).	Complete profile of all the essential amino acids, mimicking conventional meat (Toribio-Mateas et al., 2021).	Naturally might lack some amino acids (conventional crops), but can be formulated to include all essential amino acids (Toribio-Mateas et al., 2021).	Typically containing all amino acids, as it is a combination of plant-based and cultivated protein.
Production process	Traditional farming, growing and slaughtering animals.	Bioreactors to grow and differentiate cells into muscle, fat and connective tissue.	Extraction from plants and processing into concentrates or isolates.	Blending the plant-based protein with cultivated meat to reduce cost, improve taste and enhance texture.
Resource usage	High resource consumption, requiring significant land, water and feed.	Lower resource consumption compared to tradition meat production.	Lower resource use compared to animal farming and is optimized for protein production.	Lower than pure animal meat, but uses resources of both the plant-based and cultivated meat production.
Environmental impact	Major contributor to greenhouse gas emissions, deforestation and land degradation.	It has potential for reduced greenhouse gas emissions and environmental impact, but further research is needed.	Low environmental impact, but depends on the agricultural practices.	Potential reduced environmental impact compared to conventional meat, comparable to cultivated and plant-based protein.
Health impact	Overconsumption linked to heart diseases, obesity, antibiotic resistance.	Potential benefits due to absence of antibiotics, hormones and diseases.	Healthier compared to animal meat as it may improve gut microbiomes and lower chronic diseases.	Similar to plant-based and cultivated meat, but potentially more balanced.
Ethical concerns	The farming industry regarding how animals are treated and slaughtered.	No animal suffering.	Potential deforestation and poor labour conditions of agricultural workers.	Hybridization so labelling and transparency.
Costs	Cost-effective, depending on the type of meat.	Expensive.	Similar or more expensive than conventional animal protein.	Lower than pure cultivated meat, but higher than plant-based.
Consumer acceptance	Well-established, as globally meat is a major part of human diet.	Not accepted yet by the majority, still sense of unnaturalness, unsafe or unpleasant idea.	Growing acceptance, but still limited by sensory differences.	Still growing, as it offers a balance between the desired taste/texture and sustainability benefits, but still some opposing opinions as cultivated meat is included.
Taste & Texture	Widely accepted flavours and textures.	Not fully replicating taste and texture of traditional meat, but still in development.	Does not fully replicate flavour and texture of animal meat, and is seen as less favourable texture.	Still evolving, but more similar to traditional meat than plant-based protein.

Market segment

To get a better understanding of where these alternative protein sources are with regard to development, legislation and market diffusion, first a general overview is given of the development and current market situation in the Netherlands and within the world. After that some milestones are pointed out concerning the development of cultivated protein.

The Netherlands

The Netherlands has the leading position in cellular agricultural development in Europe, as large start-ups, universities and farmers are collaborating in the development. The Netherlands has also implemented a food safety framework for tastings of cultivated protein, and are the first country in the European Union to do so. Also, the development of specific technologies for plant-based protein products have received funding from the Dutch government, that aims at improving the taste of plant-based products, and gaining more customer acceptance for fermented protein by using blended technologies (The Dutch Research Council, 2023). In a study from 2022, it was found that the Netherlands had the highest consumption rate of plant-based foods per inhabitant, showing advances in the adoption of plant-based products in the Dutch society (Williams, 2024). The Aprovals program was also set up in collaboration with 8 countries in Europe, that should help companies speed up the approval in Europe for cultivated protein.

Over the period between 2019 and 2023, there has been a shift already on the Dutch market where there is a decrease in meat consumers and an increase of flexitarians. This visualizes the gradual acceptance and integration of plant-based products in the Dutch diets. Figure 4 shows this pattern.

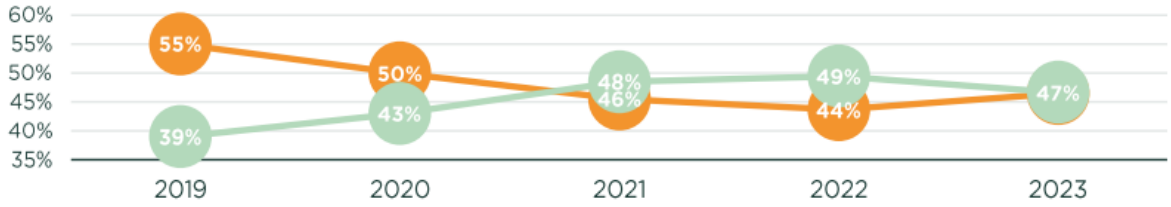

Figure 4: Changes of diet patterns over time in Dutch market, between 2019 and 2023 (Merk & Evers, 2023). In orange the meat consumers and in green the flexitarians.

The increase in acceptance can be explained by the increase in consciousness of Dutch citizens about the food and its nutrition they are consuming. In 2019 only 56% of the Dutch inhabitants were conscious about the food they were consuming, compared to 66% in 2023. There is also a significant difference between the way men and women perceive the food they are consuming. Men are more sceptical and also the level of education has an influence on the amount of thought is put into the food that is being consumed. Higher educated people are more likely to be conscious about what they are consuming (ISMI, 2024).

The market in the Netherlands of plant-based meat alternatives have decreased in total revenue between 2021 and 2023 with 6.5% to 144 million Euros. These are the alternatives that aim to replicate conventional meat, but do not include tempeh and tofu. However, the total revenue of tempeh and tofu has increased between the same time period 2021 and 2023 with 6.3% to 9.6 million Euros. This increase can be explained by the relative favourable pricing; in 2023 5,85 Euro per kilogram, where the plant-based meat alternatives were priced at 9,63 Euros per kilogram.

The price of plant-based meat was 63% higher than conventional meat in 2021, however, this difference has decreased throughout the years, in 2024 plant-based meat only being 35% higher in price. This decrease in price difference can be explained by the relative price changes, where conventional meat increased in price relatively more than plant-based meat (Good Food Institute, 2024a).

As no cultivated protein products are sold on the Dutch market yet, there is no data on that. However, there is currently a broad range of plant-based products on the Dutch market and those products have been popular for around a decade. There are now approximately 10 market leaders; Beyond Meat, Boon, De Vegetarische Slager, Garden Gourmet, AH huismerk, Valess, Naturli, Unox, Quorn and Vivera.

Globally

The global leader in the alternative protein research is Singapore, having multiple research programs focussed on cultivated protein, as well as plant-based and fermentation-derived protein. Their research programs aim to improve the customer acceptance by improving the taste and texture, and Singapore is therefore aware that the solution to food security might be consumer-driven (Battle et al., 2025). Singapore can even position itself as a regional hub for food innovation (Business Wire, 2020). The first few companies that have their regulatory approval are selling in Singapore, as Singapore has governmental support for cultivated meat commercialisation. They are also a technology driven environment and are in the forefront of development.

Table 3 gives an overview of all milestones that have taken place in the recent years with regard to the first approvals of selling alternative protein in both the Netherlands and globally.

Table 3: Timeline overview of the first companies that are (in the approval stage of) selling cultivated protein products around the globe.

Time	Company (country)	Status	Details
December 2020	East Just/GOOD Meat (US)	Selling in Singapore	Eat Just was granted the first regulatory approval for the selling of cultivated meat in Singapore. Their product is cultivated chicken that is sold to just one butcher once a week.
April 2024	Vow (Australia)	Selling in Singapore	Australia's Vow became the second company to sell cultivated meat in Singapore. Their focus is on high-end customers, wanting to offer an unique experience as it is only available in high-end restaurants (Watson, 2025).
July 2024	Gourmey (France)	Applied for European Union, Singapore, UK, US	Gourmey filled the first regulatory submission in the EU for the selling of their cultivated foie gras. In parallel they submitted this in Singapore, Switzerland, the UK and the United States (Williams, 2025) (Battle et al., 2025).
January 2025	Mosa Meat (The Netherlands)	Approval for Singapore, applied for European Union, Singapore	Mosa Meat, as the first in the Netherlands, made the second application in the EU for a cultivated product. They specifically filed for cultivated beef fat that has the aim of enhancing the taste and texture of plant-based beef (Williams, 2025). They already have the approval for Singapore.

Even though steps are made in the development of alternative protein, also resistance and opposition is a natural phenomenon to innovations. This is usually the case for groups that believe that the losses are larger than the gains (Juma, 2016). Table 4 gives an overview of the opposition to alternative protein. This gives an indication of the dynamics within the European market.

Table 4: Timeline overview of opposition to cultivated (and plant-based) protein products.

Time	Who	Details
November 2023	Italian government	A law was voted for, banning the production, sale and import of cultivated meat. This law could be challenged by the European Commission, as it had not yet been sent to the authority for approval. The main reason for the ban is their worry regarding their agricultural entrepreneurs, workers and tradition (Kirby, 2023).
July 2024	Hungary	As a member of the EU, they proposed a ban on the production and marketing of cultivated meat. This received criticism as it was perceived as unjustified and potentially harmful to the European Single Market. Therefore, the Hungarian government is still assessing whether they can amend their legislation and the proposal remains on hold. (Battle et al., 2025).
March 2025	Farming association Coldiretti	Italy's leading farmers' association Coldiretti, one of loudest opponents of cultivated meat, protested with thousands of farmers for the EU to assess novel foods in the same way they do with new drugs (Mridul, 2025).
July 2025	European Parliament	The European Parliament has reopened the debate on banning all 27 EU countries from using terms used for plant-based foods that resemble animal meat.

Relevance of hybrid protein in alternative protein landscape

Within the alternative protein landscape, the different technologies and innovations are at different stages with regards to the development, technology readiness level and market diffusion. We are now narrowing down to hybrid protein products, which provides a solution to the problems that the other options are facing. The hybrid product here is a mix between plant-based protein and cultivated protein.

The reason for choosing hybrid protein is pragmatic, based on its maturity in combination with the interesting phase of development it is currently in. The first ever hybrid protein products have recently been approved for sale in Singapore, and in the Netherlands the first hybrid protein product was submitted for approval Mosa Meat. Mosa Meat already has the first approval in the Netherlands for pre-approval tastings. The technology has therefore been through certain traceable steps in the process of maturation, which makes it useful and practical to be able to look at historical data of what this path has looked like. Not only from a market perspective, but also from the ethical and responsibility perspective it is useful to look at historical data to see what steps have been taken, what ethical issues came up during the development and how this technology has grown with regard to ethical issues and viewpoints of others. At the same time, hybrid protein is still in a phase of development and has just had its market introduction on a small scale, making it interesting to explore strategic pathways to scale cellular agriculture and reduce animal protein consumption.

Societal perspective

As hybrid protein is a mix of cultivated protein and plant-based protein, it is using the characteristics of both protein sources to its advantage. Where plant-based protein lacks the sensory preferences of consumers that resembles conventional meat, cultivated protein can improve this texture and taste. Therefore, the relevance of hybrid protein can be viewed from a consumer's perspective.

Additionally, the nutrition is of importance for the consumer. The hybrid form of the two protein sources ensure to possibility of tweaking these nutritional scores. Hybrid protein products can be seen as one of the options that consumers have when choosing their preferred source of protein. Even within the hybrid products there is a broad range of products that can fall within these terms as it can technologically be customized. Tweaking the characteristics of these products, can shift the popularity of the product and with that the diffusion, now viewing the relevance of hybrid protein from a market and consumer perspective.

Hybrid proteins are on the other hand also a result of technological advancement, where the barriers that are holding the cultivated protein and plant-based protein back from large-scale diffusion, hybrid forms are emerging technologies as a way to overcome those barriers. The advantages of both forms are thus complementing each other. This is from a technological perspective one of the reasons of hybrid protein evolving.

Summarized can be said that the consumers perspective, it being the preferences and wishes of the consumers and market, is the starting point of the development of this innovation, where the technology is making this possible. However, a broader and longer-term perspective should be considered where actors outside the market and long-term effects are also considered. So, besides the direct actors within the borders of the market, also the indirect involved or affected actors should be included, that can be described as the societal perspective. This group of stakeholders can include farmers, conventional meat producers or retailers. Their business may be affected by the introduction of these competing products, which can have broader societal implications. Also for inhabitants surrounding farms, or land where new production facilities may be build, can be affected by the broad implications this can entail (including nuisance from the factory, transport, view hindering etc.)

Conclusion – societal perspective

For the scope of this thesis, the Netherlands, and if relevant the European Union is used as the geographical scope. Developments worldwide are used for learning purposes. With regard to the time related scope, all information is based on the current situation, in 2025, with exceptions being mentioned to track progression over time. The hybrid product, a combination between cultivated protein and plant-based protein, form the product innovation within the alternative protein landscape in question. The societal perspective is taken, where the hybrid protein is a technology-driven innovation that is emerging as promising to stir the protein transition into the preferences of the consumers, considering the actors within this market boundaries as well as indirectly involved or affected actors outside this scope to get a broad and long-term perspective.

Hybrid protein are relevant in the alternative protein field, as they can help accelerate the protein transition by combining the technological feasibility and sustainable gains in one product. They are addressing the limitations the plant-based protein products and cultivated protein products face. For example, plant-based protein still struggle with the right sensory experience that consumers accept and the nutritional values to compete with other conventional protein sources, while the production price is attractive. Cultivated protein on the other hand have the high production costs, and low consumer acceptance, however it closely resembles the taste, texture and nutritional values of conventional meat. By combining these options, cost-effectiveness of plant-based protein and sensory and nutritional advantages of cultivated protein result in a more optimal and attractive product.

Chapter 2: Barriers for large-scale diffusion

"What are the barriers blocking hybrid protein from market introduction and large-scale diffusion?"
– MSc Management of Technology

Process of diffusion for hybrid protein

Innovations are usually referred to as something new, whether it is a new product, a new process, or a new idea. It is also commonly associated with something risky, time-consuming, and financially costly (Costello, 2013). Companies require to be innovative, to be able to keep up with the constant changing world. All the current challenges surrounding global warming, food scarcity and animal welfare call for radical innovations that are different from the current food system that can help tackle those issues.

The diffusion on an innovation usually follows the S-shaped curve of Rogers. The technology grows slowly, after that steadily to a mature point, and it may eventually reach its technological limit or competitive advantages, and new radical innovations can result in a new S-curve (The Open University, 1999). However, this curve does imply that the right after introduction, the innovation will show the pattern of diffusion and adaptation. Ortt argues that that is not always the case and developed a pattern that is more accurate to how innovations are adapted over time, visualized in Figure 5.

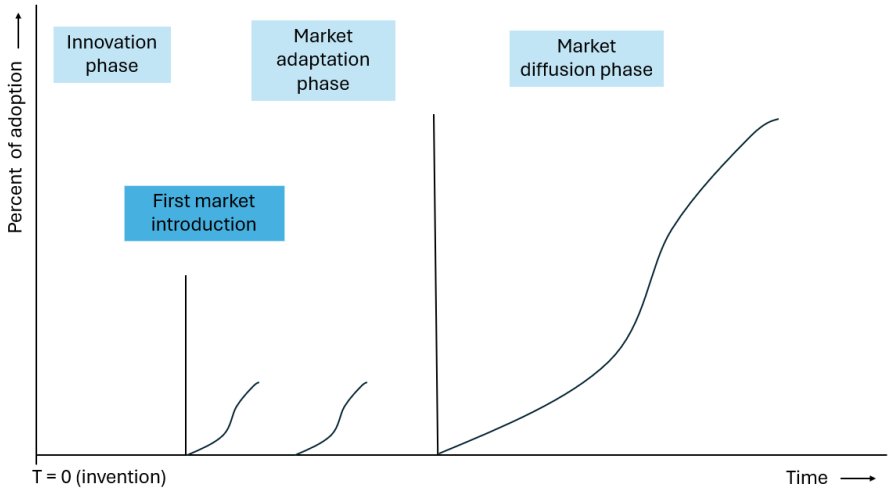

Figure 5: Pattern of diffusion of an innovation in three distinct phases showing the percentage of adaption of an innovation over time (Ortt & Schoormans, 2004).

The pattern is divided into three distinct phases, (1) the innovation phase, (2) the market adaptation phase and (3) the market stabilization phase. The invention is defined as the first time the principle is shown. This can be a demonstration of the principle, at the smallest scale. From there on, the invention moves to the innovation phase where the innovation goes from idea to marketable product. Once the first product has been introduced on the market, it continues in the market adaptation phase. In this phase, there is some focus on the fact that not all innovations directly after market introduction become a success. Technologies are often postponed, or quickly taken from the market once the first disappointing results come back (Ortt & Schoormans, 2004). These different attempts usually are niche attempts, aimed at a small group of customers that have specific demand regarding the product. This phase is estimated to take more than a decade. In this phase, a standard is tried to be established. The market stabilization phase begins when the diffusion of the product starts and ends when the

technology has substituted the previous dominant market holder. At that point, also regulations are established.

Innovation results in improvements in existing processes, as well as implementation of useful technologies that can result in operational excellence, as that requires continuous improvement to excel in business. Besides, it can be a way to outperform competition when a company uses their innovative potential. As innovation is important but at the same time requires dedication and investment in a risky and uncertain time, it is useful to know what stages an innovation goes through, to be able to anticipate on that and find the right strategy and make the right decisions.

History of development of hybrid protein

The first idea of cultured meat was shared in 1932, however for centuries it remained an idea as it posed technical limitations. In 1980, Willem van Eelen received the first patent for the production of meat from animal stem cells. In 2011, the Dutch scientist Mark Post produced the first slide of meat, and in 2013 produced the first cell-cultured patty by layering 10,000 meat slices together. At this time, it was still too costly as it had an R&D price tag of $250,000. It was also not yet approved for safe consumption and commercial sales. This can be seen as the first market introduction of cultivated meat, after a phase of development taking around 30 years. The high price tag at the time resulted in critics doubting whether this technology would be scalable to commercialisation and become a mainstream solution. Among these critics was David Humbird, who is 2021 shared a research paper doubting the economic viability of cultivated protein. This report increased the scepticism that was already a perspective in society as media were also sharing this research (Lever VC, 2025).

The main challenge to go from the development stage to the first market introduction and market diffusion was the scale-up of the production process. While the technological feasibility was there, the costs and general perception of the product were not allowing it. This same scepticism happened around other innovative technology developments like electric vehicles or solar panels, which have also shown their scalability possibilities.

The first regulatory approval was given in Singapore in 2020, to commercially sell and produce cell-cultured meat. However, Europe and North America represent the largest share of start-ups and enterprises working in the cultured meat industry (Ye et al., 2022). In 2021, also Future Meat announced that it would be able to produce cultured chicken breast, for less than $10. Also, Mosa Meat wanted to mass-produce cultured meat and be the first company to launch a cultured meat product in Europe by 2022. In 2025, they have shared that they have submitted the first application of cultured beef fat in the European Union. The fat is what gives the product the most meat like taste and thus is that the product that they submitted approval for (Ye et al., 2022) (Van de Rijdt, 2025). The alternative protein market however has not had the success of which it had hoped. The first consumers were initially driven by curiosity, but this did not lead to repeated purchases. The sales have decreased over the years, and some companies even withdrew their products (Fairr, 2023).

Current stage of hybrid protein

Even though there is potential and major milestones have been reached in the industry, like the costs reductions, cultivated protein is still not at the stage of becoming the mainstream product. It requires further cost reduction and process optimization for scaling. A range of innovative strategies are being developed to drive down the costs even more. These include the use of undifferentiated cell mass, in-house media production, using continuous production or perfusion methods, but most interesting for this research is the creation of hybrid protein (Lever

VC, 2025). By blending both the cultivated protein with plant-based protein, the amount of cultivated cell mass required is lowered. Specific formulation is created that optimizes the product to achieve the desired organoleptic, like taste and texture, while using the minimum required amount of cultivated cells.

Also plant-based proteins had been on the Dutch market since approximately 1992 and have been gaining popularity especially in recent years. These products however do lack the taste and texture, or the overall meat experience, that cultivated meat does bring with it. This is how this middle ground product, hybrid protein, started to become an interesting option. Both from a financial perspective, as it makes it possible for the mass market to afford cultivated protein, but also from a perspective of introducing a new product on the market. By starting off with a low percentage of cultivated protein, combined with more familiar plant-based protein gives room for acceptance and becoming familiar with a product. Eat Just received the first regulatory approval for cultivated meat production in Singapore in 2020, also Upside Food and GOOD Meat got approval in 2023 to market and sell cultivated chicken product. These companies are now able to sell cultivated meat, but the first product that is marketed from GOOD Meat for consumers is in a hybrid form.

Figure 6 gives an indication of where the hybrid protein currently are in time in the pattern of diffusion. The developments are in line with demand, and other forms of alternative protein have made their first market introduction, but hybrid protein in this form still need their market introduction. There is still a few barriers that is blocking that, hence the current position on the pattern of diffusion.

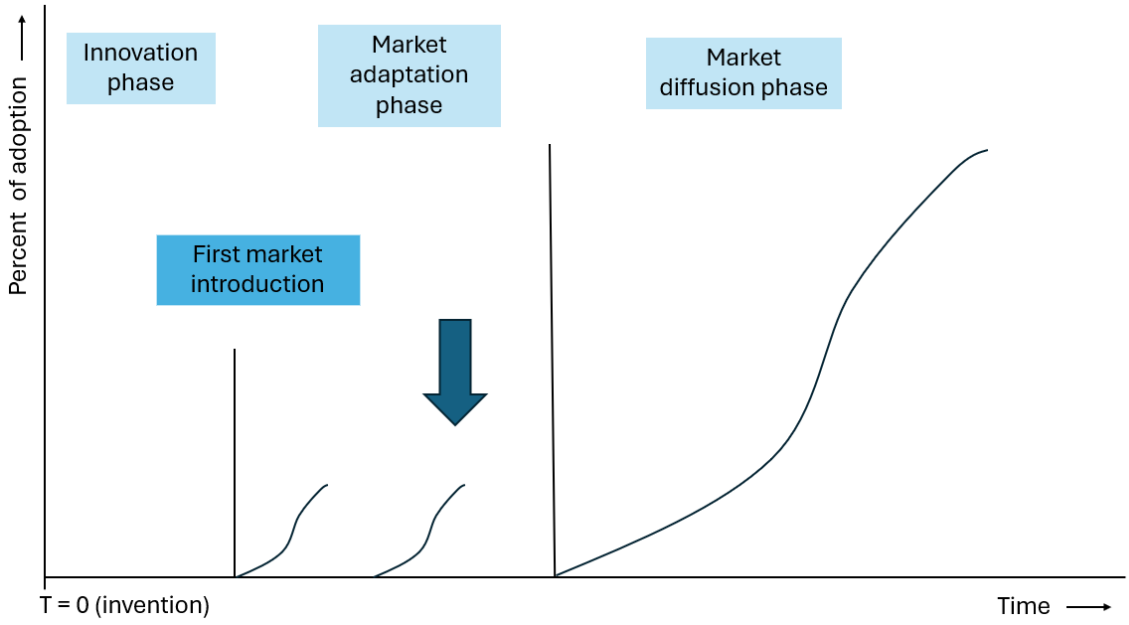

Figure 6: Estimated position of hybrid protein in the pattern of diffusion, after some other forms like plant-based have made introduction and cultivated protein tasting, but still before large-scale market introduction.

TIS framework

A Technological Innovation System (TIS) is 'a specific representation of a socio-technical system around a technological innovation and can be defined as a dynamic network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion, and utilization of technology.' (Carlsson & Stankiewicz,

1991). The TIS framework by Ortt and Kamp was designed in 2022, with the aim of exploring the context around an innovation and help formulate a niche introduction strategy that fits within this context (Ortt, Kamp 2022). This framework can therefore be used as tool to formulate a specific strategy for hybrid protein for effective market introduction and diffusion.

This framework was developed specifically for radical innovations that have already been demonstrated to work, while the large-scale diffusion has not started. This framework specifically looks at innovations that are in the adaptation phase between the first market introduction and the start of large-scale diffusion (Ortt, Kamp 2022).

The framework by Ortt focuses on a company perspective using following seven building blocks that are defined as important to consider and analyse, when formulating a strategy for the introduction of the innovation in the market:

1. Product performance and quality
2. Product price
3. Production system
4. Complementary products and services
5. Network formation and coordination
6. Customers
7. Innovation-specific institutions

The absence, incompleteness or incompatibility with the other building blocks can block large-scale diffusion (Ortt, Kamp 2022). A specific strategy can be formulated to be able to provide the lacking blocks, in fact, this strategy formation can be seen as applying combinations of resources in order to achieve large-scale diffusion.

TIS context – actors, collaboration and networks

To better understand the scope of the innovation, a Technological Innovation System (TIS) is described. The components of such an innovation system are actors, networks and institutions. They together contribute to the development, diffusion and utilization of the products or processes an innovation offers. For this case, the TIS describes the context of the innovation.

This specific TIS is about the technology of producing hybrid (cultivated and plant-based) protein products, with the scope being the Netherlands, specifically in the food industry focussing on the beginning of the development up until the current situation. The actors that are involved are listed in Table 5. Additionally, their role and collaboration is listed here, specifying formal (e.g. associations and consortia) and informal (e.g. knowledge sharing) networks, as well as the institutions including formal rules (e.g. laws and policies) and informal norms (e.g. values).

Within the group of actors, a difference is made between innovative agents, those who are actively influencing the innovation process, and other stakeholders that are not able to influence the innovation process.

Table 5: Description of the TIS context, including the actors (innovative agents or stakeholders), their roles, the collaboration links between the actors, their networks (formal and/or informal) and institutions (formal and/or informal).

	Actors	Type	Role	Collaboration	Networks	Institutions
1	Knowledge creators, like universities and research institutes	Innovative agent	Research and development of technology	2, 3, 4, 8	Formal and informal	Formal and informal
2	Start-ups and innovators	Innovative agent	Development of products and processes and test with business model.	1, 3, 4, 5, 6, 8, 9	Formal and informal	Formal and informal
3	Established market players	Innovative agent	Market access, scale-up and competition	1, 2, 4, 5, 7, 9	Informal	Formal
4	Governmental bodies	Innovative agent	Set up regulations and fundings.	1, 2, 3, 9	Formal	Formal
5	Customers	Stakeholder	Adopting the technology or product.	2, 3, 6, 7, 8	Informal	Informal
6	Retail companies	Innovative agent	Providing market access.	2, 3, 5, 7	Informal	Formal
7	Media	Stakeholder	Sharing information and opinions.	2, 3, 5, 6, 8	Informal	Formal and informal
8	Society representatives or NGO's	Innovative agent	Advocacy for societal issues.	1, 2, 5, 7	Formal and informal	Formal and informal
9	Investors and financial institutions	Innovative agent	Providing capital and influencing the technology spread.	2, 3, 4, 8	Formal	Formal

The innovative agents directly influencing the innovation process include the knowledge creators, like universities and research institutes, start-ups and innovators, established market players, governmental bodies, retail companies, society representative or NGO's and investors & financial institutions. As the consumers and media do not have a direct influence on the innovation process, those are characterised as stakeholders. Both the influence of the innovative agents and stakeholders is explained in Table 5 under 'Role'.

In the alternative protein landscape, these innovative agents and stakeholders are collaborating on e.g. the development, product testing, market entry, and providing capital. An example is the collaboration between start-ups and established market players, where they are co-developing an improved version of an already existing product on the market.

The actors in the TIS collaborate in networks, which can be either formal or informal networks. Informal networks facilitate the exchange of information, knowledge and other resources between innovating agents. In contrast to informal networks, formal networks are an organizational structure with identifiable members that come together to achieve a common goal of creating a supportive system of resources. Formal networks can also be seen as bundles of resources, made available by the network members. The resource-based view (RBV) is an approach that explains competitive advantage of firms, but it can also be used to explain why strong collaboration networks are of importance in a TIS. The RBV explains that different actors control and own different resources which can be difficult to transfer. Therefore, it is strategically beneficial to collaborate with other actors, that make it possible to share those varying resources with (Musiolik et al., 2012).

Within the TIS, there are both formal and informal institutions that have an impact on the TIS formation. The formal institutions are concerning the regulations specifically for food safety, novel foods, and cultivated protein, as well as patents for technologies, certification for the labelling of alternative protein products. These types of institutions allow for legitimacy of the technology and product. The informal institutions are regarding social norms, cultural values and societal beliefs, especially important considering the consumer acceptance for hybrid protein.

Building blocks

The seven building blocks in the TIS framework are a way of analysing whether all aspects are present to have successful market entry and diffusion. This helps assess the timing and scaling of introduction strategies. These seven building blocks are described below, after which they are analysed in this specific case.

The first building block **'product performance and quality'** is about the performance and quality of the innovative product compared to the competing products. The innovation should be a viable option or alternative to the competing products for potential customers.

The second building block **'product price'** is about whether the price is competitive with the competing alternative products. For large-scale diffusion, a reasonable price in absolute or relative terms is required.

The third building block **'production system'** is about the production systems that can both deliver the desired quality and the required quantity for large-scale production. Over time the production costs will decrease and the quality will increase, which will increase the competitiveness of the product. Yet, as it takes time, this can be a hampering factor in the diffusion process.

The fourth building block **'complementary products and services'** is about products and services that are complementary to the product that are either unavailable, incompatible or too expensive. The lack of these products can lead to block of large-scale diffusion. (service could be the collaborations or shops that sell it).

The fifth building block **'network formation and coordination'** is about the actor network in the supply chain. These actors can be the suppliers of raw materials, the production process, distributors and researchers. The coordination between the actors and governance is crucial, as their collaboration determines the success of the process. Therefore, they should also have a shared view. The presence or absence of this network can hamper or support the diffusion of the innovation.

The sixth building block **'customers'** is about both the identification of potential customers, but also about the awareness of these customers that they need or want to acquire the new product. Also, during the development phase, customer involved is important as their specific requirements in the product determine whether or not they are likely to purchase the product later.

The seventh building block **'innovation-specific institutions'** refers to the formal and informal rules and regulations from for example the government that blocks or supports the diffusion of the innovation.

Influencing conditions

The building blocks that are missing help identify what barriers are hampering large-scale diffusion. However, there is not yet enough information based on these barriers to identify what type of strategy is required for large-scale diffusion. Extra information about the cause of the barrier can help formulate a specific type of niche introduction strategy. Ortt & Kamp defined seven influencing conditions that describe the cause of the barriers in the TIS framework:

1. Knowledge and awareness of technology
2. Knowledge and awareness of application and market
3. Natural, human, and financial resources
4. Competition
5. Macro-economic and strategic aspects
6. Socio-cultural aspects
7. Accidents and events

For the first and second influencing conditions are **'knowledge and awareness of technology'** and **'knowledge and awareness of application and market'**. If either of the actors in the TIS are not aware of the technology or application, this is hampering the innovation.

The third influencing condition **'natural, human and financial resources'**, explains that the lack of either type of resource can hamper TIS formation and diffusion. Here, natural resources are raw materials of products that create the final product. Human resources are the people that have the knowledge and competences, and financial resources are the fundings that are required for the production and development.

The forth influencing condition **'competition'** is based on the competition that the new innovation has with the old existing technologies or products. Also new version of the innovation can compete. This uncertainty of competition between companies creates hampering of TIS formation, and ultimately also influences the pricing and performance of the innovation.

The fifth influencing condition **'macro-economic and strategic aspects'** includes market structure, the economic situation and strategic policies. The economic situation can for example hamper or facilitate the fundings.

The sixth influencing condition **'socio-cultural aspects'** refers to the differences in norms and values between the actors in the TIS but also of potential customers. Those are less formal than laws and regulations, and can therefore change over time making it a potential blocker of diffusion at one moment, and a stimulating factor later.

The seventh influencing condition **'accidents and events'** refers to accidents within or outside of the TIS. An example of an internal accident can be a production failure, and of an external accident is a war or changes in regulations. In certain case it can be beneficial, but it can also hamper the innovation.

Building blocks present

Following the framework, for the specific TIS each of the building blocks is analysed. Two out of the seven building blocks are present, and knowing what the foundation is to be worked with is important. The two complete building blocks are product performance and quality and complementary products and services. The product itself is ready, the production system and ecosystem around it are not.

Table 6 gives an elaboration on the presence or lacking of the building blocks and

Table 7 gives an overview of the influencing conditions.

Table 6: Overview of the TIS building blocks, indicating which are present or not and an elaboration on why they are present or not.

Building block	Present	Reason
Product performance and quality	Yes	The product performance is good, the quality is there, but it is not yet known what the long-term effects are. For the hybrid protein, the quality is improved compared to the cultivated protein and plant-based protein alone. Also, the regulations assure a standard for the food performance and quality.
Product price	No	The production costs are currently high, but the exact pricing in the Netherlands is not known yet as no products are on the market here. Based on pricing in already selling countries like Singapore, this is currently expected to be high. So, this is a diffusion hampering factor.
Production system	No	The production system is still designed for smaller scale than required for large-scale production, so this is still hampering scaling-up.
Complementary products and services	Yes	The hybrid protein can be seen as sole product, where cultivated, plant-based but also insect and algae based are complementary products that are filling up the landscape. These products can also be linked, where for example the growth of one product strengthens or weakens the position of the other.
Network formation and coordination	No	There is a TIS around this innovation, with a network of companies, start-up, researchers and technological experts that are collaborating on this development, yet there is no clear coordination yet. There is a lack of collaboration between the government and start-ups for example, and all involved stakeholders in the network have different incentives of developing this hybrid protein. A clear common incentive, to align the strategies is required, deciding who is responsible for what.
Customers	No	There are potential customers, but only high-end customers, the so-known innovators and early adopters. The customer acceptance is not there, making large-scale diffusion not possible yet.
Innovation-specific institutions	No	There are innovation institutions, like the Good Food Institute as well as regulatory institutions regulating the quality and safety of the novel foods. Also, there are regulations regarding the commercialisation of novel foods. However, regulations are currently not supporting the selling of cultivated protein in Europe or the Netherlands, and this poses a major missing building block.

Table 7: Overview of the TIS influencing conditions, indicating which are present or not and an elaboration on why they are present or not.

Influencing conditions	Present	Positive or negative influence	Reason
Knowledge and awareness of technology	No	Negative	Customers do not fully have the knowledge of the technology, also the scientists, start-up and other developing actors are not having the knowledge of how to scale-up this technology for large-scale production.
Knowledge and awareness of application and market	No	Negative	Customers are not aware of the usage of this food product. Also, the government and financial institutions/venture capital might not fully understand the value of the product.
Natural, human and financial resources	Yes	Positive	The natural resources, the raw materials, are present, human capital is present and in geographical proximity and financial resources are also present to a certain extent due to governmental support.
Competition	Yes	Positive	There are different companies working on the same technology, as well as competing products like companies working with plant-based protein. However, they can together make alternative protein more popular.
Macro-economic and strategic aspects	No	Negative	The macro-economic landscape has been rough in the last three years, meaning more strategic decision have to be made.

Socio-cultural aspects	Yes	Negative	Generally, the actors in the TIS have similar values and norms. However, the perception of cultivated protein is still widely varying among different people and different cultures. How to fit this new protein source into the cultures is still an ongoing struggle. Governmental support could be an important factor in this acceptance and also the market strategies will be made with cultural traditions in mind.
Accidents and events	Yes	Negative	Opposition to cultivated protein, for example the ban of the Italian government, has a negative influence on the market access in the European Union. Also, the ban for companies to label or name their plant-based products with animal protein derived names hampers the acceptance of customers. A plant-based burger for example is not allowed.

Building blocks lacking

More interestingly than the TIS building blocks that are already present, are the building blocks that are not yet present. These are blocking the market-introduction and diffusion and are the factors that need development. The building blocks that are forming a barrier are:

Product price: Currently the production costs are high, as the fixed costs of the bioreactor infrastructure is high and this will only be higher with large-scale production. One of the other key cost drivers in the production process is the cultivation media costs. Research of Humbird in 2021 concluded that it was 'essentially impossible' to decrease these costs to less than $1 per litre, which meant the total production costs could not be below $16 per kilogram (Lever VC, 2025). GoodMeat has shared that their cost of feed is currently within the range of dollars per litre. For them to be cost-competitive, they only have to scale that down to dollar cents per litre (Bloomberg interview). Generally speaking, the cost of media have already decreased between 10-30 times of what Humbird shared was possible. Four years after Humbird's research, multiple companies are producing cultivated meat with media at the cost of less than $1 per litre. Cell densities have also been shown to achieve densities up to 60-90 g/L, which have outgrown the projections of Humbird (Lever VC, 2025).

Besides, the cost of growth media is a cost driver, as well as the R&D of optimal cell lines, scaffolds for the meat like structure, also regulatory costs for the approval of the product, potentially patent applications, and lastly the scaling of the production process and supply chain costs large amounts of money. The ultimate price of the product will be largely influenced by the production costs, and thus the assumption can be made that the product price will be high when it enters the market. The combination of cultivated protein with plant-based protein has already been a factor that has decreased the pricing of the final product, as it decrease the amount of cultivated cell mass required to obtain the desired product. Besides, options to focus on the production of basic undifferentiated cell mass instead of structured tissue, can simplify the production process and thus lower costs. Another cost-driver is the growth factors media. This can be produced in-house, that could result in more consistency over the product, less dependence on pharmaceutical companies and eventually also reduce costs when this is done on a large-scale. Lastly, making the bioreactors perform more efficiently will help reduce costs. There are multiple bioreactor productions models that can be utilized for the production of cultivated meat, where continuous and perfusion reactors can increase the yield while reducing capital costs (Lever VC, 2025). Additionally, more circular systems can be created, coupling resources, emissions, waste products for optimal use of substances.

Production system: The production system, the infrastructure around the production system and the capacity of the production system is not developed for large-scale production yet. That means that currently the product cannot be diffusing on a large-scale. Integration with current supply chains can be an interesting development, like with conventional agri-food systems can be beneficial as these value chains are already in place, eliminating the necessity to create a completely new value chain, while at the same time keeping in mind the integration of the current human capital in the value chain instead of replacing their source of income. Co-production of cellular agriculture and livestock derived products on a farm, means working with farmers and breeders that already work in an established market. Respect Farms is an example of a foundation that was founded with the commitment of producing cultured meat in a viable way. They are collaborating with livestock farmers and food producers by blending new technologies with their agricultural expertise and infrastructure. With other words, RESPECTfarms is working on the production of cultivated meat on existing farms. This has multiple benefits for the development and realisation of large-scale hybrid protein production. First off, as it is easier to produce cultured protein in small units, this makes it possible to get a head start in the production. This creates learning opportunities and continuous improvement. As this is being developed on a local scale, it is stimulating the local economic growth, integrating with local supply chains, and embedding in local communities simultaneously building consumer trust (RESPECTfarms, 2025). Also 'Cultivate at Scale' is an example of an open-access facility that provides small scale innovators the facilities to experiment, develop and accelerate their development process in order to reach commercialisation faster. They provide the equipment to produce different type of batches that Cellular Agriculture start-ups can produce early on in their production process. Providing this reduces capital costs in the testing phases for start-ups, lowering the barrier for them to scale-up in a still uncertain phase (Cultivate at Scale, 2025).

Network formation and coordination: There is a range of relevant stakeholders that are forming a network, yet the coordination of these stakeholders that can result in collaboration is not developed properly yet. Especially the government does not have a stake in this network, which would take the leading role of getting all stakeholders on the same line. With similar incentives, this network can be coordinated for proper collaboration, that could contribute to the elimination of the lacking building blocks. Creating governance frameworks will help shape open and transparent research as well and an increase in governmental commitment will result more trust and confidence in this industry (Glaros, 2025).

Customer acceptance: The perception of plant-based protein and cultivated protein, as parts of hybrid protein, is a significant barrier. A study in the Netherlands between 2019 and 2023 showed a slight decrease of a maximum of 6% of positive association with protein alternatives, specifically meat replacers (Figure 7). In the last two years (2022-2023) of this research period, there has been a shift from negative to neutral associations. The positive associations are linked to taste (good), the providing companies and products (healthy, sustainable). The neutral associations are linked to the providing companies and the products (plant-based, tofu). The negative association is linked to the price (expensive), taste (not good), and the products (processed, fake meat) (Merk & Evers, 2023).

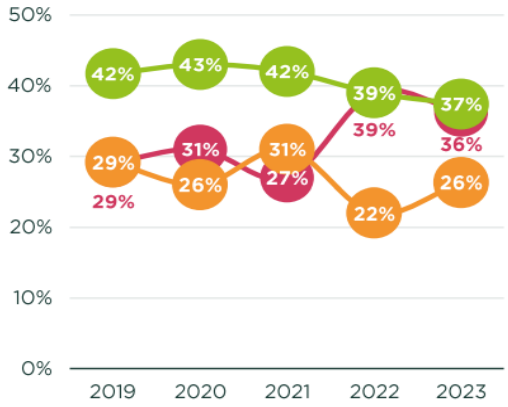

Figure 7: Trends in association with protein alternatives in the Netherland over the period 2019 to 2023. In green positive associations, orange neutral associations and red negative associations (Merk & Evers, 2023).

There are multiple reasons as of why consumers are not accepting of cultivated protein yet. For cultivated protein, the barriers are mainly about the perceived naturalness, perception about production and processing, safety and lack of trust in the product and food industry (Van de Toorn, 2025). Consumers are also unwilling to spend extra money on these protein sources (Pasca & Arcese, 2025).

One of these barriers is the use of fetal bovine as serum. This growth medium originates from cows, and thus means it keeps the reliance on animals (Ettinger, 2022). Therefore, pioneer Mosa Meat has removed their usage and published a method for using serum-free growth medium (Mridul, 2025).

Another factor that can improve the customer acceptance is the presentation of the product, this could be facilitated through the advancement of techniques that mimic real muscle fibres better, techniques that mimic the colour better or the texture and taste (Alberganti & Zaccarian, 2024). As the sale of cultivated protein is not yet approved in the Netherlands, opinions are based on depictions, perceptions and impressions, rather than on experience. This makes the presentation of cultivated products important and influential.

An important factor that determines whether consumers will grow acceptance is transparency. Learning from companies working with genetically modified organisms being perceived as secretive, transparency is a factor that builds trust. Additionally, this will communicate the benefits and production process. However, transparency can also hamper acceptance, when it results in the perception or confirmation that the production process is unnatural, processed or even artificial (Rosenfeld & Tomiyama, 2023).

Also, the legitimation of Novel Food Regulations can help overcome neophobia and scepticism towards a novel food like cultivated protein. Due to their rigorous and comprehensive authorization process they are able to provide this legitimation and feeling of safety about the product (Reinhardt & Monaco, 2025).

By implementing tastings as part of ‘regulatory sandboxes’ consumer acceptance can be improved. This is done when regulators and stakeholder lower the regulatory barriers while ensuring consumer safety (Reinhardt & Monaco, 2025). This research looks at the effects of regulations on an innovation system. It was found that the transparency and robustness of EFSA does improve knowledge diffusion and legitimation, while the process of authorization blocks entrepreneurial experimentation, resource mobilization and market formation (Reinhardt & Monaco, 2025).

Regardless of progress in the cultivated protein industry since 2024, the consumer awareness, interest and perceptions have remained stable since 2023. This also suggests that this barrier needs some attention, to be able to build consumer awareness and acceptance for the product in the future (Battle et al., 2025).

Innovation-specific institutions: Although multiple institutions like the Good Food Industry (GFI), Cellulair Agriculture Netherlands (CAN) and many others are working towards the formation of a strong network of institutions, the regulations are still the blocking barrier. The complex authorization process that EFSA requires hampers market formation (Reinhardt & Monaco, 2025). The government and European Union do not allow the selling of cultivated protein in the EU or the Netherlands.

In 2024, the Court of Justice of the European Union decided on labelling of plant-based meat alternatives. It states that Member States cannot prohibit the use of food labels that are traditionally used in the animal-based products, yet it should not be misleading to the consumers so the labelling must be clear and transparent (Tricou, 2024). As this was set out for products containing plant-based protein, this also applies to hybrid protein. An example is the Vegatarische Slager; de Nederlandse Voedsel- en Warenautoriteit (NVWA) decided using similar words that describe conventional animal protein is not allowed for their alternative meat products as that is misleading for customers (BNNVARA, 2017).

For plant-based protein, the main barriers are taste and price, while the benefits around health, nutrition and sustainability are motivators for consumers to be likely to switch according to research of the Good Food Institute in 2024 in the US. This research aligns with the European market barriers, that have also been identified as price and taste. In Europe, the three most important reasons for buying plant-based products were taste, health and affordability.

This same research identified six consumer segments in the addressable market; the types of consumers that are open to plant-based protein. Table 8 gives an overview of these different types and their share of the addressable market. Each of the types of consumers will require a different strategy, making it useful to analyse what types of consumers there are in the market.

Table 8: Different segments of consumers in the addressable market for plant-based protein products, for the US in 2024 (Good Food Institute, 2024).

Type of consumer in addressable market	Share in addressable market	Reasons for openness to plant-based protein	Reasons wanting to reduce conventional meat or not.	Likeliness to eat plant-based in the future	Reduced amounts of conventional meat *
Ethical Alternative Seekers	10%	Care for sustainability and animal welfare and are thoughtful about what they eat.	Usually already vegetarian or vegan, or trying to reduce conventional meat intake.	81%	66%
Health-Conscious Compromisers	18%	Wanting to make better health choices.	Not willing to sacrifice on taste.	60%	27%
Nutrition-Focused Integrators	10%	Care for nutritional value of their food and for health and sustainability issues open to incorporate plant-based more.	Part of their diet and culture.	86%	-10%
Protein Maximizers	19%	Value protein content of food, also if that	Emotional attachment with conventional meat as	89%	-6%

		would be in plant-based products.	source of protein and culture.		
Carefree Considerers	19%	Open-minded, but low familiarity	Stick with what they know, conventional meat is familiar favourite.	66%	-10%
Value-Driven Skeptics	24%	Are not convinced it is a good choice, also with the price and taste in mind.	Conventional meat is more natural and part of their routine.	29%	-11%

*a negative reduction, means an increase.

All consumer segments have reported to have added plant-based protein in their diet, but not all reduced the amounts of conventional meat. Only the two segments Ethical Alternative Seekers and Health-Conscious Compromisers have a portion of their segment that have reduced their conventional meat intake.

The promising segments are the ethical alternative seekers, where 66% have reduced their conventional meat intake and for 81% it is likely that they will eat plant-based products in the future. Also, Health-Conscious Compromisers, Nutrition-Focussed Integrators, Protein Maximizers and Carefree Considerers show significant likelihood of adapting plant-based products in the future.

Analysing the influencing conditions

The influencing conditions that currently have a negative impact on the diffusion of hybrid protein are the interesting conditions to delve into, as they are underlying causes of the building blocks that are missing. There is a relation between the influencing conditions and the building blocks, as not all influencing conditions have an effect on each of the building blocks. Table 9 gives an overview of this relationship.

Table 9: Relation between the influencing conditions and the building blocks.

Influencing conditions	**Effect on lack of building block**
Knowledge and awareness of technology	Product performance and quality Production price Production system Complementary products and services
Knowledge and awareness of application and market	Complementary products and services Customers Innovation-specific institutions
Natural, human and financial resources	Product price Production system Customers
Competition	Production price Customers
Macro-economic and strategic aspects	Product price Production system Complementary products and services Customers Innovation-specific institutions
Socio-cultural aspects	Complementary products and services Customers
Accidents and events	Product price Production system Complementary products and services Network formation and coordination Customers Innovation-specific institutions

Knowledge and awareness of technology: The knowledge of the technology is present for part of the stakeholders in the TIS, but specifically for the consumers it is not clear how cultivated meat is produced and also a wrong perception of cultivated protein as it being unnatural or unsafe are a result of this lack of knowledge. Another example is the lack of knowledge on how to scale up the technology for large-scale production for an affordable price. Table 10 gives an overview of what aspects are important for each of the stakeholders to understand and be aware of and to what degree.

Table 10: Aspects that are important to the actors to be aware of. The technology includes the theoretical background and the production system, the application includes the possible use and risks, and the relevance includes the reasons why it is important for this product to diffuse. The scale of high, medium and low indicates respectively that the stakeholder have a basic understanding, good understanding or perfect understanding of the aspect.

	Actors	Technology	Application	Relevance	Expected awareness level *
1	Knowledge creators, like universities and research institutes	High	High	High	High
2	Start-ups and innovators	High	High	High	High
3	Established market players	Medium	High	High	High
4	Governmental bodies	Low	Medium	High	Medium
5	Customers	Low	Medium	Medium	Medium
6	Retail companies	Low	Medium	Medium	Medium
7	Media	Low	Medium	Medium	Medium
8	Society representatives or NGO's	Low	Medium	Medium	Medium
9	Investors and financial institutions	Low	High	High	Medium

*average of the three aspects

For the TIS building block consumers, transparency was provided as one of the factors that would be beneficial for customer acceptance. Besides that, it will help provide the knowledge and awareness of the product to potential customers and other stakeholders if the research, start-ups and government is transparent around the development of the hybrid protein.

Knowledge and awareness of application and market: The consumers are again not aware of the application, the benefits, the use or safety of the product in the market. Even though a product might be promising, in terms of quality, price and all the other building blocks, if the customers are not aware of how it can be beneficial for them, it will not diffuse on large-scale. Also, for stakeholders in the supply chain this might be an issue, where they might not see the application possibilities of the product and thus, they might not contribute to the supply chain in a way it can be diffusing on large-scale. The same is true for investors or governmental bodies, that might not see the relevance and possible applications of the product, resulting in uninformed decision making.

Also, for this influencing condition, the awareness of the application in the market of hybrid protein can be spread through transparent communication, specifically about the relevance and application of the product.

Macro-economic and strategic aspects: The macro-economic landscape has been rough, with rising inflation, uncertainties leading to less risky investments, results in start-ups having to make strategic decisions (Mridul, 2025). This influences the way financial decisions can be made and the amount of fundings and investments that are available. A more stable macro-economic landscape could lead to more investments and fundings, creating more opportunities for growth of start-ups in this field. There is also a need for both public and private investments. While public investment is put towards basic research, private investment is usually more put towards commercial application, which is exactly what this industry needs (Glaros, 2025).

Socio-cultural aspects: The way meat consumption is embedded in many cultures is a barrier for the substitution of meat. When developing substitutions for conventional meat, an important factor is how deal with the cultural integration. Not only consuming meat is a significant part of many cultures, also the preparation and cooking of meat is a tradition that is embedded in cultures around the world.

Accidents and events: The recent ban of labelling plant-based products with conventional meat derived names, results in another barrier that makes new products more difficult to be accepted or integrated. Also, for existing products are using these names, they have to redesign and market their products.

Conclusion – barriers for hybrid protein diffusion

The building blocks that are currently missing are the 'production price', 'production system', 'network formation and coordination', 'customers', and 'innovation-specific institutions' and the influencing conditions that are negatively impacting large-scale diffusion are 'knowledge and awareness of technology', 'knowledge and awareness of application and market', 'macro-economic and strategic aspects', 'socio-cultural aspects' and 'accidents and events'. Figure 8 gives a visual overview. These form the barriers that are blocking hybrid protein from large-scale market diffusion.

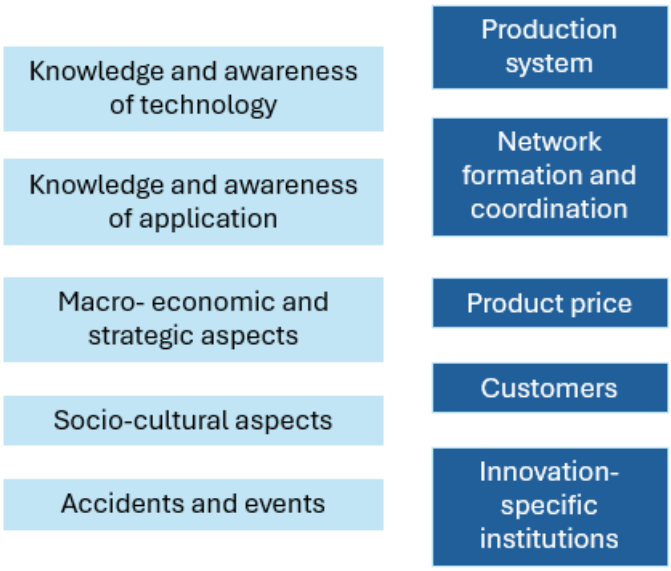

Figure 8: Current lacking building blocks and influencing conditions.

Chapter 3: Strategies to overcome barriers in the hybrid products

"What strategies can be applied to overcome those barriers?"
– MSc Management of Technology

Prior to large-scale diffusion, about 80% of the new high-tech products are introduced in niches, which are small markets where the innovation has a niche application and is developed through incremental and radical innovations (Ortt, 2013). This niche is a 'small, protected spaces where the mainstream pressure from the market or other regulatory forces is lower'. Gradually these innovations become more important and take over the dominant socio-technical regime (Hermans et al., 2012).

This niche application has a fundamentally different application than the large-scale products that emerge later. These applications have a small group of customers that demand specific wants in a product. The definition of early niche is 'the niche application that emerges in the adaptation phase prior to industrial production and large-scale diffusion of a new high-tech product in a mainstream application' (Kamp et al., 2018). There is however also another definition or viewpoint on how to explain a niche. It does not necessarily have to be a market that is being formed, it can also be a network that is formed prior to market-introduction that is called the niche, in which the same vision is shared and common goals are worked towards.

Different niche strategies

Niche strategies are often referred to as an important step to commercialize new innovation. It is a strategy to circumvent a barrier that prevents the innovation of large-scale diffusion. However, as it was not clear in literature how to distinguish different niche strategies and how to select a strategy that suits a situation, Ortt et al. published a model that aid to select the appropriate niche strategy based on historical cases to identify which niche strategies have emerged.

The different niche strategies are a combination of the missing building blocks and the influencing condition that result in that missing building block. Some strategies circumvent a conditions or causes that results in a barrier, other strategies circumvent the barrier itself. What the cause of the lack of a building block is determines what strategy is required to overcome this barrier. Table 11 gives an overview of the ten different niche strategies that have been identified by Ortt et al. Most of the niche strategies are applicable to multiple situations.

Table 11: Overview of the different niche strategies that can be applied for market introduction, where the combination of the different missing building blocks and influencing conditions result in a specific niche strategy (Ortt et al., 2013).

Niche Strategy	**Building block missing**	**Influencing conditions**	**Description of niche strategy**
Demo, experiment and develop niche strategy	Quality	Knowledge of technology	Demonstrate product in public in a controlled manner, so the limited quality is not a problem. Further develop the product in a research environment.
Top niche strategy	Price Quality	Knowledge of technology Resources	Produce hand-made products for a specific top-end market in small numbers. A skimming strategy can be used where the top niche of customers is supplied first with special product.

Subsidized niche strategy	Price	Knowledge of technology Resources	If the use of the product by a particular segment is considered socially relevant, the product can be subsidized.
Redesign niche strategy	Price Customers	Knowledge of technology Knowledge of application Resources Institutional aspects Socio-cultural aspects	Redesign the product to a simpler version of the product requiring less knowledge and resources that leads to a lower price, or explore an application where the institutional aspects are more favourable or the customers have less resistance.
Dedicated system or stand-alone niche strategy	Complementary products and services	Knowledge of technology	Use the product in a stand-alone mode or design a dedicated system of complementary product and services.
Hybridization or adaptor niche strategy	Complementary products and services	Knowledge of technology Resources	Combine the use of the old product with the new product, so the complementary products and services can be reused, or make the product compatible with the existing complementary products and services.
Educate niche strategy	Customers	Knowledge of technology	Knowledge can be supplied to suppliers as a strategy or educate and experiment to increase customer knowledge.
Geographic niche strategy	Institutional aspects Complementary products and services Customers	Knowledge of technology Resources Socio-cultural aspects Institutional aspects Accidents	Relocate to an area where the institutions are easier to arrange, resources, suppliers and customers are available or no unexpected events or accidents happened.
Lead use niche strategy	Customers	Knowledge of application Socio-cultural aspects Macro-economic aspects Accidents	Find lead-users with whom co-development can be done and innovators that are willing to experiment with the product.
Explore multiple markets niche strategy	Customers	Knowledge of application	Explore multiple customer applications, where the visibility of the first application might stimulate other applications.

Not for all combinations of missing building blocks and/or influencing conditions there is a niche strategy. This has to do with two factors, one being the complexity of a certain situation. A strategy can only be designed if it can circumvent a certain set of causes and barriers. If this set of barriers is too large, the variety of different combinations becomes too large. If this is the case, this framework is not relevant to the situation as it cannot provide a fitting strategy. Also, this complexity of a situation can mean that no market-introduction strategy can be proposed yet as the innovation is not at the right timepoint. Too many barriers also indicate that the innovation is not ready yet for market-introduction.

Secondly, the barriers are not independent variables, but they are linked to each other, where solving one barrier can result in solving another barrier as well. Think of production system and price, when the production system is able to produce on a larger scale, that might mean the prices can be lowered or regulations that are keeping the other barriers from being overcome. As the barriers are sequential or connected, the framework with strategies can be used, even in complex situations, where a subset of strategies can be applied, to overcome barriers one by one making the situation less complex.

Insight from expert interviews: Sequential barriers

That the barriers are not independent variables has been confirmed during expert interviews. It was mentioned that barriers can be sequential problems. If one barrier has been overcome, the other barriers can be solved. For example, regulations are the barrier that first are required to be overcome, before other barriers can be. Quotes from interviewees I1 and I2 are supporting this:

"I think there are multiple big challenges, but there is some sort of sequence in there." - I1

"[Talks about different barriers] .. but I would say the regulations and market-introduction come first. They are not the only barriers, but they are the first." – I1

"Obviously the biggest barrier is that these cellular agriculture products are still restricted to be used in the European Union, by the Novel Food regulation and then, if they would become available, it is the question how expensive or how cost competitive can they be?"- I2

"Approval does not directly lead to scaling, but it is a prerequisite to see if it is scalable, how we can produce it, in what forms and for what price to see if there is acceptance from consumers." – I1

Specific niche strategies for hybrid protein case

The "redesign niche strategy" resembles the strategy that has been applied to plant-based protein products and can be applied to cultivated protein as well. This strategy aims to circumvent the barrier 'price' and 'customers' and influencing conditions of either 'knowledge of technology', 'knowledge of application', 'resources', 'institutional aspects' or 'socio-cultural aspects'. The idea of combining cultivated protein with plant-based protein resulted in a hybrid form that can be seen as a redesigned product. Not only does this redesign lower the production costs, but it also poses benefits regarding the nutritional features that can be customized per product, and it provides opportunities to improve the product on sustainability. The hybrid form can have added value in terms of marketing as well, where the argument of having an opportunity for easier intake of extra vegetable without having to change the diets drastically (Good Food Institute, n.d.).

The strategy of "demo, experiment and develop" is what is currently being used on the cultivated protein products, for example in the Netherlands with the tastings, that act as a controlled environment of demonstrating the product.

As has been identified in Chapter 2, the barriers hybrid products are facing are 'production system', 'network formation and coordination', 'innovation-specific institutions', 'price' and 'customers'. And the influencing conditions are 'knowledge of technology', 'knowledge of application', 'macro-economic aspects' and 'accidents'. Following Table 11, multiple strategies can be fitting for the next stage; "top niche strategy", "subsidized niche strategy", "redesign niche strategy" and "geographic niche strategy".

Strategies lacking responsibility

As innovators are aiming to solve societal challenges, they have more responsibilities than that is legally required of them, they have social and moral responsibilities. The strategies that are focussed on introducing innovation on the market, are the first step of these innovations to be introduced in society. RRI has been focussing on enhancing the social embeddedness of innovations, to make sure the impacts of the innovations can be anticipated and reflected on and the innovation can be adjusted in response to these considerations. The four main pillars of RRI are inclusion, anticipation, responsiveness and reflexivity and they describe what is important for an innovation to be responsible. The TIS framework lacks this responsible perspective, but does provide the strategies for market-introduction. The meta-responsibility framework does have this responsible viewpoint, and helps allocating responsibilities and identifying conflict of interests. If the market-introduction strategies were to be responsibly assessed and adapted, a more inclusive and responsible innovation market-entry will be the results. In the long run, this means more an innovation that is aligned with values and needs, ensuring inclusivity, producing a more sustainable sector.

Currently the strategies are proposed based on the output of the TIS framework to eliminate the barriers to market-introduction. However, it is not taking into consideration what it can imply in terms of consequences. The strategies only state how to introduce the innovation to the market, by trying to circumvent the barriers, without descriptions or details on how to apply that strategy responsibly (e.g. safely, without harming other actors, taking the future into account). For example, the "demo, experiment and develop niche strategy" describes how an innovation that is still lacking quality (building block) due to lack of knowledge on the technology (influencing condition) can be demonstrated in public in a controlled manner and further developed in a research environment. This strategy does not specify what the definition of quality is and what the minimum required 'quality' of the product must be. Does quality mean the exterior features, the user-experience, or the safety? For this strategy to be responsible, there should be a clear description of what is meant by quality and what the requirements are for a product to be demonstrated in a controlled environment to the public.

This framework and strategies also assume that introducing an innovation to the market is a responsible choice. However, it can be argued that the decision of introducing an innovation to the market is a responsibility in itself. The choice of introducing the innovation to the market can have wide effects, both on direct and indirect stakeholders, ranging from stakeholders closely related to the innovation, to actors that are not directly linked to the innovation. In other words, it is not only about how to introduce an innovation to the market responsibly, or which strategy to use, it is also about at what point in time and even whether to introduce an innovation at all, that requires conscious choices that need to be made by an innovator.

The perspective is taken where an innovation is at a timepoint right before market-introduction. This being said, there is a timeframe before and also after market-introduction where important decisions can be made that the innovator at the timepoint of introducing to the market has no influence on. For example, the stage before market introduction in the value chain, governmental regulations can result in support of hybrid protein products, venture capital trends can result in access to venture capital in a certain network, already existing food safety frameworks decide how the products are being tested and what is entails for a product to be safe. Also, in the stage after market introduction, there are influences that the innovator is not responsible for but are able to shape the adaption of the product. For example, the way retailers

choose to make the appearance of the product, how media frames the products or how competitors choose to behave and react to the new products. The strategies proposed in this thesis are focussed on the market-introduction phase as depicted in Figure 9.

This means that before and after the stage of market introduction, decisions can still be made that can influence the process but are not taking into consideration with the strategies.

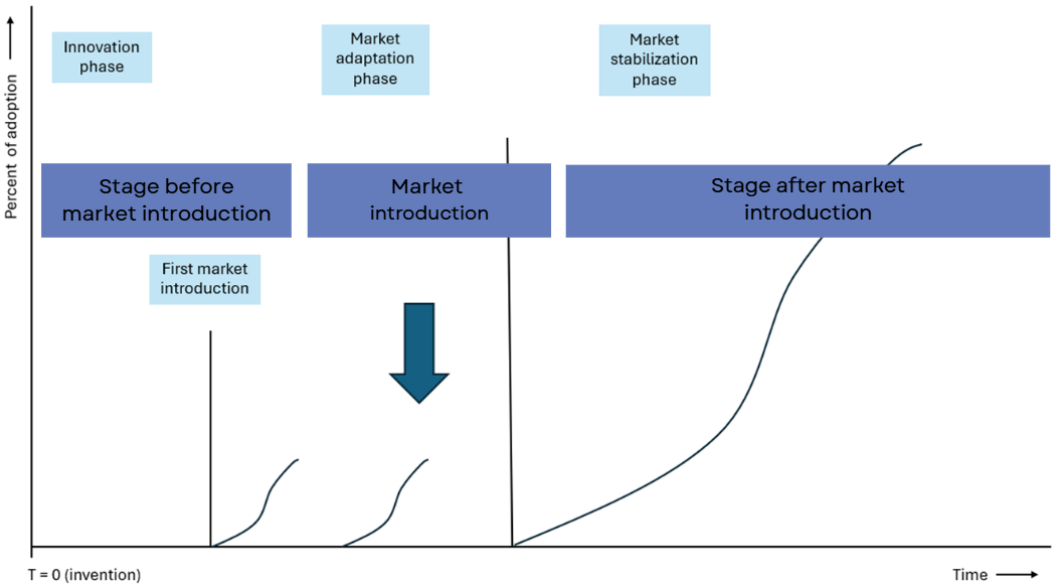

Figure 9: Period in the pattern of diffusion where the strategies are focussed on; market-introduction. Before and after this time frame also important decisions are made, and responsibilities are present.

Conclusion – a need for responsible niche strategies for hybrid products

Based on the outputs of the TIS framework, so the barriers that are the missing building blocks and the influencing conditions that are the causes of this barrier, niche strategies can be formulated that aim to circumvent the barriers. These strategies are aimed at market introduction. It was found in expert interviews that the barriers can be sequential, where one barrier should be tackled first, before it is effective to work on the other barriers. For example, regulations must allow the selling of cultivated protein, before other barriers like customer acceptance and price can be tackled.

From the TIS framework, the proposed strategies that can be applied are the “top niche strategy”, “subsidized niche strategy”, “redesign niche strategy” and “geographic niche strategy”. Also the “redesign niche strategy” and “demo, experiment and develop strategy” are being applied already. These strategies do however lack a responsible viewpoint that is needed to make long-term sustainable innovation happen.

Chapter 4: Responsibility of actors

"How to systematically identify and classify innovator's responsibilities to support responsible market introduction strategies?"
- MSc Life Science & Technology

Responsibility can be defined in the most broad sense as 'a duty to be in charge of someone or something, so that you make decisions and can be blamed if something bad happens', or 'something that you must do as part of your job or duty', or 'something that you ought to do because it is morally or socially right' (Pearson, 2025). Companies and institutions hold wide responsibilities in society. They have economic obligations, legal obligations, but also social and moral responsibilities that is required of them (Sonck et al., 2019). A different focus of responsibility has emerged in the field of research and innovation (R&I) that focussed on 'social embeddedness' called Responsible Research and Innovation (RRI) aiming to promote responsibly conducting innovation. RRI takes into consideration four main pillars; anticipation, deliberation, reflectiveness, and responsiveness (Genus & Stirling, 2017).

The meta-responsibility framework

The RRI framework lacks a systematic approach to both describe, inventories, and manage the different responsibilities that actors hold in companies and society. Therefore, the meta-responsibility framework was developed by Sonck et al. in 2019 to be implemented in corporate R&I and it helps to operationalize the theoretical elements of responsibility in R&I in practise.

The framework is built up from the concepts of Pellizzoni, that itemized responsibilities into four different types: care, liability, accountability and responsiveness. It conceptualized these types on the basis of two facets, imputation and justification. Figure 10 shows the visualized framework with the different concepts.

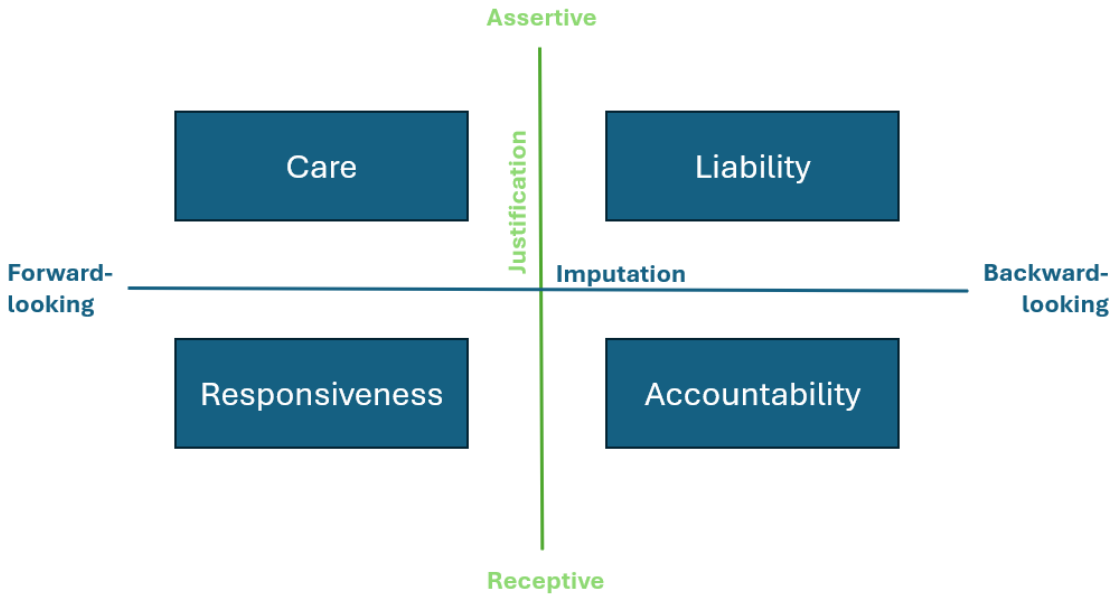

Figure 10: Visualization of the meta-responsibility framework (Sonck et al., 2019)

Imputation

Imputation is visualized on the horizontal axis, ranging from forward-looking to backward-looking responsibility. It refers to the event of tracing an action back to its origin. Forward-looking

responsibility is driven by the aspiration to improve the current stage of affair, and if that fails try to do better next time. Backward-looking responsibility is driven by retrospective evaluation on the possible harm (or benefit) caused by the action (Sonck et al., 2019). Care and responsiveness are on the forward-looking side, while liability and accountability are on the backward-looking side.

Justification

Justification is visualized on the vertical axis, ranging from receptive to assertive. It refers to how to justify acts in light of high uncertainty. In assertive justification, it is known what is wrong or right. This is the case with clear moral norms and values. In receptive justification it is less clear what is right or wrong, for example in cases of high ambiguity, uncertainty or moral complexity. In practice this implies that in some cases a responsibility can be allocated in a straightforward manner, while in other cases, a responsibility cannot be allocated easily and should be explored based on context, dialogue and re-evaluation. So, for assertive justification, the responsibility is clearly linked to standard norms, while for receptive justification, the responsibility should be explored and evaluated. Responsiveness and accountability are responsibility types on the receptive side, while care and liability are on the assertive side.

The four types of responsibilities

The meta-responsibility framework uses the work of Pellizzoni that itemized responsibilities into four types; care, liability, accountability and responsiveness. These four types all fall in a certain grid in the framework. Table 12 gives an overview of the characteristics of each of the four responsibilities. By mapping out the responsibilities that each of the actors in the TIS context have in the framework, the dynamics of the responsibilities can be identified.

Table 12: Overview of the types of responsibilities including the classification of imputation, (forward- or backward-looking) and justification (assertive or receptive) that leads to the responsibility class.

Type of responsibility	Imputation	Justification	Description	Example of hybrid protein
Care	Forward-looking	Assertive	Knowing what is good or bad and acting upon it to improve current state to reach this outcome.	Environmental footprint, avoid misleading claims.
Responsiveness	Forward-looking	Receptive	Reflection on what is right and desirable while improving the status quo.	Changing the product, communication, pilots based on stakeholder feedback and emerging evidence.
Liability	Backward-looking	Assertive	Compliance with society's rules that are known to be right and avoid harms and risks.	Compliance with Novel Food regulations, labelling requirements and safety standards
Accountability	Backward-looking	Receptive	Contemplation of what would be the right thing to do according to one's knowledge at the time and focus on the expected impact of that action.	Documenting decision rationale under uncertain situations.

The different responsibilities elements are intertwined, where forward- and backward-looking as well as receptive and assertive aspects can co-exist. This can both be resulting in tension or synergies, but also trade-offs. The research of Sonck et al. concluded on three major dynamics between the responsibility elements, namely the accountability-responsiveness, care-responsiveness and liability-responsiveness dynamics. These three combinations were found iteratively in their empirical studies as most common, but this does not eliminate the possibility of other combinations to occur. The three most common ones will be discussed:

The **dynamic accountability-responsiveness** covers the balance between risk-taking and being precautious under uncertain conditions. The managing approach suggested describes that for the accountability part, uncertainties must be mitigated by knowing the impacts before decisions are made. For the responsiveness part, it is suggested to learn about and address impacts while doing. Seeing the different viewpoints in early stages helps provide a responsibility frame for the later-stage discussions. It helps to broaden the scope in early stages of anticipating future responsibilities (Sonck et al., 2019).

The **dynamic care-responsiveness** covers the balance between doing what is right, while not yet knowing what the impact of the innovation will be. It can be explained by the dynamic between two fundamental approaches in determining what a good impact is; the normative and procedural approach. The normative approach is applying agreed norms and principles, which is referred to as care. The procedural approach is continuously reassessing the right impacts of an innovation, which resonates with responsiveness. The managing approach suggests acting with care based on knowing what is right, and in a responsive way actively (re)asses what the right impact is. It helps to broaden the scope with regard to the impact the innovation makes (Sonck et al., 2019).

The **dynamic liability-responsiveness** covers the balance between acceleration of novel innovations while at the same time safeguarding the own area of operation. It describes the dynamic between power asymmetry that results in a competitive advantage, while at the same time aiming for transparency and openness that results in lack of control and sharing of information. Responsiveness here takes responsibility to reach certain common goals through interaction and sharing of information, while liability means taking responsibility with the purpose of protecting one's assets. It is about the balance between different objectives. The managing approach suggests that for liability oneself should be protected, and for responsiveness there should be openness and dialogues to achieve joint goals (Sonck et al., 2019).

The meta-responsibility framework therefore sheds light on three dynamics: balancing risk and precaution, exposing and addressing concerns about the goals and impact of innovation, and accelerating sectoral transition whilst securing one's own competitive advantage (Sonck et al., 2019). When adopting this framework in the early stages of the development of an innovation, it can help the trajectory by identifying systematically what the different responsibilities and how to balance between them.

In the context of high uncertainty as well as high levels of innovation, responsiveness is found as the most dominant responsibility. For responsiveness an open process is required and adaptive learning should be implemented. Rödl et al. argue that responsible innovation should be moved from responsible to responsive innovation. Responsible innovation currently lacks the historical viewpoint. The challenges that the innovation are sought to solve, are the effect of the unintended results of the 'responsibly' designed solutions in the past. It is future oriented and does not explicitly use specialized knowledge of past developments. As it is being dealt with high uncertainty of consequences in the future, we can retrospectively look at current consequence of past innovations, especially actively reflecting on actor motivations, sequences of events and emerging negative evaluations of consequences. Also, it focusses on a single technology instead of technological systems, where it looks at changes within the system and not of changes of the system (Rödl et al., 2021). Therefore, Rödl argues that instead of focussing on a responsible approach (normative and top-down), it should be analysed from a more responsive approach (systematic, dynamic and historically situated). The meta-responsibility

framework also sheds light on this viewpoint, as it structures and coordinates the existing responsibilities of actors in a systematic manner taking into account different dynamics. It still lacks the historical viewpoint.

A specific type of responsiveness is dialogical responsiveness, which recognizes the importance of keeping the dialogue with stakeholders and include actors to enhance corrigibility of decisions (Genus & Stirling, 2017). This responsibility type is important throughout the whole pattern of diffusion; from the development and innovation, to the market introduction and diffusion, even when the innovation has diffused on the market. It calls for responsiveness of the actors in changing situations; not only listening but responding to the dialogue. Also in the meta-responsibility framework, dialogical responsiveness enables mutual responsiveness among actors.

Responsibility in the pattern of diffusion

First off, it is important to point out that all four elements of responsibility are encountered during the pattern of diffusion. One element can be more relevant than the other at certain stages, but all elements are to be considered at each stage of the pattern.

The meta-responsibility framework is designed with the perspective of uncertainty in mind. It acts as a tool of how to manage responsibility in high uncertain situations. Early-phase R&I is characterized by high uncertainty. So, in the first stage of the pattern, during the development of the innovation, this framework is an useful tool to map out and inventories the responsibilities. Sonck et al. also point out that in the early phase of the development of an innovation, the occurrence of forward-looking practices is logical.

For example, during the innovation phase the forward-looking responsibility care is important. The development should be designed with care and there should be room to anticipate the risks. During this phase, frameworks like Responsible Research and Innovation (R&I) as well as Value Sensitive Design (VSD) are useful. Also in the first phases, accountability is important, which can be taken in the form of deliberation or inclusion of stakeholders (Besti et al., 2018).

More than ever in the market introduction phase, the responsibility of responsiveness is required, where the innovators and producers must respond to the market behaviour and initial feedback. During the market adaptation phase, the responsibility of accountability becomes more formal, as regulations, standards and best practices are formed. However, as the technology becomes less flexible, responsiveness is harder, while still important. In the last phase of market stabilization, liability and accountability are one of the responsibilities, with formal and institutionalized regulations. At this point, there is an aspect of care, specifically looking backwards, that touches the surface where it should be analysed whether the right responsible decisions were made prior in the process. Again, this comes back to the argument about the intentions of the development of an innovation that should be monitored throughout the innovation trajectory. The case specific responsibilities over time will be further elaborated on in Chapter 6.

Responsibly designing market entry and diffusion strategies

The aim of this research is to design a framework that can be used as a tool to responsibly design market entry and diffusion strategies. The two frameworks of importance have been explained conceptually in Chapter 2 and 3. There are some additional considerations that must

be addressed outside of the frameworks when designing a strategy that are described in this subsection.

What to take into account with the strategy design?

Intrinsically, innovations are considered to be morally good. Innovations can easily be justified by linking them to societal challenges in a direct or indirect way. Irrespective of the kind of innovation, or the alternatives that this innovation is thereby eliminating, innovations are usually considered positive by EU initiatives and policies. It is important to keep in mind when designing market-entry strategies, that the underlying aim of this innovation should iteratively be assessed to see if it still aligns with the goals and wishes of society (Genus & Stirling, 2017). The current TIS framework does not pose in-depth questions around the building blocks that form barriers. It is focussed on market-entry, not around processes or whether the process is done responsibly.

The challenge of determining who is responsible?

The paper on the meta-responsibility framework states that the question of who has to take responsibility is not taken into account. However, in light of designing a combined framework that aims to responsibility design market introduction and diffusion strategies, the question is of relevance. This specific type of responsibility is referred to as 'role responsibility'. Not all TIS actors that should be involved in the process, have role responsibilities.

The actors who have to take more responsibility also shifts during the pattern, from individual innovators and companies in the first three stages, to larger institutions, corporations and governments during market stabilization, as the level of involvement differ per actor across time. This also shifts from individual responsibility to shared responsibilities when more actors are involved. A responsibility evolves as an individual stakeholder's responsibility, where for example the researchers on this topic are first to be responsible for providing correct information. If later on an innovator starts developing this innovation further and bring it to market, the responsibility shifts to a shared responsibility if there are unintended or long-term negative consequences. If regulators have approved the innovation to be safe and have permitted it to be on the market, this also means there is another shared responsibility. This means that in the progression of time, the responsibility might shift towards more actors. The combined proposed framework aims to propose a structured manner of allocating responsibilities of an actor.

Conclusion – Need for framework for responsible strategy design

The TIS framework is designed with a company perspective in mind, providing a tool to design suited strategies that will result in sustainable market introduction of the innovation, with the aim of spreading the innovation and eventually resulting in large-scale market diffusion.

Here, sustainable market introduction is defined as economic sustainability. In principle, the only way for an innovation to survive on the market, is if it is economically sustainable. That means economically viable, or even profitable. It is to a lesser degree focussed on the social and environmental sustainability that are the two additional layers that are the foundation of sustainability. Also, in sustainability literature and bio-economy literature, the social dimensions of sustainability are least prominent (Janker and Mann, 2018)(Ferreira et al., 2022).

When considering sustainable innovation, sustainability is defined as 'meeting the needs of the present, without compromising the ability of future generations to meet their own' (Brundtland, 1987). It considers the social, environmental and economic impacts of actions and decisions taken today. Therefore, the TIS framework requires further development where the focus on

social and environmental sustainability is increased. Also, a more responsive viewpoint should be taken, instead of the responsible innovation only. In the context of high uncertainty that is present in innovation, the dominant responsibility is responsiveness and should be included in the design process of finding market introduction strategies more explicitly.

By combining both the strategies from the TIS framework with the insights from the meta-responsibility map, the strategies can be adapted towards a responsible niche introduction strategy that takes into account the different types of responsibilities.

Chapter 5: Development of responsible market introduction strategies

"How to integrate responsible innovation principles into strategies for overcoming market introduction or diffusion barriers?"
- MSc Life Science & Technology
- MSc Management of Technology

The Triple Bottom Line, or the 3P's, describes essential factors for organizations or businesses to achieve long-term and successful societal impact; People, Planet and Profit. Or in other words, social, environmental or economic sustainability. The TIS framework mainly focusses on economic sustainability. That is the factor that eventually does determine whether or not an innovation can be successful, with social and environmental sustainability but a lack of economic sustainability, the innovation cannot be long-term sustainable. Also to contribute to the challenges of climate change and health threats, the food system requires to re-orientate its focus to go beyond productivity and cost-effectiveness. It should go towards social justice, sustainability and resilience (Timotijevic et al., 2021). So, the TIS framework focusses on the economic sustainability, and therefore lacks social and environmental responsibility viewpoints. There the meta-responsibility framework can add value of including a broader viewpoint and longer-term mindset in the TIS framework.

As responsibility can entail a wide range of different applications in different contexts, Ceicyte et al., proposed a framework that divides responsibilities in three elements: legal, contractual and moral responsibilities. The legal responsibilities are based on laws and jurisprudences, whereas contractual elements are based on obligations that are set in agreements between stakeholders and moral elements are based on norms in value systems and cultural context (Ceictye et al., 2021). They argue that within RRI the focus is mainly on moral responsibility elements, but also legal and contractual elements should be included when responsible innovation is desired.

Both the TIS framework that has a focus on the economic sustainability and the RRI framework that focussed mostly on the moral responsibilities show the lack of an inclusive, all-round framework that focusses on the different types of sustainability following the 3P's, but also the different types of responsibility.

Challenges of allocation of responsibilities

Assigning responsibility can be difficult, especially in multi-actor, complex situations where different actors are collectively working towards a common goal. Even though responsibilities seem of individual character, they are of networked character (Timmermans, 2017). The problem of many hands describes the issues that arise with allocating or assigning responsibility, when actions are intertwined and individual contributions may not solely be responsible for the outcome. This problem of many is hands is specifically focussed on moral responsibility (Van de Poel et al., 2015). Especially when there are lengthy and (geographically) fragmented networks that involve multiple actors, there is little joint areas of interaction and thus little joint commitment. The result of this phenomenon is that for unintended impacts, there is not a clear responsible actor (Sonck, 2023). Especially the food system is governed via international and national agreements, regulations and approaches, going beyond the Netherlands as a country with its own regulations. This increases segmentation and fragmentation even more (Timotijevic et al., 2021).

Governance implies allocation of responsibilities. In the food system, networks need clarity about how responsibility is conceptualised and enacted (Timotijevic et al., 2021). There are four

reasons why the allocation of responsibilities is difficult in multi-actor situations. The first two are related to actors being unclearly defined that takes responsibility of an object. This can either be because of the overlap of responsibilities when processes intertwine, or because there is a lack of authority that demand accountability when the impact is either indirect, in a later stage or wider. The third reason is when normative goals are prioritized and understood differently between the actors in the value chain due to shortcomings in interaction. So, this means there is normative uncertainty. And lastly, as the norms and regulations are institutionalized based on the existing value chain, it can be inconsistent with new opportunities as that brings new risks and ways of working with it. This uncertainty in regulations can therefore result in unclear norms and responsibilities for the new innovation (Sonck, 2023).

Additionally, allocating accountability is generally perceived as easier when actors are closer to each other in the value chain. Further up or downstream the value chain, or when there are broader impacts, the roles are more difficult to be distinguished and the responsibilities also become less obvious, as more actors are involved and the interaction between the actors is less frequent or even present at all (Sonck, 2023).

Effects of responsibility in innovation process

Similarly to regulations that can form a barrier for the innovation process (Reinhardt & Monaco, 2025), responsibilities can also result in friction in the process. Primarily this is related to the short-term speed limitations and transaction costs, as more research, stakeholders input, governance, and considerations are required to be made. Having to identify, analyse and manage the different responsibilities can slow down the process as well as the decision-making that is more complex in this situation, especially in the beginning. Also, broader considerations can be a constraint to certain ideas, where originally problems were not identified that are now becoming visible. Therefore, it can be argued that it might limit the options during the design process.

Proper regulations analysis does however result in the reduction of risks, as more complete considerations and decisions are made. This can be compared to the speed limitations that safety and impact analysis have. For example, EFSA and the European Parliament form a limiting factor that effects the speed to market, as their assessment take time and possibly shed light on new risks. They might form a barrier in the speed of the innovation process, however their purpose to ensure safety weighs heavier. Once this assessment is done, the innovation can more safely be presented on the market, resulting in risk reduction longer-term. Also, the decision-making might be hampered in the beginning stages by the regulatory environment, it does however prevent problems later on in the process if risk assessment and safety insurance is not done correctly. Therefore, there is certain balance and decisions that can be made what is more important in an innovation process, is it speed, or certainty of safety.

The absence of clear responsibility aspect in the TIS framework can result in unforeseen consequences when implementing the resulting strategies from the framework. It also does not include substantial considerations of future impact of the strategies and the consideration of what responsibilities each of the stakeholders hold. There can be unintended consequences, despite the intentions; however, there is always someone responsible for the consequences, despite good intentions. Adding responsibility into the innovation process leads to stakeholder engagement, making it an interactive process where involved actors and the innovator respond to each other about different concerns like sustainability, social desirability and acceptability. The aim of this is to make sure the successful acceptance and adoption of the innovation by

society (Von Schomberg, 2013). Also, adding a responsible viewpoint to the innovation process does in fact not slow the process down, it helps design the innovation in a future-proof approach, where risk anticipation is done more thoroughly and stakeholders are involved in the process and taking into consideration effecting in less problematic situations along the way. This longer-term risk reduction results in better legitimacy, fewer downstream delays, and fewer crises. It is argued here that the safety and proper regulations is more important than speed in this process and the safety assessment and regulations can even provide more certainty for longer-term sustainability and success.

Including responsibility in framework

Both the TIS framework and the meta-responsibility framework portrait elements that are crucial for the development and design of cultivated protein products. The TIS framework aims to (1) identify barriers to large-scale market diffusion and (2) provides strategies to overcome these barriers and achieve market introduction leading to large-scale diffusion. The meta-responsibility framework helps to manage and allocate the different responsibilities that R&I units have in both the company and further in society. What both frameworks have in common is their focus, which is R&I. They are both focussed on improving the introduction of innovations, but the TIS framework lacks a viewpoint of responsibility that the meta-responsibility framework clearly offers. The meta-responsibility framework distinguishes four elements of responsibility, both with an imputation and justification outlook. Making a distinction in these four types of responsibilities helps with tackling the problem of many hands. The receptive and assertive distinction of justification concedes that innovation is inherently uncertain and the impact cannot be anticipated fully beforehand. It explains that uncertainties cannot be completely eliminated before an innovation is introduced to market. This also explains that from an imputation viewpoint, it is difficult to pinpoint back the responsibilities of indirect social impacts.

Both the TIS framework and the meta-responsibility framework provide relevant input for responsible market introduction strategies for innovations. The TIS framework provides a basis for the strategies to be utilized, the meta-responsibility framework provides insights in what conflicts there are between responsibilities and thereby provide starting points of thought about the current strategies. These insights help the user adapt the strategies or add on to the strategies to make them comply more to the responsibilities. So, by combining the two framework the responsibility in the design increases. The proposed new framework is named the Responsible Market Development (RMD) framework.

Figure 11 gives a visual representation of the combination of the two frameworks over the axis of the pattern of diffusion.

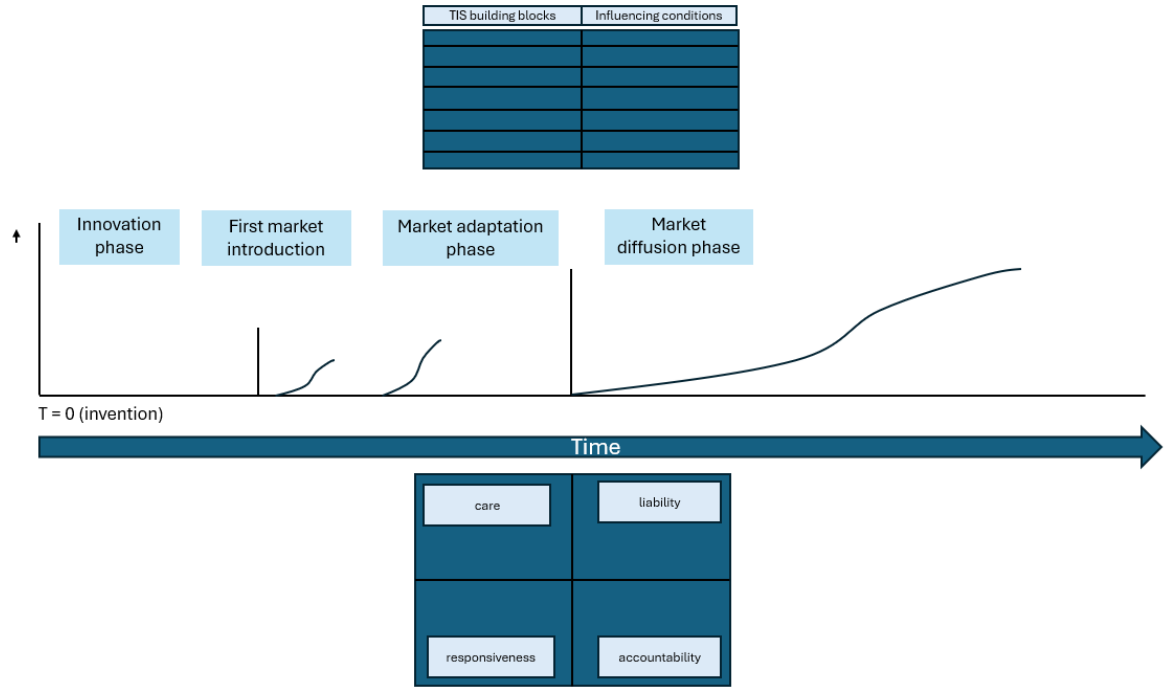

Figure 11: The Responsible Market Development (RMD) framework, combining the TIS framework and the meta-responsibility framework on the pattern of diffusion.

The Responsible Market Development (RMD) framework

The RMD framework is designed in two stages, the TIS framework application in stage 1 called the 'Strategy identification' (steps 1-4) and the meta-responsibility framework application in stage 2, called 'Responsibility creation' (steps 5-8). Step 9 is the combination of the outputs of the two frameworks. Before these stages can be entered to apply the frameworks, a prior step should be taken.

Process flow of RMD framework

First, the identification of the point in time should be done. Only if the innovation is at the stage before market introduction and large-scale diffusion, the TIS framework is relevant, and thus that is the constraint check that has to be done. If an innovation is too early in the process and not ready for market introduction, too many building blocks are missing. The building blocks are not independent variables, and it occurs that solving one building block results in the presence of the other building blocks. Using the TIS framework too early in the process might result in a large number of missing building blocks and influencing conditions causing that, that makes designing an useful strategy difficult. The steps in the workflow of the RMD framework are described below. The steps of stage 1 are described in Figure 12.

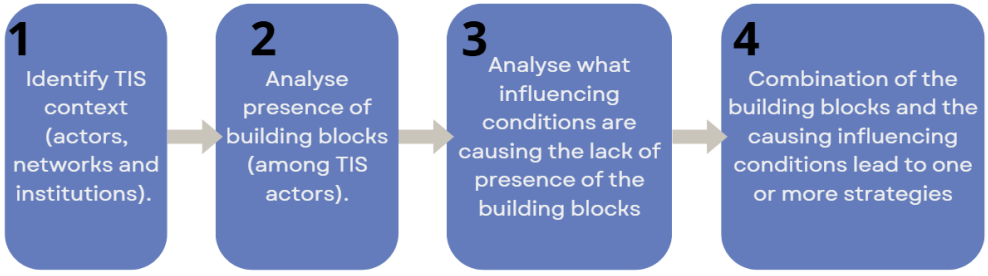

Figure 12: Workflow of stage 1 'Strategy identification' by applying the TIS framework.

Step 1: In the first step, the general TIS context is analysed to get a clear picture of the actors, networks and institutions involved. Here a complete list of types of stakeholders with the relevant actor is in the case should be set up, evaluating their values and in what type of relation they act related to the other actors. Once this context identification is done, the two frameworks can be applied.

Step 2 & 3: The second and third step is to apply the TIS framework. The TIS building blocks and influencing conditions are analysed among the TIS actors. Identify which building blocks are currently lacking in the TIS context, and identify what influencing conditions are the cause of this missing building block.

Figure 13 provides an overview of the TIS framework by Ortt and Kamp. This describes the influencing conditions on the left column, followed by the TIS building blocks in the second column and based on the combination of lacking building blocks and the influencing condition, a proposed niche strategy is provided.

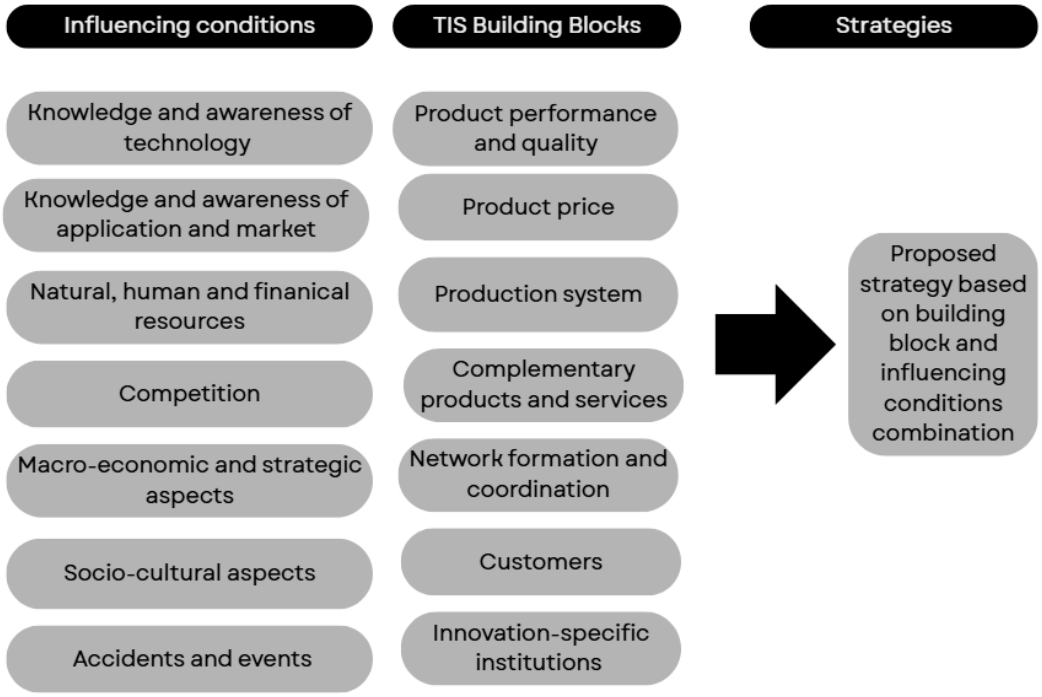

Figure 13: Basis of the TIS framework by Ortt and Kamp.

One by one, the building blocks are evaluated, is this factor blocking the innovation from market introduction? If the answer is yes, this building block is a barrier. The same applies to the influencing conditions, is any of the influencing conditions a cause of the lack of a building block, than this should be noted as a blocking influencing condition.

Step 4: The specific combination of the lacking building blocks and the causing influencing conditions results in a proposed niche introduction strategy. This list of combinations is provided in Chapter 3, Table 11. Identify what strategies fit the combination of building blocks and influencing condition and decide whether this is a fitting strategy for the specific case.

This marks the end of stage 1 'Strategy identification'. After the TIS framework is applied, and a proposed niche introduction strategy is the output, the meta-responsibility framework will be

applied and will mark the start of stage 2 'Responsibility creation'. The steps of the workflow of stage 2 are described in Figure 14.

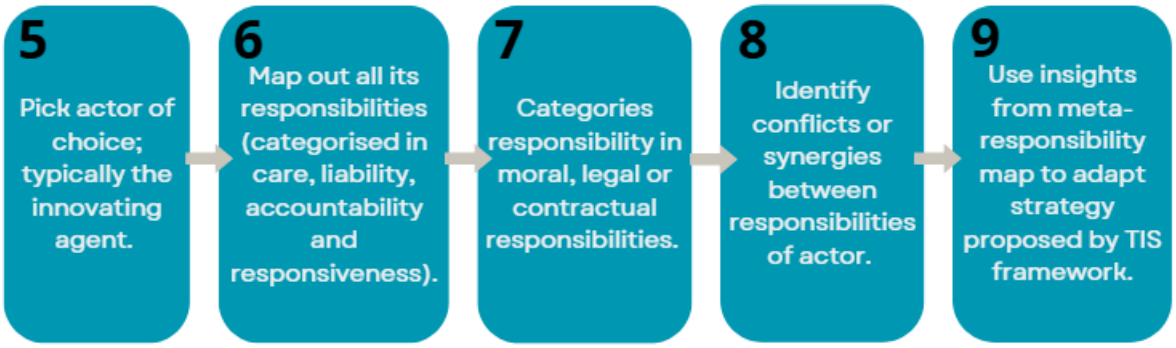

Figure 14: Workflow of stage 2 'Responsibility creation' by applying the meta-responsibility framework.

Step 5: First, an actor of choice is picked from the TIS context. This is typically the innovating agent, as this actor will be the one introducing the innovation to the market with the final proposed strategy. This actor will be the centre point of the meta-responsibility framework.

In this step, it is advised to remind the user of the fact that the strategies are aimed at the market-introduction. This therefore influences the scope of the responsibilities, as responsibilities can range from the origin all the way to long-term effects.

Step 6: The responsibilities of the actor are mapped out on the meta-responsibility map based on the backward or forward-looking imputation and the assertive or receptive justification. They are categorized accordingly in the quadrant of care, liability, accountability or responsiveness. Figure 15 gives an overview of the meta-responsibility framework by Sonck et al. Per category, a brainstorm can be done to collect the responsibilities, as well as interviews with experts that can complete this list.

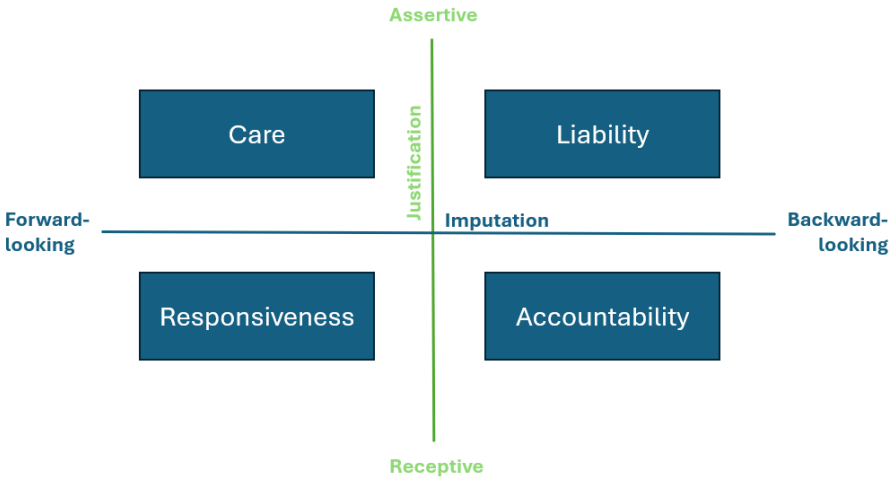

Figure 15: Meta-responsibility framework map by Sonck et al. 2019.

A methodology to categorise and allocate responsibilities in the meta-responsibility framework is used following the framework of Timotijevic (Timotijevic et al., 2021). The guiding questions to allocate the responsibility in the corresponding quadrant are as follows:

- Does the responsibility look at future-oriented of past-oriented decisions?

- Is the responsibility based on high uncertainty or low uncertainty context?

Figure 16 gives the decision tree following the principles of Timotijevic.

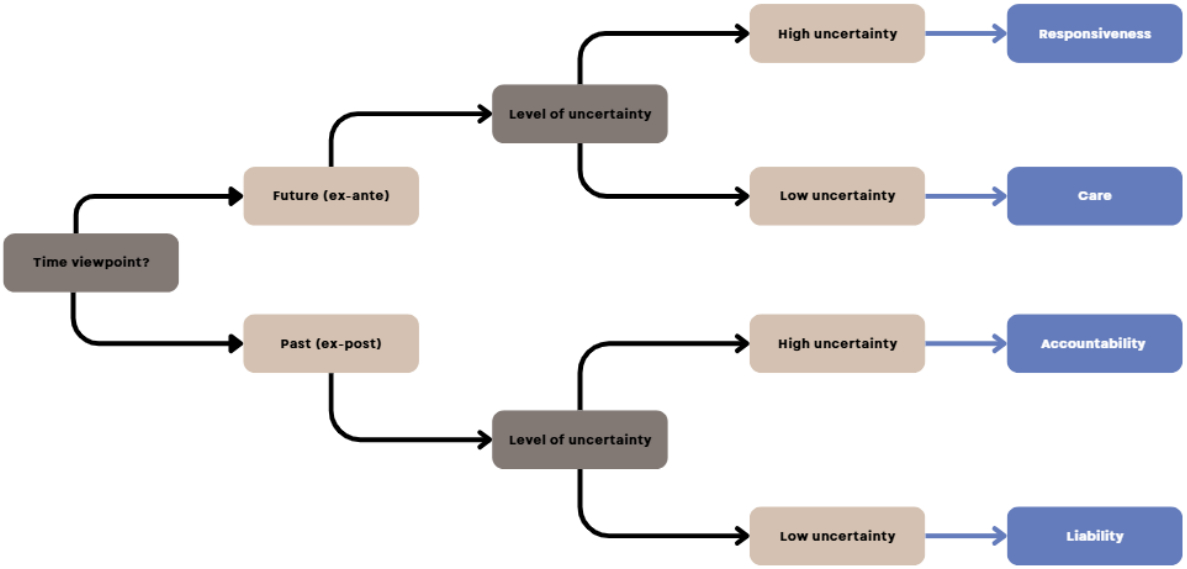

Figure 16: Decision tree to categorise responsibilities in the corresponding quadrant of the meta-responsibility framework following the framework of Timotijevic et al., 2021.

Step 7: Besides the categories provided by the meta-responsibility framework, the responsibilities are subsequently categorized as moral, legal or contractual responsibilities. This gives a feeling of what types of responsibilities the case is dealing with and can be acted upon accordingly. As legal responsibilities usually face clearer consequences if not acted upon than moral responsibilities, it is useful to have an overview of the moral and legal responsibilities to see if there might be responsibilities that are less likely to be considered for inherently.

Step 8: Once the responsibilities are identified, the relationship between these responsibilities can be identified, looking for conflicts and synergies between responsibilities of an actor. Between the responsibilities in the meta-responsibility map, arrows can be drawn to represent these conflicts or synergies. This map is the output of the meta-responsibility framework. A systematic approach is described in Chapter 6.

Step 9: Using the meta-responsibility map, the proposed strategies by the TIS framework can be adapted to make them (more) responsible. The different responsibilities and conflicts between the responsibilities or actors can be used to make the strategies more responsible.

To make this framework applicable for any innovation, the way the conflicts are derived should also be systematically determined. Once the different responsibilities are identified, mapped out in the appropriate quadrant on the meta-responsibility map and categorised in moral, legal and contractual responsibilities, one by one, the responsibilities are analysed in comparison to another responsibility. This analysis requires intra- and inter-type comparison as well as within-quadrant and cross-quadrant comparison. If the co-existence of the responsibilities does or does not align, this is noted as subsequently a synergy or conflict. It is also possible there is no direct link between the responsibilities. The aim of this identification of conflicts or synergies is finding potential point of different interests or choices that need to be made. These choices are in the benefit of the one choosing, but not always in the benefit of the other actors and therefore

provide an interesting starting point to include measures or controls to prevent that from happening and making the strategy more responsible or inclusive.

Conclusion

The proposed combined framework called the Responsible Market Development (RMD) framework aims to aid an innovator to identify what strategies are effective to be used for an innovation at sake to bring it to the market. Both for market-introduction and large-scale diffusion, strategies are proposed based on a certain set of barriers that are blocking this innovation to enter the market or diffuse on the market. These barriers are identified as missing building blocks within the first stage of the framework 'Strategy Identification', by applying the TIS framework. Also causing influencing conditions are identified and the two results in a proposed strategy to apply for market-introduction. This is usually a niche strategy. In the second stage of the combined framework 'Responsibility Creation', the meta-responsibility framework is applied. Here the responsibilities that have been identified can be categorised in the different quadrants of the meta-responsibility framework and into different types of responsibilities. The meta-responsibility framework categorises the responsibilities into 'care', 'liability', 'responsiveness' or 'accountability', which explain whether the responsibility is forward- or backward-looking oriented and the degree of uncertainty. Conflict between the responsibilities can then be identified, which gives the opportunity to re-think the strategies proposed in stage 1. By seeing what conflicts can arise between the responsibilities of one specific actor, or between different actors, these pain points can be tackled partly in the strategies by including solutions so that conflict does not arise or is tackled. This RMD framework therefore results a more responsibly oriented framework.

Chapter 6 dives into the application of the RMD framework to the hybrid protein case, aiming to find market-introduction strategies. By focussing more on the societal viewpoint instead of what is commonly the case, profit driven viewpoint, the end result might become more long-term sustainable. The product will be introduced in the market in a more responsible manner, that considers more social values and perspectives, providing a more rigorous product that can survive in the market that is driven by the consumers.

Chapter 6: Responsible Market Development (RMD) framework applied to hybrid protein case

"What responsible strategies to apply to hybrid protein case?"
- MSc Life Science & Technology
- MSc Management of Technology

The RMD framework will be applied to the case of hybrid protein. The process steps in the workflow described in Chapter 5 will be followed. According to the findings from the case application, possible adaptions can be made in the workflow.

Before following the workflow, the moment in time where the innovation is currently at should be identified to check whether it is before market introduction. As mentioned before, the hybrid protein products are currently right before market introduction and thus comply with the criteria of using the RMD framework.

Stage 1 'Strategy Identification': steps 1 – 4

Step 1: TIS context, case specific actors

The first step is to analyse the TIS context and set up an overview of the different TIS actors and their values or goals. The scope of this case is in the Netherlands at the current timeframe. Table 13 provides the overview of this TIS context.

Table 13: TIS context, describing the TIS actor types, the specific actors in this case and their values or goals based on the geographic location of the Netherlands.

TIS actor types	TIS actors in categories within the types	Values or goals of TIS actor categories
Knowledge creators	Universities (e.g. TU Delft, Wageningen UR) Research Institutes (e.g. NIZO food Institute or TNO) Colleges (e.g. HAS Green Academy) Consortia (e.g. Cellular Agriculture Netherlands)	Using research to tackle sustainability challenges.
Start-ups and innovators	Plant-based (e.g. De Vegetarische Slager, Vivera) Cultivated (e.g. Mosa Meat)	Using innovation to tackle sustainability challenges. Be economically profitable. (De Vegetarische Slager, 2025).
Established market players	Primary production (e.g. FrieslandCampina and farmers) Processing (e.g. Vion Food Company, Zwanenberg Food Group, Aviko) Ingredients (e.g. DSM)	Work together with start-ups to comply with the customers' demands of sustainable products. They use their reach to attract start-ups to work with them. Connecting role in food supply chain (Aviko Food Service, n.d.)
Governmental bodies	Ministerie van Landbouw, Natuur en Voedselkwaliteit (LNV) Minisiterie van Volksgezondheid, Welzijn en Sport (VWS) Nederlandse Voedsel- en Warenautoriteit (NVWA) Nederlandse Organisatie voor Weterschappelijk Onderzoek European Food Safety Authorisation (EFSA)	Push sustainability development and research, while at the same time make sure the innovation comply with (safety) regulations (NVWA, 2023).
Customers	Ethical Alternative Seekers Health-Conscious Compromisers Nutrition-Focused Integrators Protein Maximizers Carefree Considerers	Care for sustainability and animal welfare and are thoughtful about what they eat. Wanting to make better health choices. Care for nutritional value of their food and for health and sustainability issues open to incorporate plant-based more.

	Value-Driven Skeptics (Good Food Institute, 2024)	Value protein content of food, also if that would be in plant-based products. Open-minded, but low familiarity Are not convinced it is a good choice, also with the price and taste in mind. (Good Food Institute, 2024)
Retail companies	Supermarkets (AH, Jumbo) Supermarkets (Lidl, Plus or Aldi)	Promoting alternative protein and expanding in protein-rich products. Making alternative protein accessible.
Media	Television (e.g. NOS, RTL) Newspapers (e.g. Volkskrant) Websites/social media (e.g. Foodlog, X, Instagram)	Informative on the protein transition. Discussions on the debate.
Society representatives or NGO's	Animal Rights (e.g. Stichting Dier&Recht) Food Systems and sustainability (e.g. ProVeg Nederland or Good Food Institute Europe)	Advocate to choose for plant-based instead of animal products to contribute to animal welfare (Dier&Recht, 2025). Researching stakeholder that tries to influence policy, share knowledge and steer the developments in desired direction. Accelerate alternative protein innovation to build a more sustainable, secure, and just food system (GFI, 2025)
Investors and financial institutions	Banks (e.g. Rabobank) Foundations (e.g. DOEN foundation) Investing companies (e.g. InvestNL, InnovationQuarter, SHIFT invest)	Make investments to help accelerate the alternative protein transition with financial resources as well as providing connection in the field.

Insights from expert interviews: Goals of innovator

The goals of the innovator are mentioned as broad. When categorising them, it can either be idealistic or corporate goals. On the one hand innovators have sustainability goals, wanting to improve the food system, solve problems surrounding nature, climate or animal welfare, these are the idealistic goals that innovators have where they hope to find solutions for global problems. On the other hand, there is the corporate goals that have a more commercial interest and are driven by economic aspects. The following quotes from the expert interviews confirm these statements.

"There is the more idealistic start-ups, that see a problem in the world, for example climate change, and want to find a solution and bring that to the market, in a way to positively influence global problems. Then there is corporates that have a commercial interest from the start. They have relevant IP that they might be able to sell. They see a chance and act based on that." – I1

"I think that the goals are different for different stakeholders. And you would hope that they all have climate goals or goals for animals. Most of them have, especially in the beginning, but at a certain time when it becomes a market chance, it leads to mixed motives." – I3

"You do not have the responsibility to earn money, but you do have the responsibility to do something good in the world. But motives are different in practice, very often actually" – I3

Also is mentioned that innovators want to prove regime players wrong when is said that it is not possible what they are desiring.

"So, in a broader transition perspective, the value of startup startups and true innovators is to basically prove the regime players wrong. In innovations, when new, there are numerous questions to be asked about, does it really fulfil a demand on the consumer side? Can you really earn money? Is there a demand anyway? And for larger companies these are all valid questions and often also reasons why not to invest in innovations, because the business proposition doesn't add up, and that's of course where innovators and young companies step in. They have

other risk profiles. They are very dedicated to and they believe in their proposition.
So they have different reasons to do what they do and to invest their time. And a successful startup is really also proving them wrong and them being the regime player." – I2

Step 2 & 3: TIS framework

The TIS framework has already been applied on the case in Chapter 2. Concluding from this analysis, the missing building blocks and influencing conditions causing this are summarised in Table 14.

Insights from interview: Barriers and influencing conditions

Collectively, the interviewees mentioned the same or similar barriers as were found in the TIS framework. Only additional influencing conditions have been mentioned as described in Table 14. Perception and overpromising were mentioned as causes of why the barrier of customers is present.

Perception was said to be a driver of consumer behaviour change. Specifically, it was mentioned that there is a cultural perception in society where we are currently in an 'individualistic culture' instead of in a 'collectivist culture'. This individualistic culture is mostly seen in Western countries, and the last decades this is showing more and more clear that society prioritizes the individuality. Consumers hop on trends that show quick wins or gains for them, for example the protein-rich products, that are promoted to be healthy and beneficial for your health.

".. perception proves to be more of a driver, it can be positive, it can be negative. .. there are some examples also in the recent years that show that perception can indeed change people's food purchase and consumption behaviour. .. if you look at everything that's happening around protein rich products. Why did millions of people now change their food habits and are willing and able to spend a lot of money on protein rich products and that is because they have the feeling, the perception that eating a lot of proteins almost instantly brings you a benefit." – I2

If that is the case for hybrid products as well, if we promote the product in such a way that is becomes clear 'what is in it for me' or how would the consumer benefit from this product, it could be beneficial for the acceptance. This could be a topic of further research.

Also, overpromising is a common theme. Promises are made which cannot be realised, partly because reality is moving faster than hoped, but also because of overestimation of possibilities. For example, creating a completely identical steak, with the whole complexity in texture and structures in the product, was something that later was identified to be too complex for this moment in time. Later the focus has been shifted towards more unstructured or processed forms of 'meat' products. But this results in a decrease in trust from consumers in innovators. The opposite is what is required, innovators need to create trust and support from stakeholders.

"So, you might also say that that could be seen as a barrier as well to over-promise and under-deliver while reality is progressing." – I2

Overpromising is related to creating a hype, this is when expectations exceed reality (Heupel et al., 2024). This happens when a simple innovation-diffusion paradigm is predicted, but instead the innovation follows a more realistic evolutionary pattern. If it is assumed that directly after the first market-introduction the innovation diffuses on large-scale, overpromises are made and the promises are likely to not be met. This results in a lack of trust. Figure 20 later in this Chapter also shows the relation between the pattern of diffusion and the hype cycle, related to investments.

The two mentioned causing influencing conditions during the expert interviews are depicted in grey in Table 14. These 'influencing conditions' are not included in the original framework, but adding additional case specific influencing conditions in the stage of applying the framework can be useful to create more awareness for in the further analysis of the causes of the barriers. Perception is already covered in the causing influencing condition of socio-cultural aspects. The TIS framework alone is not normative, that is where the meta-responsibility can make the framework more normative.

Table 14: Summary of output from TIS framework applied on hybrid protein case, with in grey additional interview insights.

Missing building blocks	**Causing influencing conditions**
Production system	Knowledge and awareness of technology
Network formation and coordination	Knowledge and awareness of application
Product price	Macro-economic and strategic aspects
Customers	Accidents and events
Innovation-specific institutions	Socio-cultural aspects
	Perception
	Overpromising

Step 4: TIS-derived strategy

From the missing building blocks and causing influencing conditions, the following strategies are proposed by the TIS framework: "top niche strategy", "subsidized niche strategy", "redesign niche strategy" and "geographical niche strategy".

The first proposed strategy, "top niche strategy", proposes to produce products for a specific 'top-end' market first in smaller number. This top-end market would be consumer that are described as early adopters, that are interested in sustainable products, but also want to contribute to the development of a new innovative product. The strategy aims to overcome the barriers 'price' and 'quality' and influencing conditions 'knowledge of technology' and 'resources'. Following Table 8 (Chapter 2), the top segment of customers are most likely to be the protein maximizers, the ethical alternative seekers and the health-conscious compromisers as they either care for sustainability, or are conscious about their protein intake. For this strategy, a skimming pricing strategy can be applied, where for the top-end market, the price is higher to maximise the revenue and slowly bring down the price once the demand increases. This strategy aims to start a consumer base, from where the demand can slowly increase. This group of early adopters act as promotors and opinion leaders that can prove that the product is to be trusted and their experience can influence other potential interested consumers.

The second proposed strategy, "subsidized niche strategy", proposes to focus on the social relevance of the product, where subsidies are granted when the product is considered socially relevant. The strategy aims to overcome the barrier 'price' and influencing conditions 'knowledge of technology and resources'. The government is providing financial resources to help the product be integrated in the market. This helps to lower the product price and thus eliminate one of the barriers. Currently, subsidies are already in place for research and development, as well as for major players like Mosa Meat to lower their costs (Nationaal Groeifonds, 2025).

The third proposed strategy, "redesign strategy", aims to overcome the barriers 'price' and customer', and the influencing conditions 'knowledge of technology', 'knowledge of application', 'resources', 'institutional aspects' and 'socio-cultural aspects'. The strategy proposes to develop a simpler version of the product, that lowers the amount of knowledge and resources required

and thus makes it possible to produce the produce for a lower price. Also, different applications can be explored where regulations are more favourable or what has a higher customer demand. Moving from pure plant-based product, or cultivated products, the hybrid form already applied this strategy before. It was originally designed due to techno-economic limitations to make whole cultivated protein products. This redesign also complies to the customer preferences regarding taste, and it also acts as a tool to get consumers used to the product (specifically the idea) and grow acceptance. This is different from the hybridization strategy in two ways; first, it focusses on overcoming different barriers, where the hybridization is aiming to integrate the innovation in a system where there is a lack of complementary product, what in this case study is not relevant. The hybridization strategy tries to integrate the new innovation within an existing product, but this more focussed on an external complementary product that is needed for to use the product, for example in computer system you need a PlayStation to play the games.

The fourth "geographical niche strategy" aims to overcome the barriers institutional aspects, complementary products and services, and customers, and the influencing conditions 'knowledge of technology', 'resources', 'socio-cultural aspects', 'institutional aspects' and 'accidents'. The strategy proposes to relocate to different area where the institution, resources, supplier or customers are present or in favour. As the scope of this research is on what strategies to apply to the geographic location of The Netherlands, this strategy is not relevant. This strategy has been adopted by innovators that have started selling their products in the United States or Singapore, as the regulations are allowing the selling of cultivated protein there. It can also be helpful as it can prove that the product is safe, there is demand and with that speed up the process in the intended location.

Also, the "demo strategy" has been applied to cultivated and plant-based protein before, where tastings have been done to introduce the product on a small-scale and without a final marketable product to a restricted group of interested people. This not only gives the possibility for early-on consumer feedback and development of the lacking building block quality, but it also aids for educational purposes and building consumer confidence.

As was discussed, the barriers stopping the innovation from entering the market, are related to each other in a sequential manner. First off, it is important that the regulatory system is allowing the product to enter the market, so the barrier of 'Innovation-specific institutions' has to be overcome first. After that, the strategies "top niche strategy", "subsidized niche strategy" and "redesign niche strategy" can be applied (Table 15)

Table 15: Strategies that can be applied to the case of hybrid protein.

Strategy	**Barriers**	**Influencing conditions**
Redesign niche strategy	Price Customer	Knowledge of technology Knowledge of application Resources Institutional aspects Socio-cultural aspects
Top niche strategy	Price Quality	Knowledge of technology Resources
Subsidized niche strategy	Price	Knowledge of technology Resources

The subsidized niche strategy is not advised to be used in the first stage, as this has shown to have adverse effects on the perception of the innovation. If the product is first subsidized, and becomes available for a broad group in society, it will be more difficult to come to a perception of this product to be for a certain class of society. For example, when assistive technologies are subsidized and used by people with disabilities, the product creates a stigma that is not easily overcome when the product later becomes available for the mass market (Parette & Scherer, 2004). However, is that even what is desired if it is looked at from a responsible perspective. Also, looking at the barriers that the strategies are aiming to overcome, it makes more sense to apply a strategy that tackles more barriers first. If the subsidized strategy is used first to tackle the barrier of price, that would mean still the barriers of 'customers' and 'quality' are present, while if the "top niche strategy" or "redesign niche strategy" is applied, it tackles the barrier of 'price' as well as either 'quality' or 'customers' respectively. Between the last two strategies, it makes in this case most sense to start with the "redesign niche strategy", as this tackles more barriers and influencing conditions. However theoretically, both could be started with.

These strategies from step 4 conclude the first stage 'Strategy Idenfitication' of the proposed RMD framework.

Stage 2 'Responsibility Creation': steps 5 – 9

Step 5: Actor for meta-responsibility framework

Firstly, the actor of interest is the innovator. That is the actor that is eventually bringing the product to the market, making the strategy most relevant for this actor. In this case, the innovator is a start-up.

Step 6: Map out responsibilities in meta-responsibility map

Figure 17 gives an overview of the meta-responsibility map for the innovator.

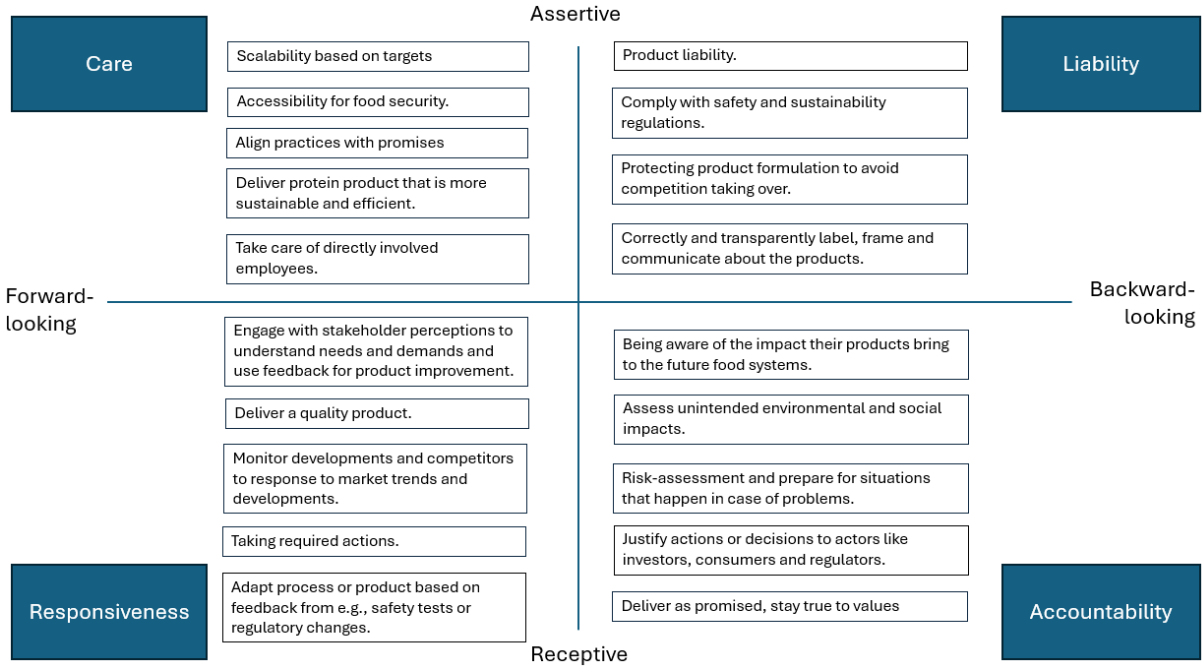

Figure 17: Meta-responsibility map of the innovator mapping the responsibilities in the four different quadrants.

In the quadrant of care (forward-looking and assertive responsibilities) the innovator has the responsibility to scale their product based on their targets. They want to scale their product to

make it available, so that sustainable alternatives of animal protein are more broadly available for the greater good and for food security. Additionally, they are responsible to deliver alternative protein products as they care for sustainability and efficiency in the industry. They have the responsibility to align their practices with their promises as well as taking care of their employees.

In the quadrant of liability (backward-looking and assertive responsibilities) the innovator has the values of complying with safety regulations, to make sure the product is safe for its consumers. They want to keep their product formulations protected, to avoid competition from replicating the product and take over (parts of) the market shares. At the same time, they value being transparent and honest about the labelling of the products to avoid miscommunication as well as to build trust. The innovator also has product liability, meaning when the product has any malfunctions, the innovator can be held responsible for this. In the EU, the European Commission is in charge of approving Novel Foods after the scientific assessment of EFSA. The EU 27 ultimately decides, based on the advice of EFSA and regulation plan of the EC, when the product is safe for market introduction (Eskola, 2025), also meaning that when there are any safety issues or claims from the product, the European authorities are responsible for safety of food. Only when it is because the product itself has a malfunction or something in the production process has not followed procedures (for example in case of contamination that results in an unsafe product) the innovator is responsible. The reason that some of the innovators start selling in the US first while in the EU it is not allowed yet, is because there is limited safety assessment requirement from authorities. Innovators can self-affirm their product is safe, by applying a pre-market consultation with the Food and Drug Administration (FDA) providing data why the product is safe for human consumption (Good Food Institute, 2022). This does result in the full responsibility and liability when any claims about malfunctions or unintended side-effects occur. This again shows the difference between speed of introducing the innovation to the market and thorough assessment of safety and regulations.

In the quadrant of responsiveness (forward-looking and receptive responsibilities) the innovator values engaging with its stakeholders to understand their needs, demands and perspectives. This feedback can be used for product improvement and is a tool for them to deliver a quality product. By monitoring the developments and competitors, the innovator is able to respond to market trends and developments. They also are responsible to adapt the product based on the consumer feedback as well as regulations, and should be taking required actions to make the innovation work.

In the quadrant of accountability (backward-looking and receptive responsibility) the innovator is responsible to monitor the impact the product is making, in terms of social, environmental impact, but also assess the impact of the product on the long-term or future food system. The innovator is responsible to do risk assessments of the impact of the product and how plans of what happens when the worst-case scenario might appear. They are also accountable to justify actions and decisions to their stakeholders like investor, and most importantly they are accountable to deliver what they have promised. It is seen as a factor that leads to a lack of trust if innovators do not do what they promise.

Step 7: Categories responsibilities – legal, contractual and moral

Table 16 categorizes the responsibilities into either moral, legal or contractual responsibilities.

Table 16: Categorised responsibilities among moral, legal and contractual responsibilities.

Responsibility	**Quadrant framework**	**Type of responsibility**
Scalability	Care	Moral
Delivering sustainable product	Care	Moral/contractual
Accessibility	Care	Moral
Aligning practices with promises	Care	Moral
Taking care of employees	Care	Moral/contractual
Engagement with stakeholders	Responsiveness	Moral
Develop quality product	Responsiveness	Moral
Monitoring developments and competitors	Responsiveness	Moral
Taking required action	Responsiveness	Moral
Adapt process/product based on feedback	Responsiveness	Legal
Comply with regulations	Liability	Legal
Product liability	Liability	Legal
Protection company knowledge/assets	Liability	Legal/moral
Transparency	Liability	Legal/moral
Awareness of impact	Accountability	Moral
Assessing unintended impacts	Accountability	Moral
Prepare for worst case scenario outcomes.	Accountability	Moral
Deliver what you promise, stay true to values.	Accountability	Moral/contractual
Justify actions to stakeholders	Accountability	Legal/contractual

The moral responsibilities are the most identified responsibilities for this specific case. In general, in RRI the most focus is put on moral responsibilities. Each quadrant in the framework is differently important for different actors. For example, for the government, the legal responsibilities are more important, while for an innovator, also the moral responsibilities are important. All actors in a system together cover all the types of responsibilities.

The legal responsibilities are specifically linked to regulatory frameworks like the General Food Law Regulation (EC) No 178/2002, Food Information to Consumers Regulation (EU) No 1169/2011, Additives, Enzymes and Flavourings Regulations (EC) No 1333/2008, 1332/2008, 1334/2008, Health and Nutrition Claims Regulation (EC) No 1924/2006, and the Novel Food Regulations 2015/2283, that have set certain rules on what a company is responsible for when introducing a product to the market. Europe has a legislative approach that reflects precaution, as innovative foods as meant for human consumption and thus require careful risk assessment (Lanzoni et al., 2024). When specifically looking at novel foods, the Novel Foods Regulation assesses safety through scientific risk evaluation by EFSA. It considers the composition, production process, nutritional impact and toxicity. If the novel food aims to replace an existing food, comparable nutritional values should be provided to make sure there is no nutritional disadvantage to consumers. So this regulation determines what the rules are regarding safety and regulation. Within these regulations, responsibilities are also clearly defined and there is a determined legal consequence if not complied to the regulations and responsibilities.

The contractual responsibilities are responsibilities that are agreed between the stakeholders that have any form of contract while collaborating, where responsibilities are specifically discussed and allocated. These responsibilities are difficult to be considered for one

stakeholder only, without considering the other actors. Also, these responsibilities are clearly defined and there is a legal consequence if not complied to the responsibilities.

For moral responsibilities, it is less clearly defined where the responsibility lies, and also there are no consequences for not complying to the responsibility. Therefore, this type of responsibility is usually overlooked.

The legal responsibilities do not necessarily require this responsibility framework, as the laws and regulations are clearly written down and need to be met. This is already the case in the TIS framework and the following strategies. However, as the moral responsibilities are vaguer, they do need to be described in the meta-responsibility framework in combination with the strategies from the TIS framework. From the meta-responsibility map however, it can be seen that most responsibilities listed are moral responsibilities as this research is conducted from a research group focussing on responsibilities of actors in innovation, that are thus well aware of these responsibilities. Also, the socio-technical system this case of hybrid protein is in, already brings about impacts at broader societal level, including moral issues. Identifying these moral responsibilities in this framework help with making it more responsible and sustainable.

Insights from expert interviews: Responsibilities

With regard to responsibilities, a pattern was identified in the interviews. Most responsibilities that were mentioned were legal, and it was more complex to identify exactly what an innovator is morally responsible for. From interviews, the first responses mentioned where usually legal responsibilities.

This suggests that the perspective the user of this framework have, can influence what direction the thought-process goes to. This can be due to the fact that moral responsibilities can be unclear. Also, this can be based on the background of the interviewee, that determines from what perspective the responsibilities are looked at. Therefore, this step is important, to categorizes the responsibilities, as it becomes apparent that a certain type might be overrepresented and results in the realisation to take all types of responsibilities into account.

“So morality is not always the most important driver when it comes to regime players, because they also have a lot to lose in terms of losing a business that they currently have so sticking to your moral compass as a startup and also extrapolating/diffusing that to the world basically I think that's a very important responsibility” – I2

Some types of responsibilities can be linked together, where the moral responsibility is translated into a legal responsibility. That regulatory framework results in the actual compliance to the legal responsibility and thus also the moral responsibility. With the problem of many hands, it was described that the moral responsibilities are spread over a large geographical and time space, meaning that it becomes more difficult for the stakeholders to understand who is in the end morally responsible. When a moral responsibility is translated into a legal responsibility, it can be allocated to one or more stakeholders, making the responsibility more explicit. This results in clear boundaries of the allocation and content of the responsibility. Through responsibilities that are shared between actors, different actors can be identified from this step onwards.

There are also responsibilities that are not linked to one individual actor, but to a collective of actors, for example the collaboration with consumers, considering their ideas and communicating developments and important information. This is a joint responsibility between multiple actors that could be better enforced by creating a consumer society or organisation.

Representatives from the different stakeholders are involved in this organisation and jointly contribute to the responsibility of communicating with the consumer.

"It's not so much a responsibility of an individual company. It is a responsibility of a joint society of these company. So what I also did many times in my life is to is to create new organisations, societies that entail and all the startups and scale-ups in a certain sector and they all tap in some money and then you have a joint voice and a joint responsibility" – I2

Contractual or legal responsibilities are easier to be enforced and allocated than moral responsibilities, as it is clearer who is assigned to a certain responsibility and what the consequences are if these responsibilities are not taken. However, a different approach of positive enforcement is also more responsible, where taking responsibility is rewarded or stimulated. In the long run, this builds more intrinsic motivation for the right reasons. This however does not deliver the desired results in today's society, seeing the legal system is currently build up by negative reinforcement if something is done wrong.

"With responsibilities comes also the implication that there are consequence when you do not comply to the responsibilities. And who is that authority that checks or enforces these consequences in case of moral responsibilities, or it is a more collective punishment, less clear who does that." – I1

Step 8: Identify conflicts or synergies between responsibilities of the innovator

A relationship can be present between the different responsibilities, either this is positively influencing each other (a synergy) or negatively influencing each other (a conflict). The multiple relations are visualised in Figure 18 where the conflict are depicted with black arrows and the synergies with grey arrows. Also Table 17 describes these conflicts and synergies in more detail.

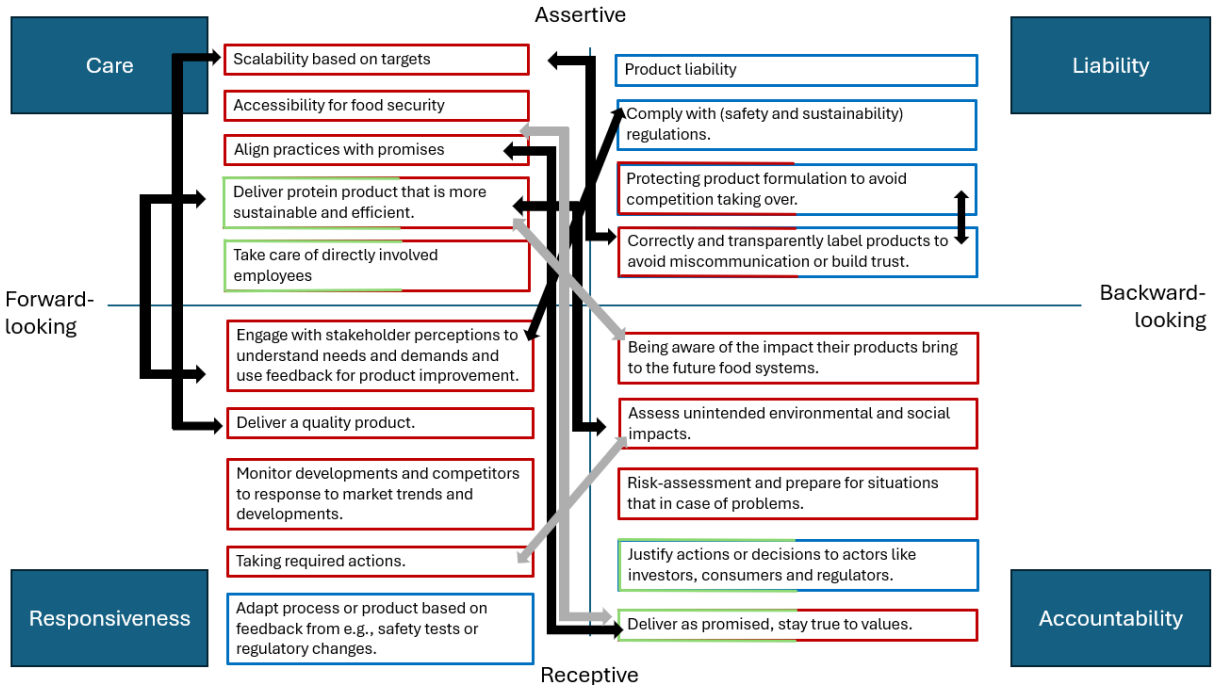

Figure 18: Visual representation of the conflicts (black arrows) and synergies (grey arrows) between the responsibilities in the meta-responsibility framework. The red responsibilities are moral, the blue are legal and the green are contractual.

Table 17: Overview of relationship between the responsibilities, either having a conflict or synergy and the reason for this relationship. The examples are further explained in the text.

Responsibility (type)	**Responsibility (type)**	**Conflict or synergy**	**Reason (example)**
Comply with regulations (liability)	Engage with stakeholders to understand demands and wants (responsiveness)	Conflict (1)	The actor wants to engage with a stakeholder to act on the demands of the customer, while at the same time they need to comply to (safety) regulations and limitation to design or process steps. (tastings)
Protecting product formulation (liability)	Transparency (liability)	Conflict (2)	On the one hand innovators want to be open about their product and process to relevant stakeholders, but at the same time it is important not to share confidential information or information on IP. (labelling, EFSA assessments, patents)
Scalability (care)	Transparency (liability)	Conflict (3)	On the one hand it is known that plant-based or cultivated protein give a certain sentiment to mainstream consumers, this means that it is known that by being transparent about the content of the product, consumers might be repelled just by certain information or naming (van der Toorn, 2025). While innovators are responsible to be transparent and report about the ingredients, it is not always beneficial to attract customers that way and scale the product in that way.
Align practices with promises (care)	Stay true to your values (accountability)	Conflict (4)	On the one hand an innovator must have ambition to be able to make it and with that align their practices with their promises, but on the other hand, innovators are ought to not overpromise, to be able to stay true to the promises. Currently this is what is happening, there is being overpromised, which results in lack of trust. (cellular meat on market promise)
Deliver protein product that Is more sustainable and efficient (care)	Assess unintended environmental and social impacts (accountability)	Conflict (5)	An innovator has the responsibility to deliver a sustainable and more efficient protein product, which can be in conflict with the responsibility of assessing unintended environmental or social impacts, as this might mean that it brings about environmental and social impacts to farmers, as that might mean there is no co-existence with animal protein production which results in bringing their business in danger. (farmers)
Scalability (care)	Delivering quality product (responsiveness)	Conflict (6) or synergy	Scalability is only a responsibility when this is promised by the innovator to make it widely available or make the general food system better, but only if this can be done sustainably and with quality. These two responsibilities can go hand in hand, but one of the other is usually seen as less important than the other, where one is prioritized over the other. In this conflict it is also important to keep in mind what the initial goal has always been and work towards that goal. If to scale the goal to make a sustainable product is not met, a conscious choice needs to be made to see what decisions are made from there on.
Getting funding for growth (part of scalability in care)	Deliver as promised (accountability)	Conflict (7)	One the one hand, an innovator wants to attract investors for funding to grow, however, that might mean they have to overpromise in order to receive the funding. (hype cycle)
Align practices with promises (care)	Adapt processes based on feedback (responsiveness)	Synergy	While having the ambition for successful innovation to enter the market, adapting the process or product on consumer feedback can help achieve that and align their practices with their promises. So, the ambition has certain ideas in mind based on what is perceived to be

			right, while customer feedback can change the perspective if is found that it is not completely right. Therefore, this can be two responsibilities that can work together towards a greater goal.
Risk-assessment (accountability)	Delivering quality products (responsiveness)	Synergy	By doing the required research on the impacts of the innovation, a better-quality product can be put on the market.
Align practices with promises (care)	Stay true to your values (accountability)	Synergy	If the innovator has a responsibility to align their practice with their promises, this can be done by staying true to your values. This does not mean they cannot change the plan, but the values has to be consistent.

Conflicting responsibilities of actors

Conflict 1: Complying with regulations vs engaging with stakeholders

On the one hand, the innovators has to comply to the existing regulatory frameworks like the Novel Food Framework. These pose limitations to what the innovator is allowed to do during the design or production process. However, the innovator also wants to engage with a stakeholder to act on the demands of the customer, to be able to be responsive and anticipate to their demands and understand the impacts. This conflict in practice shows that regulations limit the collection and/or usage of the stakeholder input, for example tastings would be beneficial to have consumers try the product and directly provide feedback.

It was also mentioned during one of the expert interviews that there is a conflict in the way the regulations are established, as this is a biased process, based around certain views.

"I think the legal frameworks that we construct our world around and the rules and regulations that exist in the world, they're not fully neutral, they're always kind of a result of the ideas of the ideologies and the world views people have had in the past and they're still having, and they also reproduce certain values and ideas around how the world should be. There is this interesting tension of who makes those choices? What are they based on, who was asking the questions?" – I5

"I think it's important to question, who was going to be affected by it. And there we might be able to ask better questions, if we include more people that are currently working with providing food and the animals as part of an actor in the whole question." – I5

There are policies around regulations introduced to increase stakeholder engagement in the process. The European Commission has posed guidelines to the Organisation for Economic Cooperation and Development (OECD) regarding the engagement of stakeholders in due diligence processes for example, as part of the Responsible Business Conduct (RBC). It visualizes how to embed RBC into policies and management systems (Figure 19), clearly outlining an ongoing engagement with stakeholders. This shows that steps are taken to make engagement more embedded in policies. Regardless, regulations can still be a limitation for innovators. An innovator can engage with the stakeholders and include them in the process, but there are still limitations that the innovator runs into regarding regulations that do not allow certain consumer wishes.

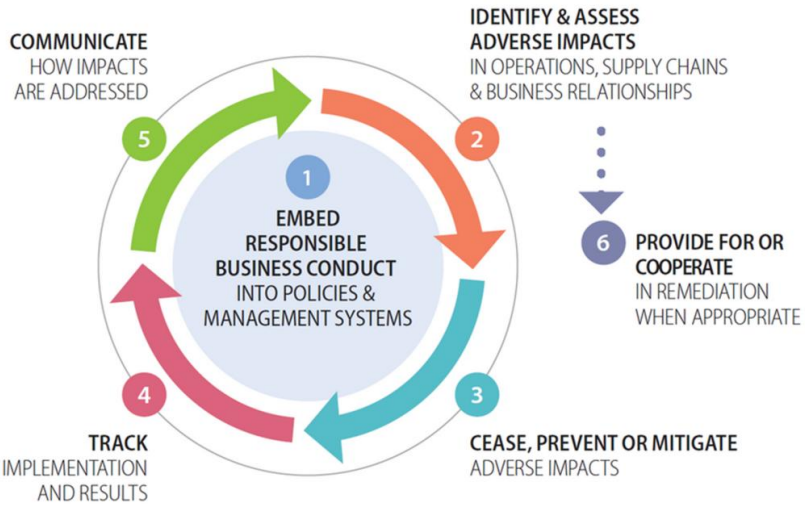

Figure 19: OECD guidelines for embedding RBC into policies and management systems (OECD, 2018).

Conflict 2: Protecting product formulation vs labelling products correctly

On the one hand, the innovator has the responsibility of protecting the product formulation for the sake of Intellectual Property (IP), patents or business competition. This means the transparency about the product is limited to a certain degree. On the other hand, the innovator has the responsibility to for example label the product in a way that is it clear what the product entails and consists of. Also, if EFSA is conducting safety assessments, it is important that confidential information is not released when the application report is published. Another example is regarding patents, in return to fully disclosing production information, the innovator receives exclusives rights in the form of IP to prevent others from selling it. This means there is full transparency ones the IP is there, but before filing, it is important to not disclose any information, as that might mean it cannot be patented anymore. That is a conflict that innovator face, where they want to be transparent, but cannot be to be able to patent their innovation. This shows a conflict of values, where the legal responsibilities and economic incentives of protecting your business are opposing the moral responsibilities of being open and transparent about the product to the consumer and other stakeholders.

Conflict 3: Transparency vs scalability

On the one hand it is known that explicit communication about plant-based or cultivated protein ingredients give a certain sentiment to mainstream consumers, this means that by being transparent about the content of the product (in labelling or naming), consumers might be influenced or even repelled only by certain provided information of the product or ingredients (van der Toorn, 2025). Technical accurate terms can repel customers, but at the same time makes sure consumers are not misled with the wording used. So being transparent is not always beneficial to attract customers that way, which is a responsibility to be able to grow and survive as a company. Not only for economic reasons, but also moral reasons of providing your employees a stable income. If they cannot attract customer, they cannot scale either.

Conflict 4: Aligning practices with promises vs staying true to values

On the one hand an innovator must have ambition to be able to make it they should have a certain drive to pursuit their innovation for good purposes, and have a drive to put in energy and time to thrive in the business. With that drive they can align their practices with their promise. On the other hand, innovators are ought to not overpromise, to be able to stay true to the promises

and values. Currently this is what is happening, there is being overpromised, which results in lack of trust. For years promises are made that keep being not met, which lowers the trustworthiness and makes it feel unpromising and unrealistic. An example is the promise that NU.nl made in 2016, that in 5 years there would be affordable cellular meat on the market. Five years later, they again promised the same, within the 5 years it would be on the market, and now they are saying 'we are a step closer to meat without animal suffering' (NU.nl, 2016), (Schuttenhelm, 2020) (Bergeijk, 2023).

Conflict 5: Deliver a sustainable protein product vs assessing unintended social or environmental impacts

An innovator has the responsibility to deliver a sustainable and more efficient protein product, which can be in conflict with the responsibility of assessing unintended environmental or social impacts, as that might mean it brings environmental and social impacts to farmers. For example, by producing a product that does not use animal protein, there might be no co-existence with animal protein production. Also, the direct competition that the innovator might pose to the farmers, means bringing their business in danger, which have unintended social impacts.

Conflict 6: Scalability vs sustainable or leading-quality products

Scalability is only a responsibility when this is promised by the innovator to make it widely available or make the general food system better, but only if this can be done sustainably and with quality. These two responsibilities can go hand in hand, but one of the other is usually seen as less important than the other, where one is prioritized over the other. In this conflict it is also important to keep in mind what the initial goal has always been and work towards that goal. If to scale the goal to make a sustainable product is not met, a conscious choice needs to be made to see what decisions are made from there on.

During expert interviews this conflict was also mentioned:

"Scalability doesn't equal sustainability" – I5

"I think the questions around scalability in general, they are very paradoxical to me. There's this one paradox, that talks about that you could make something more efficient and have it very scaled up in the sense that you will make a lot of something with less resources and you change the food system. Therefore, make it more sustainable, but there's always going to be the risk that you will start making more of the same thing and use the same amount of resources they had before." – I5

Conflict 7: Getting funding for growth vs delivering as promised

In the pattern of diffusion, the most important phase in which fundings are crucial is in the phase right before market introduction. Receiving funding or investment for an innovation is required to be able to grow. In an industry, funding is a proxy for the resources that are required for start-ups or companies in general to improve and grow (Battle et al., 2025). As can be seen in Figure 20, the stage right before market introduction is also the point in the hype curve that the expectations are lowest and thus investors are less likely to invest. That brings the conflict, where on the one hand an innovator wants to be honest and not overpromise, but on the other hand, the innovator needs the investment to get their product to the market as thus some overpromising might be required to get fundings.

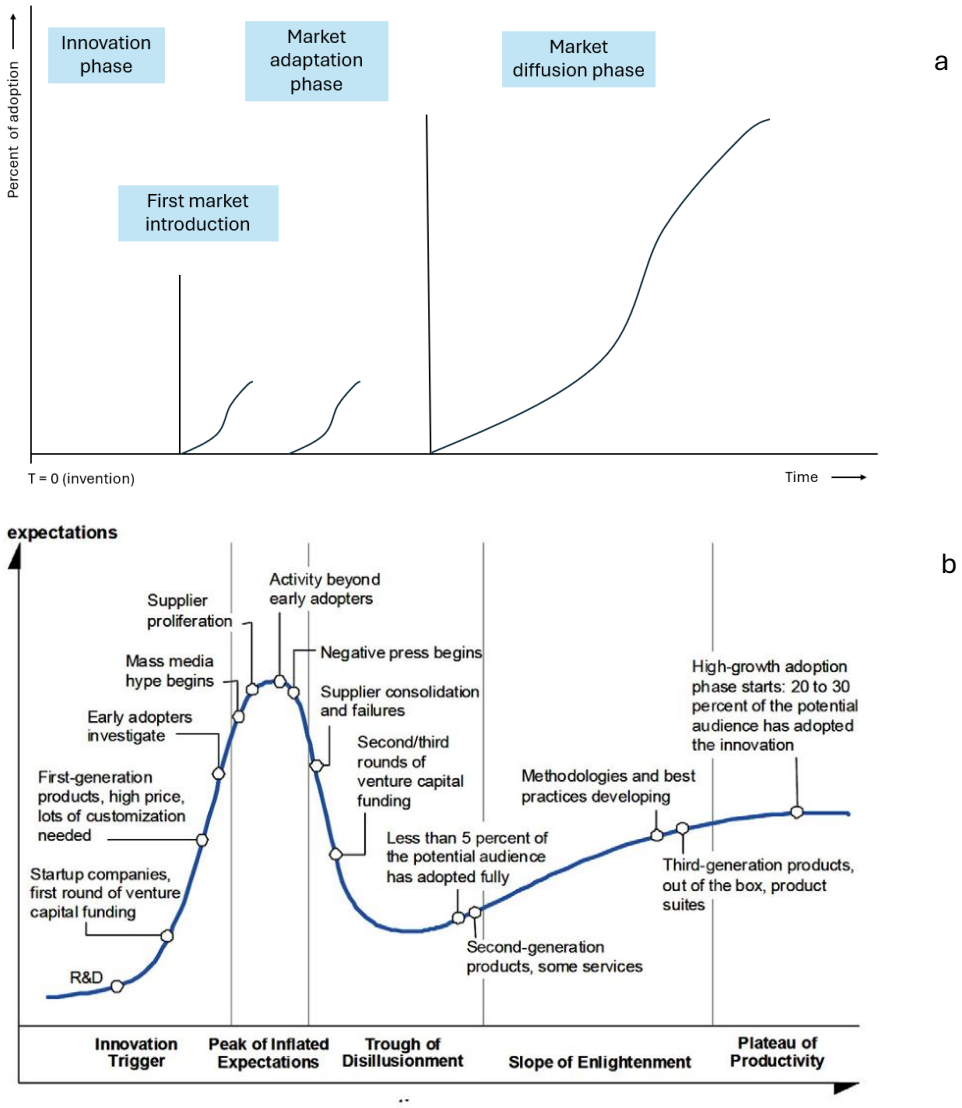

Figure 20: Pattern of diffusion (a) and hype cycle (b) (Dedehayir & Steinert, 2016) showing the relation between the expectations during the hype cycle in the pattern of diffusion.

Conflicting responsibilities between actors

In this analysis, mostly conflicts and synergies between responsibilities have been identified based on the viewpoint of one actor; the innovator. However, also conflicts and synergies between responsibilities of different actors can be identified. In this analysis, only the conflicts with other actors still from the innovator's point of view is shortly touched upon.

Conflicts and synergies between innovators and conventional farmers or meat producers

When an innovator brings a new product to the market, this can disrupt the existing value chain. In this specific case, that is the current food supply chain, and more specifically the protein producers such as farmers and meat producers. Both actors have a conflict in interest as their products might not co-exist or compete for the consumer base. However, it can also work out as a synergy where different stakeholders collaborate. An example is the farm in Schipluiden (The Netherlands), the first cultivated protein farm in the world has opened on a conventional dairy farm. 'It is a chance for a new revenue model, alongside our own farm' (Van Leeuwen, 2025). This is realised in collaboration with RespectFarms (collaboration between farmers and researchers). This farm is also meant to become a place where stakeholders like farmers,

researchers, citizens and policy makers can come together and see what it entails (NOS Nieuws, 2025).

Conflict between innovators and government/regulatory bodies

When an innovator wants to bring an innovation to the market, there is a need to act on the demand and developments to be able to outcompete competition for example. If they wait too long, other innovators might be quicker and take the consumer base. At the same time, the government is served by ensuring safety of the Novel Food products and regulatory bodies want longer-term risk assessments. So, their interests are not aligned, as their responsibilities are different. The innovator has to make sure it captures its share in the market before competitors do, and the government and regulators want to ensure safety for its consumers. This was confirmed by an interviewee.

"EFSA has the responsibility to ensure that everything we eat is safe and healthy. So when a new type of product is introduced that they do not yet fully know how to deal with, they have a duty to investigate it thoroughly and examine it in great depth. Meanwhile, companies have the responsibility to market and sell their products. These responsibilities may therefore be somewhat at odds with each other."- I1

Also, a conflict is seen within the EU, where on the one hand, universities and research institutes are focussed on research and development on alternative protein field with investments from the governments and EU. At the same time, these advancements that are made are not directly applicable to innovators that want to use that knowledge to bring their products to the market, as their growth and development is not supported in the same manner. Also this was discussed in an expert interview.

"The European Union invests heavily in research and development, and there are many universities and very strong start-ups with a lot of potential. A great deal of funding is being invested in this, so the EU is clearly taking this responsibility very seriously. At the same time, however, the actual scaling up and growth of companies is not supported in a way that aligns well. This is often described as having one foot on the accelerator and one on the brake: a lot is being developed, but successfully translating all that innovation into market value is not being done effectively." – I1

However, synergies between the government and innovators can also occur, take Singapore as an example, their approval of the cultivated protein as an ingredient for sale have led to them being the 'global leader' in cultivated meat.

Step 9: Adapt TIS strategy based on meta-responsibilities insights

The following strategies are proposed by the TIS framework: "top niche strategy", "subsidized niche strategy", "redesign niche strategy". It must be noted that these strategies are aimed at market-introduction, not necessarily large-scale diffusion and thus long-term success. However, the strategies must still be responsible and keep in mind responsibility viewpoint as the introduction does influence the perception consumers have of a certain innovation, which is a driver for consumer behaviour change (interview, 2025).

***Top niche strategy*:** This strategy focusses on a certain group in society first, usually the more privileged group. This shows a lack of inclusiveness and social equity if that 'top end' group is society is also the target customer in the longer run. A skimming strategy is adapted here, where a higher price is set with market-introduction, that results in some profits that will help decrease

the pricing for the mainstream market (see Figure 21). A skimming strategy in which the top layer of customers is targeted first (with a high price) is only responsible, if that is an entry strategy and the target customer is adapted ones the desired effects have been shown. It is not desired that the top niche customer segment is the group that will eventually be the only customer segment able to purchase this product.

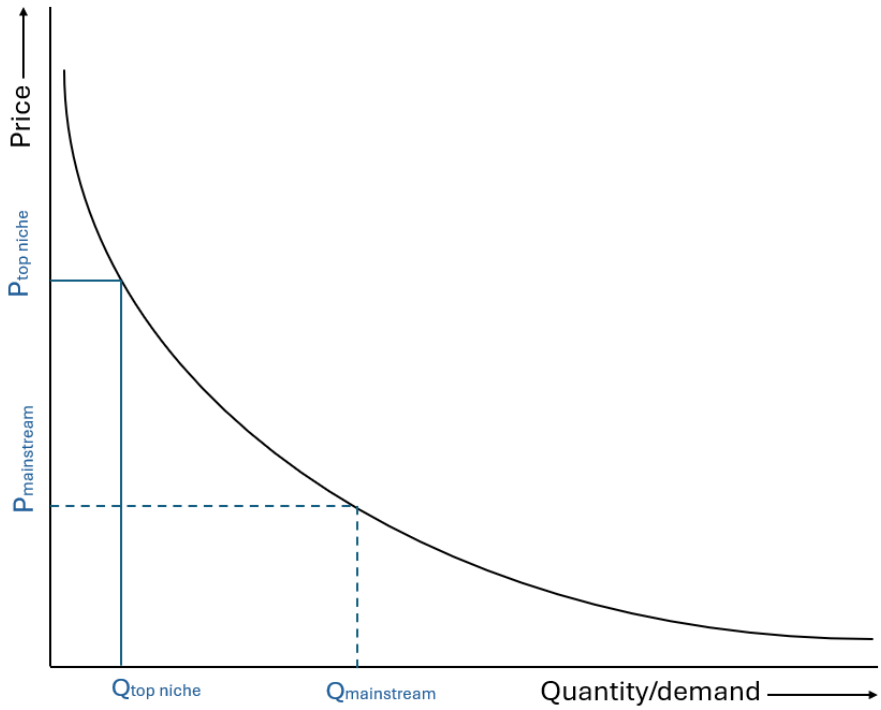

Figure 21: Price-quantity curve, showing a higher price for the top niche ($P_{topniche}$) with the corresponding top niche quantity ($Q_{topniche}$) and the lower price ($P_{mainstream}$) for the mainstream market ($Q_{mainstream}$)

The aim of hybrid protein is to make the food system more sustainable, increasing animal welfare and making society more protein self-sufficient. When introducing the product to a certain segment only, this goal is not achieved and will not be achieved based on this strategy alone. By evaluating the responsibilities that the innovator has, it can be concluded that the strategy is not complying to certain responsibilities, for example accessibility and engaging with stakeholders is not included in this strategy.

By adding a layer of social demand to the strategy, it can become a responsible strategy. The goal should not be to get a customer base of high-end customers, but balance technical feasibility with accessibility. So, making a top end product for only a selected segment of society versus making a qualitatively good product for a much broader segment of society. Insights can also be gained from this first broader group, so it can be improved for the mass market and large-scale diffusion later. The strategies can be compared in Table 18.

***Subsidized niche strategy*:** This strategy focusses on innovations that are determined to be socially relevant products to a certain customer segment. It is using public funds to help innovations survive in the starting phases and stimulate early markets by making market competitive pricing possible. The funding itself is not irresponsible, what is lacking responsibility is the decision-making and driver behind the funding. Often, even when fundings go to sustainability-oriented innovations, the sustainability becomes an economic opportunity rather than sustainability being the goal. Sustainability is framed in economic terms. It can also be

focussed more on the sustainability of the innovation itself, so will it be successful on the market, is it scalable, will it attract private funding, boost competitiveness in the market, but not on the social sustainability, is it accessible for all, does it distribute the advantages in a fair way, does it fit within the ecosystem, desirable in the long-term? It lacks a dimension of inclusion, also in the decision-making. This is done top-down, without including other stakeholders in the decisions on what innovations to subsidize.

In order to make this strategy be more responsible, it should be clearly defined what innovation receives this funding, where this funding is coming from and what it will be used for. It states that is given to innovation that are seen as socially relevant or important, but by whom? The decision-making should be defined in the strategy, to make sure this is done transparent and inclusive. The redefined subsidized niche strategy can be found in Table 18.

Redesign niche strategy: This strategy focuses on changing the state or the application of a product in a way that is more favourable for a certain reason. This might be the price that is too high for the standard product to be made, resulting in simplification of the product. It could also be the context in which the product is applied that is not fitting, resulting in a change of application, either for the purpose of institutions and regulations to align, or customers to be more open to the product in a different context. What this strategy is lacking is the question whether the product is still having the same goal as it was originally designed for. It is not a requirement, however it shows that by trying to fit a product into a market, other factors can become more important, like economic viability. The aim might shift towards trying to make it sellable, fundable or scalable, or making it fit within the regulatory landscapes, while this reframes from the original ideas, goals or values. It also focusses on short-term success, by trying to get the product on the market quicker, while the original approach was based on long-term goals.

To make this strategy responsible first of all stakeholders need to be included to see how a redesign is most effective. This can help the goal of social relevance and acceptance work. Also, making sure the goals are reiterated on a regular basis, to make sure the purpose of the product stays in line with the initial goals and values, will result in the market entry in a redesigned form, without derailing from the track the innovation was supposed to go. When promises are made that the product will reduce environmental impact by x percent and the redesigned product does not, that means that strategy is not moving in the desired direction, so that should be evaluated correctly. Lastly, the perception of this strategy can be changed, where instead of trying to adapt the product to fit the existing regulations, decisions to try to improve the regulations can also be made. The rules and regulations can be shaped according to the innovation, if it would be beneficial for broader society. Table 18 describes the adapted strategy definition.

Table 18: Current definition vs adapted strategy definition based on the RMD framework

Strategy	Definition following TIS framework	Adapted definition following RMD framework
Top niche strategy	A niche strategy can be adopted where hand-made products can be made to order, in small numbers, for a specific top-end niche of the market. A skimming strategy can be adopted in which the top niche of customers is supplied first with a special product.	A niche strategy can be adopted where quality products can be made to order, in small numbers initially, acting as feedback on how to comply to the social demand of the mass market.

		Balancing quality and accessibility to focus on consumer needs and gain insights for broader societal benefit.
Subsidized niche strategy	A niche strategy can be adopted where the product is subsidized if the use of the product by a particular segment of users is considered as societally relevant or important.	A niche strategy can be adopted where the product is subsidized to support innovations that are inclusively decided to be societally desirable, environmentally sustainable and ethically responsible, ensuring that public support align with broader societal values.
Redesign niche strategy	A niche strategy can be adopted where the product is introduced in a simpler version that can be produced with the existing knowledge, less use of resources and therefore for a lower price. A niche strategy can be to explore an application where institutional aspects are more favourable. Mostly leads to redesign. A niche strategy can be to explore an application where suppliers or customers have no resistance to produce and use it. Mostly leads to redesign.	A niche strategy can be adopted where the product is introduced in a different version, but still complies with the same standards the original product was meant to deliver. Whether that is a different application or in an simplified product version.

Conclusion - Strategies in practice

The adopted strategies explained in Table 18 are more general theoretical descriptions. In practice, the strategies can again mean different things based on the innovation that it is applied to.

The “adapted top niche strategy” for hybrid protein can mean that instead of making the hybrid protein available in top end restaurant (what happens now in for example Australia and the US) meant as a luxury experience in small quantity, the hybrid product can be made available in the Netherlands on a smaller scale for general customers, not with the aim of the product being some luxury item, but to have consumers give their feedback on the product for further refinement and also to have them serve as promotors to let the acceptance of the hybrid product grow. When regulations allow it, it can be introduced at local butchers or supermarkets for example, with for example small-scale tastings or introduce the hybrid product at festivals or food markets. Collaborations can be established with universities, making it available on campus, or with local influencers that can introduce the product to create more awareness and slowly acceptance. It is important here that the aim of these small-scale exposures to hybrid products is to gather feedback and collect a better understanding of the sentiment that people have about cultivated protein while at the same time educating them. An approval and code of conduct was set up for pre-approval tastings of precision-fermented foods (Ministerie van Landbouw, Visserij, Voedselzekerheid en Natuur, 2025), a similar approach can be taken for hybrid food products.

The “adapted subsidized strategy” can in practice mean collaborating with public-private partnerships (PPP’s). These are cooperations between the government, companies, knowledge

institutes and NGO's (RVO, 2022). They value following Sustainable Development Goals (SDG) and fund projects for food security in middle and low-income countries. If PPP's could fund projects that assess customer acceptance, or measure environmental impacts, that can help the development of hybrid protein products. They could even subsidize the small-scale tastings and combine this with research.

The "adapted redesign strategy" in practice can mean first shifting the application of the product from standalone protein product to an ingredient incorporated in another food product. For example, when using the hybrid protein as hybrid 'meat' balls in soups, there are three different reasons why this might be an interesting introduction strategy. First of all, by introducing it in indirect manner, acceptance can grow when consumers get familiar with having hybrid ingredients in their foods. Also, by not directly letting consumers choose for a hybrid product as alternative for their conventional meat but as product in another product, it might increase the willingness to consume. Thirdly, this buys innovator times to further develop the taste and texture sensation for lower prices, as in the proposed form it is not necessary to have the same quality of texture/taste. This still aligns with the values and final goal of the innovator, thus making it a responsible redesign.

To conclude, the RMD framework has identified the barriers to market introduction and found suitable niche strategies using the TIS framework to overcome these barriers in the 'Strategy Identification' stage. In the second stage 'Responsibility Creation', the meta-responsibility framework has categorised the responsibilities of the innovator and identified conflict between these responsibilities or between actors. Based on these conflicts and responsibilities, the strategies from stage one have been adapted to more responsible strategies.

Conclusions

Each of the chapters of this thesis report have answered a corresponding sub-question that led to answering the main research question "How can responsible strategies be designed to overcome barriers to market introduction and large-scale diffusion of hybrid food products that combine cultivated and plant-based proteins?". In this section, the conclusions for each of the chapters is touched upon. As the different chapters and its sub-questions show, two different disciplines have been combined in this thesis, showing relevant frameworks and literature can be combined to help aid in the way to more responsible innovation.

Sub-questions	**Methods used to answer sub-question**	**Designated programme**	**Dedicated chapter**
"How are hybrid proteins relevant in the alternative protein landscape?"	Literature	MSc Life Science & Technology	1
"What are the barriers blocking hybrid protein from market introduction and large-scale diffusion?"	Literature Interviews	MSc Management of Technology	2
"What strategies can be applied to overcome those barriers?"	Literature	MSc Management of Technology	3
"How to systematically identify and classify innovator's responsibilities to support responsible market introduction strategies?"	Literature Interviews	MSc Life Science & Technology	4
"How to integrate responsible innovation principles into strategies for overcoming market introduction or diffusion barriers?"	Literature Interviews	MSc Life Science & Technology MSc Management of Technology	5
"What responsible strategies to apply to hybrid protein case?"	Designed framework Interviews	MSc Life Science & Technology MSc Management of Technology	6

Sub-question one states: *"How are hybrid proteins relevant in the alternative protein landscape?".* Chapter one has discussed that hybrid protein are relevant in the alternative protein field, in the possible accelerate of the protein transition. The product combines the technological feasibility and sustainable gains of cultivated protein and plant-based protein in one product. They are addressing the limitations the plant-based protein products and cultivated protein products face. For example, plant-based protein still struggle with the right sensory experience that consumers accept and the nutritional values to compete with other conventional protein sources, while the production price is attractive. Cultivated protein on the other hand have the high production costs, and low consumer acceptance, however it closely resembles the taste, texture and nutritional values of conventional meat. By combining these options, cost-effectiveness of plant-based protein and sensory and nutritional advantages of cultivated protein result in a more optimal and attractive product.

Sub-question two states: *"What are the barriers blocking hybrid protein from market introduction and large-scale diffusion?"* The TIS framework in Chapter two has helped identify the barriers that hybrid protein are facing for market-introduction. The building blocks that are currently missing that are forming the barriers are the 'production price', 'production system', 'network formation and coordination', 'customers', and 'innovation-specific institutions'. The influencing conditions that are negatively impacting the market-introduction or large-scale diffusion are 'knowledge and awareness of technology', 'knowledge and awareness of

application and market', 'macro-economic and strategic aspects', 'socio-cultural aspects' and 'accidents and events'.

Sub-question three states: *"What strategies can be applied to overcome those barriers?"*. Chapter three has helped understand what (niche) strategies based on the outputs of the TIS framework (barriers and influencing conditions), can be applied that aim to circumvent the barriers specifically for market introduction. It was found in expert interviews that the barriers can be sequential, where one barrier should be tackled first, before it is effective to work on the other barriers. For example, regulations must allow the selling of cultivated protein, before other barriers like customer acceptance and price can be tackled. From the TIS framework, the proposed strategies that can be applied are the "top niche strategy", "subsidized niche strategy", "redesign niche strategy" and "geographic niche strategy". Also the "redesign niche strategy" and "demo, experiment and develop strategy" are being applied already. It was found in this Chapter that the niche strategies do however lack a responsible viewpoint that is needed to make long-term sustainable innovation happen.

Sub-question four states: *"How to systematically identify and classify innovator's responsibilities to support responsible market introduction strategies?"*. It was found in Chapter 4 that the TIS framework is designed with a company perspective in mind, providing a tool to design suited strategies for sustainable market introduction of the innovation. Here, sustainable market introduction is defined as economic sustainability. It is to a lesser degree focussed on the social and environmental sustainability that are the two additional layers of sustainability. Therefore, the TIS framework requires further development where the focus on social and environmental sustainability is increased.

At the same time the meta-responsibility framework was introduced in this Chapter, that helps operationalize theoretical elements of responsibility in R&I practices. The framework is built up from the concepts of Pellizzoni, that itemized responsibilities into four different types: care, liability, accountability and responsiveness. It conceptualized these types on the basis of two facets, imputation and justification. The idea of combining the outputs of the framework was introduced here, where combining the strategies from the TIS framework with the insights from the meta-responsibility map results in responsibly adapted strategies.

Sub-question five states: *"How to integrate responsible innovation principles into strategies for overcoming market introduction or diffusion barriers?"*. In Chapter 5, the combination proposed in Chapter 4 was conceptualised, resulting in a combined framework named the Responsible Market Development (RMD) framework. The RMD framework results a more responsibly oriented framework. The output of the stage 1 ('Strategy Identification') provides strategies to overcome the identified barriers using the TIS framework. These strategies still lack a certain viewpoint of responsibility. The output of stage 2 ('Responsibility Creation') using the meta-responsibility framework, provides responsibility conflicts that can help adapt or add to these proposed strategies to make them more responsible or inclusive.

Sub-question six states: *"What responsible strategies to apply to hybrid protein case?"*. In Chapter 6 the RDM framework has identified the barriers to market introduction and found suitable niche strategies using the TIS framework to overcome these barriers in the 'Strategy Identification' stage. In the second stage 'Responsibility Creation', the meta-responsibility framework has categorised the responsibilities of the innovator and identified conflict between these responsibilities or between actors. Based on these conflicts and responsibilities, the strategies from stage one have been adapted to more responsible strategies.

Both the TIS framework from the 'Strategy Identification' stage and the meta-responsibility framework from the 'Responsibility Creation' stage are already existing frameworks. The TIS framework is aimed at a company perspective and the meta-responsibility framework is also designed for corporate purposes. The viewpoint of the innovator that has been taken in this case is therefore applicable. However, both frameworks are in different research fields, and have not been looked at in the same context. Both frameworks are of added value to each other and therefore the RMD framework proposes a valuable framework for the design of strategies for innovation to get to the market of diffuse on the market in a responsible way.

Conclusion from applying the RMD framework

The three strategies that are the output of the RMD framework for this specific case of hybrid protein products, are the adapted top niche strategy, the adapted subsidized niche strategy and the adapted redesign niche strategy.

The top niche strategy was lacking an inclusive viewpoint, where the focus was on providing a high-quality product to the top end customer. The adapted strategy has added a layer of social demand balancing technical feasibility with accessibility (an identified conflict), making the good quality product available to a broader group of customers and using the feedback of this group to improve the product for larger-scale accessibility. In practice this means making the product available at small-scale local entrepreneurs in forms of tastings, or collaborate with research institutes or universities to make it available to an interested group of consumers with the aim of getting useful feedback for improvement.

The subsidized niche strategy was missing an inclusive decision-making description. In order for this strategy to be responsible, the decision-making on when an innovation gets a subsidy and where that investment comes from should be clear. It should be inclusively decided what innovation is seen as socially relevant. In practice this could mean collaborating with public-private partnerships and make sure there is alignment with public values.

The redesign niche strategy was lacking alignment with goals and values. It described that the product must be redesigned in order to make market-introduction more suitable. However, alignment with the innovators goals and values should always be prioritized. Redesigning or changing the plan is acceptable, as long as the values and goals are not changed or neglected. In practice this can mean introducing hybrid protein as a product for another final product first instead of directly aiming for a final product. Goals and values stay the same, and acceptance, development and perception can grow in this manner. A point of discussion could be looking at how to lobby for changes in the regulations with different stakeholders, for example trying to find ways on how to safely let tastings be approved.

It is proposed to start with the redesign strategy and/or the top niche strategy after which the subsidized strategy can be applied if price is still a barrier.

Missing viewpoint in stand-alone frameworks

The frameworks that are part of the RMD framework pose interesting opportunities, but also have their limitations and challenges.

What was found in the TIS framework, is that the building blocks lack a societal value or sustainability viewpoint. It only includes the practical viewpoint in the building blocks, like 'customers', 'production system' and 'price'. For example, in the building block 'production system', no considerations are made whether this production system can be realised in a

sustainable manner. The same goes for 'consumers', a certain innovation might have a potential consumer base, however do these consumers demand this innovation for the right reasons? For example, a certain AI-tool that provides consumers private information from companies. The innovation might be ready for market-introduction based on the building blocks of the TIS framework, but is it for the right reasons? We fail to consider this using that framework only. Only the influencing conditions 'natural, human and financial resources' might consider the sustainability viewpoint, but the focus is on the resources and not necessarily on the impact. Also, the 'socio-cultural aspects' as influencing condition are more focussed on the cultural aspect, which are something different than the societal values. This is missing in the current framework. By including the meta-responsibility framework, a responsibility layer is added in the framework. This aims to start responsible considerations, with the added value of resulting in the output of either added strategies or adapted strategies.

A second limitation from the TIS-framework has to do with the degree of complexity of the innovation at stake. When identifying the strategies based on the missing building blocks, it is seen that not the whole list of combinations is present. These combinations of missing building blocks are also only useful when there is a clear combination of missing building blocks and influencing combinations. When there is a more complex situation, like the used case, there combinations are too shallow to result in a fitting strategy. When there are one, two or three missing building blocks, the different resulting strategies can be identified and compared, and the most relevant strategy can be chosen. However, when more than three building blocks are missing, it is not advised to find a fitting market-introduction strategy, but rather try to find ways to eliminate a certain barrier first before introducing it to the market.

Not only does the TIS framework have limitations, also the proposed RMD framework has limitations and assumptions that are made.

Limitations and learnings from applying the case to the RMD framework

The limitations that the RMD framework are mainly based on assumptions and scopes that are taken for this thesis. One of the points that should be noted is that the focus in this thesis has been on the innovator as the main actor and the corresponding societal responsibilities are focussed on the consumer side as they are the main target for market-introduction from the TIS framework. However, other relevant stakeholders such as farmers or animal welfare activists are hardly taken into account.

The RMD framework is applied to a hybrid protein case, but can be applied to any innovation that meets the requirements of the current stage of the innovation being before market-introduction. In that sense the framework is generalized for broader application to any innovation that meets that requirement. This requirement is based on the scope of the TIS framework, that also focusses on the phase from the invention to the market-introduction and large-scale diffusion in the pattern of diffusion. Therefore, we look at the responsibilities in that phase as well. However, as was mentioned before, other important decisions are made and responsibilities lie in the phases before and after market-introduction. The meta-responsibility framework is not limited to a certain phase in the pattern of diffusion, therefore, this can also be the basis from which it looked, resulting in potentially different responsibilities coming to the surface that will be integrated into the strategy adaptation. Figure 22 gives an overview of scope of the application of the two frameworks.

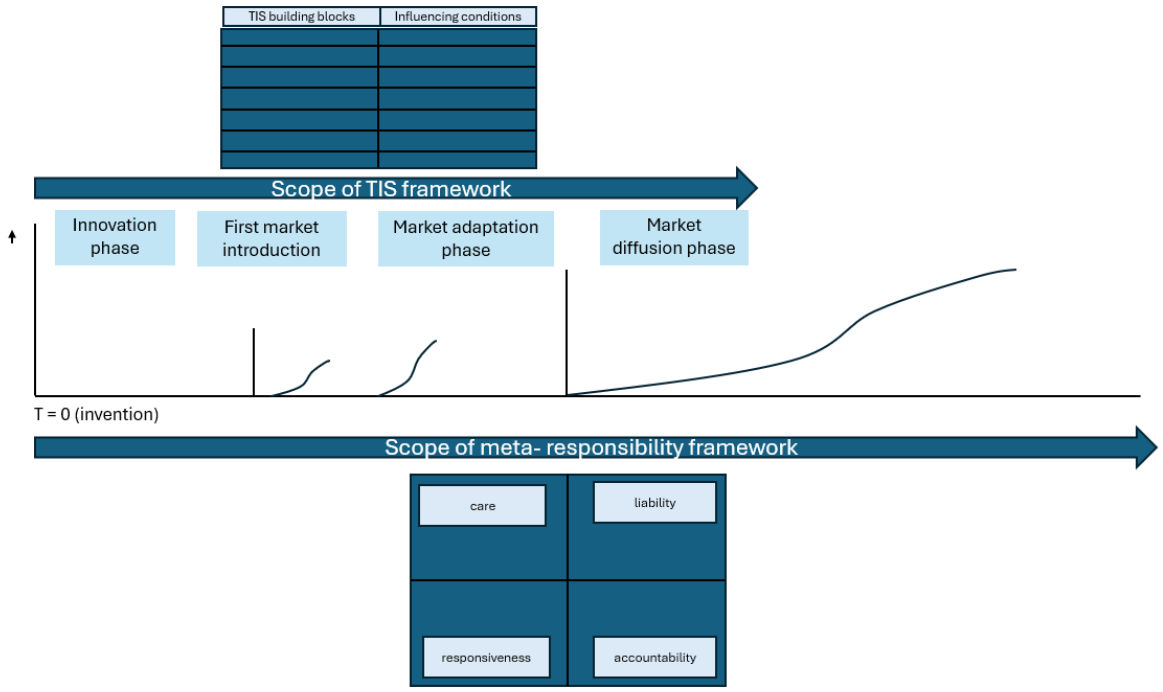

Figure 22: time scope of the two frameworks (TIS framework and meta-responsibility framework) on the pattern of diffusion.

One of the questions this poses is the order in which the frameworks are applied in the RMD framework. It becomes apparent here that the meta-responsibility framework is applicable throughout the whole pattern of diffusion and the TIS framework only in a limited scope. Now, in stage 1 the TIS framework is applied, and in stage 2 the meta-responsibility framework. Within the thesis, it becomes evident that responsibility is found to be important, so if that is also the case, why is the meta-responsibility framework not the starting-point of the RMD framework?

This different way of looking at the framework is also linked to the way the strategy is derived. It can be tackled in two manners, either by selecting or by adapting, depending on what framework is utilized first. If we have responsibility as a starting-point, that leads to selecting strategies that are responsible. The other possibility, what the RMD framework now proposes, is having the TIS framework as starting point, and thus having to adapt the strategies to make them responsible.

Additionally, a limitation is that there is a fixed amount of strategies that fit with certain missing building blocks and causing influencing conditions. However, as each case is slightly different and the most effective strategy is very context dependent, it can also be an option to have the opportunity to create a new strategy. This might be useful when the proposed strategy do not fully fit the context or is not responsible enough. This was also an improvement found when applying the RMD framework to the case; adding extra strategies. For example, a strategy that tackles the lack of acceptance by consumers. This strategy could entail to include more stakeholders to the decision-making or designing of the product. By including more stakeholders, especially ones that are not directly influenced by the innovation, but do have a level of knowledge, a more inclusive design process can be achieved. This could result in more acceptance from consumers if more stakeholders had their say in the design of the product.

The RMD framework also assumes that the process of finding strategies for market-introduction is a linear sequential process, where one step at the time is taken from the beginning to the end of the framework. The limitation of the framework is the lack of iteration steps within the process to check whether additional insights or developments have influenced decisions within the

process. This also applies to the limitation that the RMD framework is a combined framework, more so than an integrated framework. This poses opportunities for further research.

Further research

The initial idea was to develop an integrated framework based on the two existing frameworks. In light of complexity, it was decided to start with a combination of the frameworks as a basis to build upon if possible. The framework is generalized for any innovation, and thus for further research, integration of the two frameworks could be valuable. Based on the results and learnings from the application of the hybrid case, some points have been learned that could lead to an integration step. One of these learnings is that is can be interesting to integrate sustainability as a building block stage 1 of the RMD framework, or within one of the existing building blocks to include a sustainability viewpoint right from the start. The building blocks can also be defined more clearly, stating also responsibility and sustainability viewpoints in the description. For example, if the building block of production system is assessed, the description could include whether the production system can produce the product in a sustainable manner, even with certain thresholds or conditions that must be complied with in order to assess that building block as present.

Further research could include looking at ways to make an integration step to policy making in the framework. What if the output of the framework is not only strategy but also policy in how to use the strategy with the other actors that it becomes responsible in the way we work together. Also, can we integrate policy makers into this framework, where they are part of the stakeholders to collaborate with or create strategies that focus on working together with policy makers to design responsible strategies.

Marketing strategies can be further looked at, for example one specific ways of framing an innovation, in a way that it tackles the reasons why consumers do not accept the innovation. For hybrid protein, promote the product in such a way that is becomes clear ‘what is in it for me’ or how the consumer would benefit from this product, would be beneficial for the acceptance.

Appendix

Appendix 1: Overview tables

Appendix 2: Overview figures

Appendix 3: Interview questions guidelines

"What do you see as the barriers to market introduction or large-scale diffusion of cultivated protein?
"And is there a difference between hybrid and full cultivated protein?".
"Do you see hybrid product as a strategy as to introduce cultivated protein?"

"Do you agree with the following barriers, or do you feel there are barriers missing for cultivated protein?"

- Production system = scalability
  And is this for market introduction, large-scale diffusion or both?
- Network formation and coordination = regulations
  And is this for market introduction, large-scale diffusion or both?
- Product price
  And is this for market introduction, large-scale diffusion or both?
- Customers
  And is this for market introduction, large-scale diffusion or both?
- Innovation-specific institution (includes the regulations that is not supporting the innovation). = EFSA
  And is this for market introduction, large-scale diffusion or both?

"What do you see that the ultimate goal of innovators is?
"Is it to make cultivated proteins widely available/accessible, make protein products that are more efficiently and sustainably made, lower conventional meat sales?
"Are innovators acting towards that goal?"

We have been looking into the responsibilities that the innovator has. We have been looking into moral, legal and contractual responsibilities.
"What do you think are the responsibilities of the innovator in this field?"

"Do you think there is conflict between responsibilities?"
For example the responsibilities they have towards investors, vs doing what is right and sustainable. What if delivering (or making profits) is what keeps them alive, while it moves away from the initial purpose of the innovator?
"What other actors are mostly responsible for market introduction?"
"Who else could be involved to achieve this?"
"What do you think the goal of an innovator should be?"

References

Aviko Food Service. (z.d.). https://www.avikofoodservice.nl/we-bring-joy-tables-all-around-world/duurzaamheid

Ahmad, M., Qureshi, S., Akbar, M. H., Siddiqui, S. A., Gani, A., Mushtaq, M., Hassan, I., & Dhull, S. B. (2022). Plant-based meat alternatives: Compositional analysis, current development and challenges. Applied Food Research, 2(2), 100154. https://doi.org/10.1016/j.afres.2022.100154

Alberganti, S., & Zaccarian, F. (2024, 27 augustus). Same Beef, New Process: The Mosa Meat Journey with Sebastiano Alberganti and Francesco Zaccarian [Video]. YouTube. https://www.youtube.com/watch?v=tIh2tTRyxrw

Battle, M., Bomkamp, C., Carter, M., Clarke, J. C., Eastham, L., Fathman, L., Gertner, D., Kirchner, J., Harsini, F., Leet-Otley, T., & Swartz, E. (2025). 2024 State of the industry: Cultivated meat, seafood and ingredients. In *The Good Food Institute*. The Good Food Institute. Retrieved December 8, 2025, from https://gfi.org/resource/plant-based-meat-eggs-and-dairy-state-of-the-industry/

Battle, M., Carter, M., Chaudhary, A., Holst, A., Hong-Mitsui, K., La, Y., Liu, G., The Good Food Institute, Netto, M., Sharma, V., & Voldman, A. (2025). Public investment in alternative proteins to feed a growing world. Geraadpleegd op 8 mei 2025, van https://gfi.org/resource/alternative-proteins-state-of-global-policy/

Bergeijk, E. (2023). Vlees zonder dierenleed stap dichterbij: consumenten gaan kweekvlees proeven. NU.nl. https://www.nu.nl/klimaat/6271118/vlees-zonder-dierenleed-stap-dichterbij-consumenten-gaan-kweekvlees-proeven.html?referrer=https%3A%2F%2Fwww.google.com%2F

Besti, F., Samorè, F., & Fondazione Giannio Bassetti. (2018). Responsibility driven design for the future self-driving society: Autonomous systems and the complex challenges to designing a responsible, driverless future. Geraadpleegd op 25 juni 2025, van https://selfdrivingsociety.fondazionebassetti.org/wp-content/uploads/2019/01/Responsibility-driven-design-for-the-future-self-driving-society.pdf

Brundtland, G., 1987. Report of the World Commission on Environment and Development: Our Common Future. United Nations General Assembly document.

Business Wire. (2020, 1 december). Eat Just Granted World's First Regulatory Approval for Cultured Meat. Business Wire. https://www.businesswire.com/news/home/20201201006251/en/Eat-Just-Granted-Worlds-First-Regulatory-Approval-for-Cultured-Meat

Carlsson, B., & Stankiewicz, R. (1991). On the nature, function and composition of technological systems. *Journal Of Evolutionary Economics*, *1*(2), 93–118. https://doi.org/10.1007/bf01224915

Chen, L., Guttieres, D., Koenigsberg, A., Barone, P. W., Sinskey, A. J., & Springs, S. L. (2021). Large-scale cultured meat production: Trends, challenges and promising biomanufacturing technologies. Biomaterials, 280, 121274. https://doi.org/10.1016/j.biomaterials.2021.121274

Churchill, W. (1931). The Strand Magazine.

Ceicyte, J., Petraite, M., Blok, V. & Yaghmaei, E. (2021). Responsible innovation in industry: The role of firm's multi-stakeholder network. In E. Koukios & A. Sacio-Szymanska (eds.), *Bio# Futures*, (pp. 581-603). Springer, Cham, Switzerland.

Collingridge, D. (1980). *The Social Control of Technology*.

Costello, T. & Prohaska, B. (2013). Innovation, IT professional, 15:3, 62-64

Cultivate at Scale. (2025). Cultivate At Scale. https://www.cultivateatscale.com/

Dier&Recht. (2025, November 18). Onze missie en visie. https://www.dierenrecht.nl/over-dier-en-recht/onze-missie-en-visie/

De Vegetarische Slager. (2025). Ons verhaal. https://www.devegetarischeslager.nl/ons-verhaal.html

Elmadfa, I., & Meyer, A. L. (2016). Animal Proteins as Important Contributors to a Healthy Human Diet. *Annual Review Of Animal Biosciences*, *5*(1), 111–131. https://doi.org/10.1146/annurev-animal-022516-022943

Eskola, M. (2025, January 10). Novel foods in the European Union explained. Medfiles. https://medfilesgroup.com/novel-foods-in-the-european-union/

Ettinger, J. (2022, 30 januari). How Mosa Meat Ditched Fetal Bovine Serum and Bioengineering In Its Cultivated Meat. Green Queen. https://www.greenqueen.com.hk/mosa-meat-fetal-bovine-serum-cultivated-meat/

European Commission. Novel Foods. https://food.ec.europa.eu/food-safety/novel-food_en

European Commission. Food Authorisation. https://food.ec.europa.eu/food-safety/novel-food/authorisations_en

Fairr. (2023, 16 oktober). *From Niche to Norm: The Decade of Alternative Proteins*. Geraadpleegd op 22 maart 2025, van https://www.fairr.org/news-events/insights/from-niche-to-norm-the-decade-of-alternative-proteins

Ferreira, V., Fabregat-Aibar, L., Pi´ e, L., Terce˜ no, A., 2022. Research trends and hotspots in bioeconomy impact analysis: a study of economic, social and environmental impacts. Environ. Impact Assess. Rev. 96, 106842. https://doi.org/10.1016/j. eiar.2022.106842.

Finnigan, B. (2017). Buddhism and animal ethics. *Philosophy Compass*, *12*(7). https://doi.org/10.1111/phc3.12424

Genus, A., & Stirling, A. (2017). Collingridge and the dilemma of control: Towards responsible and accountable innovation. Research Policy, 47(1), 61–69. https://doi.org/10.1016/j.respol.2017.09.012

Good Food Institute. (2022, November 16). *Cultivated meat's regulatory pathway - The Good Food Institute*. The Good Food Institute. https://gfi.org/resource/fda-cultivated-meat-clearance-explainer/

Good Food Institute. (2024a). De Nederlandse retailmarkt voor plantaardige voeding. In Good Food Institute Europe (p. 4) [Report]. https://gfieurope.org/wp-content/uploads/2024/10/NL-De-Nederlandse-retailmarkt-voor-plantaardige-voeding-Oktober-2023.pdf

Good Food Institute. (2024b). Plant-based meat consumer segmentation. *Good Food Institute*. https://gfi.org/resource/plant-based-meat-consumer-segmentation/

Good Food Institute. (n.d.). *Hybrid products to optimize nutrition, taste, cost, and sustainability - The Good Food Institute*. The Good Food Institute. https://gfi.org/solutions/hybrids-blends-nutrition-taste-cost-sustainability/

Hermans, F., Van Apeldoorn, D., Stuiver, M., & Kok, K. (2012). Niches and networks: Explaining network evolution through niche formation processes. Research Policy, 42(3), 613–623. https://doi.org/10.1016/j.respol.2012.10.004

Heupel, K., Fonseca, J. A., Rutherford, M., & Edwards, B. (2024). Feeding the hype cycle: Entrepreneurial swagger, passion, and inflated expectations. Journal of Business Venturing, 39(6), 106432. https://doi.org/10.1016/j.jbusvent.2024.106432

Janker, J., Mann, S., 2018. Understanding the social dimension of sustainability in agriculture: a critical review of sustainability assessment tools. Environment Development And Sustainability 22 (3), 1671–1691. https://doi.org/10.1007/ s10668-018-0282-0.

Jones, K. (2022, 10 maart). Timeline: The Rapid Evolution of Plant-Based Alternatives. Visual Capitalist. Geraadpleegd op 22 maart 2025, van https://www.visualcapitalist.com/sp/timeline-the-rapid-evolution-of-plant-based-alternatives/

Juma, C. (2016). Innovation and Its Enemies: Why People Resist New Technologies. OUP Catalogue. https://ideas.repec.org/b/oxp/obooks/9780190467036.html

Kamp, L. M., Ortt, J. R., & Doe, M. F. A. (2018). Niche Strategies to Introduce Kite-Based Airborne Wind Energy. In Green energy and technology (pp. 665–678). https://doi.org/10.1007/978-981-10-1947-0_27

Kirby, B. P. (2023, 17 november). Italy bans lab-grown meat in nod to farmers. https://www.bbc.com/news/world-europe-67448116

Lanzoni, D., Rebucci, R., Formici, G., Cheli, F., Ragone, G., Baldi, A., Violini, L., Sundaram, T., & Giromini, C. (2024). Cultured meat in the European Union: Legislative context and food safety issues. *Current Research in Food Science*, *8*, 100722. https://doi.org/10.1016/j.crfs.2024.100722

Lever VC. (2025). A Second Generation of Cultivated Meat Companies Breaks Through Projected Cost Barriers. Geraadpleegd op 1 mei 2025, van https://www.levervc.com/wp-content/uploads/2025/04/Lever-VC-A-Second-Generation-of-Cultivated-Meat-Companies-Breaks-Through-Projected-Cost-Barriers-4.pdf

Merk, M., & Evers, P. (2023). Vleesvervangers Monitor 2023. In *Markteffect*. Geraadpleegd op 12 augustus 2025, van https://markteffect.nl/whitepapers/78

Ministerie van Landbouw, Visserij, Voedselzekerheid en Natuur. (2025, November 24). Code of Practice for Safely Conducting Tastings of innovative fermentation-based food Prior to EU Approval. Rapport | Rijksoverheid.nl. https://www.rijksoverheid.nl/documenten/rapporten/2025/11/24/code-of-practice-for-safely-conducting-tastings-of-innovative-fermentation-based-food-prior-to-eu-approval

Morais-Da-Silva, R. L., Reis, G. G., Sanctorum, H., & Molento, C. F. M. (2022). The social impact of cultivated and plant-based meats as radical innovations in the food chain: Views from Brazil, the United States and Europe. *Frontiers in Sustainable Food Systems*, *6*. https://doi.org/10.3389/fsufs.2022.1056615

Mount, D. (2022, 18 februari). *Deep dive: Plant-based meat ingredient optimization | GFI*. The Good Food Institute. https://gfi.org/science/the-science-of-plant-based-meat/deep-dive-plant-based-meat-ingredient-optimization/

Mount, D. (2023, 9 augustus). *Deep dive: Plant-based meat crop development | GFI*. The Good Food Institute. https://gfi.org/science/the-science-of-plant-based-meat/deep-dive-plant-based-meat-crop-development/

Mridul, A. (2025, 25 maart). The biased science that fuelled Italian farmers' Anti-Cultivated-Meat march. Green Queen. https://www.greenqueen.com.hk/coldiretti-farmers-italy-lab-grown-meat-cultivated-efsa-novel-foods/

Musiolik, J., Markard, J., & Hekkert, M. (2012). Networks and network resources in technological innovation systems: Towards a conceptual framework for system building. Technological Forecasting And Social Change, 79(6), 1032–1048. https://doi.org/10.1016/j.techfore.2012.01.003

Nationaal Groeifonds. (2025, July 7). Cellulaire agricultuur | Nationaal Groeifonds. http://nationaalgroeifonds.nl/overzicht-lopende-projecten/thema-landbouw-voedsel-en-land-en-watergebruik/cellulaire-agricultuur

NOS Nieuws. (2025, November 26). Schipluiden krijgt de eerste kweekvleesboerderij ter wereld. NOS. https://nos.nl/artikel/2592079-schipluiden-krijgt-de-eerste-kweekvleesboerderij-ter-wereld

NU.nl. (2016). Binnen vijf jaar betaalbaar kweekvlees op de markt. *NU.nl*.

NVWA. (2023, 27 oktober). Over de NVWA. NVWA. https://www.nvwa.nl/over-de-nvwa

OECD (2018), OECD Due Diligence Guidance for Responsible Business Conduct

Ortt, J. R., & Kamp, L. M. (2022). A technological innovation system framework to formulate niche introduction strategies for companies prior to large-scale diffusion. *Technological Forecasting And Social Change*, *180*, 121671. https://doi.org/10.1016/j.techfore.2022.121671

Ortt, J. R., Langley, D. J., & Pals, N. (2013). Ten niche strategies to commercialize new high-tech products. *ResearchGate*, 1–12. https://doi.org/10.1109/itmc.2013.7352687

Ortt, J. R., & Schoormans, J. P. (2004). The pattern of development and diffusion of breakthrough communication technologies. *European Journal Of Innovation Management*, *7*(4), 292–302. https://doi.org/10.1108/14601060410565047

Pasca, M. G., & Arcese, G. (2025). Sustainability and Quality of Cultured Meat: Consumer Perceptions. *Sustainability*, *17*(4), 1633. https://doi.org/10.3390/su17041633

Pastrana-Pastrana, Á. J., Rodríguez-Herrera, R., Solanilla-Duque, J. F., & Flores-Gallegos, A. C. (2024). Plant proteins, insects, edible mushrooms and algae: more sustainable alternatives to conventional animal protein. *Journal Of Future Foods*, *5*(3), 248–256. https://doi.org/10.1016/j.jfutfo.2024.07.004

Pearson. (2025). Responsibility. In *https://www.ldoceonline.com/*. https://www.ldoceonline.com/dictionary/responsibility

Post, M. J. (2012). Cultured meat from stem cells: Challenges and prospects. Meat Science, 92(3), 297–301. https://doi.org/10.1016/j.meatsci.2012.04.008

Quorn. (2025). *The Story of Quorn Foods | Quorn*. https://www.quorn.co.uk/company

Reinhardt, T., & Monaco, A. (2025). How innovation-friendly is the EU Novel Food Regulation? The case of cellular agriculture. Future Foods, 11, 100574. https://doi.org/10.1016/j.fufo.2025.100574

Reiss, J., Robertson, S., & Suzuki, M. (2021). Cell Sources for Cultivated Meat: Applications and Considerations throughout the Production Workflow. International Journal Of Molecular Sciences, 22(14), 7513. https://doi.org/10.3390/ijms22147513

RESPECTfarms. (2025). RESPECTfarms. Geraadpleegd op 3 juni 2025, van https://www.respectfarms.com/about-us

Rödl, M. B., Boons, F., & Spekkink, W. (2021). From responsible to responsive innovation: A systemic and historically sensitive approach to innovation processes. Technological Forecasting And Social Change, 174, 121231. https://doi.org/10.1016/j.techfore.2021.121231

Rogers, E. M., Singhal, A., & Quinlan, M. M. (2005). Diffusion of Innovations. In *An integrated approach to communication theory and research* (2de editie). https://www.taylorfrancis.com/chapters/edit/10.4324/9780203887011-36/diffusion-innovations-everett-rogers-arvind-singhal-margaret-quinlan

Rosenfeld, D. L., & Tomiyama, A. J. (2023). Toward consumer acceptance of cultured meat. *Trends in Cognitive Sciences*, *27*(8), 689–691. https://doi.org/10.1016/j.tics.2023.05.002

RVO [Rijksdienst voor Ondernemend Nederland]. (2022, 4 januari). *Public-private partnerships*. RVO.nl. http://english.rvo.nl/topics/public-private-partnerships

Schuttenhelm, R. (2020). Fabrikanten willen “Kweekburger” binnen vijf jaar in Nederlandse supermarkt. NU.nl. https://www.nu.nl/ondernemen/6081958/fabrikanten-willen-kweekburger-binnen-vijf-jaar-in-nederlandse-supermarkt.html

Sonck, M., Asveld, L., & Osseweijer, P. (2019). Meta-Responsibility in Corporate Research and Innovation: A Bioeconomic Case Study. *Sustainability*, *12*(1), 38. https://doi.org/10.3390/su12010038

Sonck, M. (2023). A framework to identify and coordinate responsibilities in industrial research and innovation. In Research Repository (Delft University of Technology). https://doi.org/10.4233/uuid:df45d4e5-0504-470e-b7e6-0fa3d5231709

Southey, F. (2023, 10 januari). *Blending meat and mycoprotein: New hybrid products prepare to enter European market*. FoodNavigator.com. https://www.foodnavigator.com/Article/2023/01/10/blending-meat-and-mycoprotein-new-hybrid-products-prepare-to-enter-european-market/

Swartz, E. (2024, 5 november). Deep dive: Cultivated meat cell lines | GFI. The Good Food Institute. https://gfi.org/science/the-science-of-cultivated-meat/deep-dive-cultivated-meat-cell-lines/

Taebi, B., Correljé, A., Cuppen, E., Dignum, M., & Pesch, U. (2014). Responsible innovation as an endorsement of public values: the need for interdisciplinary research. *Journal Of Responsible Innovation*, *1*(1), 118–124. https://doi.org/10.1080/23299460.2014.882072

Tavan, M., Smith, N. W., McNabb, W. C., & Wood, P. (2025). Reassessing the sustainability promise of cultured meat: a critical review with new data perspectives. *Critical Reviews in Food Science And Nutrition*, 1–9. https://doi.org/10.1080/10408398.2025.2461262

Thavamani, A., Sferra, T. J., & Sankararaman, S. (2020). Meet the Meat Alternatives: The Value of Alternative Protein Sources. *Current Nutrition Reports*, *9*(4), 346–355. https://doi.org/10.1007/s13668-020-00341-1

The Dutch Research Council. (2023). From sustainable high-tech to better plant-based nutrition: 35 million euros for technological innovation. The Dutch Research Council (NWO). https://www.nwo.nl/en/news/from-sustainable-high-tech-to-better-plant-based-nutrition-35-million-euros-for-technological-innovation?utm_campaign=nwo-nieuwsbrief&utm_content=2023-24&utm_medium=newsletter&utm_

The Open University. (1999). *Innovation and the S-curve*. https://www.open.edu/openlearn/nature-environment/organisations-environmental-management-and-innovation/content-section-1.7

Timotijevic, L., Hodgkins, C. E., Peacock, M., & Raats, M. M. (2021). Conceptualizing responsibility in food research and innovation to promote healthy and sustainable food systems. *Frontiers in Sustainable Food Systems*, *5*. https://doi.org/10.3389/fsufs.2021.584566

Toribio-Mateas, M. A., Bester, A., & Klimenko, N. (2021). Impact of Plant-Based Meat Alternatives on the Gut Microbiota of Consumers: A Real-World Study. *Foods*, *10*(9), 2040. https://doi.org/10.3390/foods10092040

Tricou, A. (2024, 21 november). Breaking Barriers: EU court decision boosts transparency in Plant-Based Food labelling. RegASK. https://regask.com/eu-plant-based-food-labelling/

Van de Poel, I., Royakkers, L., & Zwart, S. D. (2015). *Moral Responsibility and the Problem of Many Hands*. https://doi.org/10.4324/9781315734217

Van de Rijdt, T. (2025b, januari 22). *Submitting our first EU market authorisation request — Mosa Meat*. Mosa Meat. https://mosameat.com/blog/submitting-our-first-eu-market-authorisation-request

Van der Toorn, M. A. (2025). *Shaping consumer acceptance of alternative protein: The impact of bioengineering and health messaging on mycoprotein acceptance* [Master's Thesis, Technical University of Delft]. https://resolver.tudelft.nl/uuid:9f18ca71-363c-42d3-bd5b-087b7cccb0f4

Vegetarische Slager mag geen vegetarische "kip" en "speck" meer verkopen. (2017, 3 oktober). *BNNVARA*. https://www.bnnvara.nl/joop/artikelen/vegetarische-slager-geen-kip-speck

von Schomberg, R. (2011b). The quest for the "right" impacts of science and technology. An outlook towards a framework for responsible research and innovation.

Von Schomberg, R. (2013). "A vision of responsible innovation". In: R. Owen, M.

Heintz and J Bessant (eds.) Responsible Innovation. London: John Wiley, forthcoming

Watson, E. (2025, 8 januari). Vow becomes third company to launch cultivated meat, but it isn't starting with chicken nuggets. AgFunderNews. https://agfundernews.com/vow-becomes-third-company-to-launch-cultivated-meat-but-it-isnt-launching-with-chicken-nuggets

What Is Cultivated Meat. (2023). How is cultivated meat made? Geraadpleegd op 22 maart 2025, van https://www.whatiscultivatedmeat.com/process

Williams, A. (2024, 24 oktober). Market insights on European plant-based sales 2020-2022 - GFI Europe. GFI Europe. https://gfieurope.org/market-insights-on-european-plant-based-sales-2020-2022/?_ga=2.7657204.715137571.1748598127-1672935674.1748598122#netherlands

Ye, Y., Zhou, J., Guan, X., & Sun, X. (2022). Commercialization of cultured meat products: Current status, challenges, and strategic prospects. Future Foods, 6, 100177. https://doi.org/10.1016/j.fufo.2022.100177