

Academic Consultancy Training

Exploring Alternatives: Operationalisation of New Economic Paradigms for Fossil Free Agriculture on an Organic Farm



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1. INTRODUCTION

In a global and regional scale, the agrifood system is a major driver of ecological destruction (Poore & Nemecek, 2018; Springmann et al., 2018). Agrifood systems contribute to biodiversity loss, soil degradation, water depletion, greenhouse gas (GHG) emissions, and water and air pollution (Müller et al., 2017; Poore & Nemecek, 2018; Springmann et al., 2018; Willett et al., 2019). Poore & Nemecek (2018) calculate that 26% of anthropogenic GHG emissions are from the agrifood industry. This is due to the dominance of the agricultural sector in resource usage, including land use. These impacts are expected to increase by 50-90%, with the greatest increase being 80-92% of GHG emissions, if there are not necessary changes made to our agricultural system (Springmann et al., 2018). As these impacts risk pushing the world past its ecological boundaries it is essential that we address the agrifood system as a major contributor to multiple ecological boundaries (Springmann et al., 2018). Concerning the agricultural sector in Europe, production is also increasing to comply with the increasing demand (Verburg et al., 2022). This sector must deal with challenges beyond the extremes posed by environmental and climate factors such as drought, cold, pests, and diseases, which are putting food security under considerable pressure (Blom-Zandstra & Gremmen, 2012). It must also address issues within its own system which are contributing to the very factors putting food security at risk.

The neoliberal economic paradigm is viewed by many as destructive to the planet (Fremstad & Paul, 2022; Martínez-Alier, et al., 2010; Stevens, 2011). In order to create an agrifood system which supports the regeneration of the ecological processes for which it relies, the implications of alternative economic paradigms are being researched (McGreevy et al., 2022). This paper explores three alternative scenarios: green growth, agrowth, and degrowth. We examine what each of these alternative economic paradigms means, how they are applied in the agricultural context, and how to operationalise them to observe their potential future impacts. Each of these economic paradigms has a common goal: to replace the current neoliberal economic system with a sustainable alternative. Where they differ is in their assumptions about what the issue with the current system is and what changes are required to improve it. There is then a case study focused on an organic farm located in Drenthe, who has a practical goal of reducing fossil fuel usage by 25% over the next four years.

The following are the two main questions that will aid us with the project and deliver results (with the addition of some examples of sub-research questions that would help us in getting to the results):

1. Theoretical purpose-related question: How can "green growth", "agrowth", and "degrowth" be operationalized in the context of Dutch agriculture?
 - a. What is the role of agriculture according to the different paradigms?
 - b. What are the quantifiable elements of these paradigms and what are not?
 - c. What are the differences between these paradigms in terms of both core beliefs and operationalization processes?
 - d. To what extent are the main features of the concept of sustainability or transformative change internalized in the different economic paradigms?
 - e. What are the trade-offs and limitations in terms of implementation of such paradigms?
2. Practical purpose-related question: How can weed control be carried out differently on an organic farm that wants to reduce its fuel consumption?
 - a. What alternatives do already exist in terms of weed management practices in organic farming?
 - b. What does weed management look like under different economic paradigms?
 - c. What are the trade-offs between different weeding control practices?

Due to the double nature of the issue at stake, meaning the distinction between theoretical and practical problems that represents different sides of the same coin, the report follows the logic from the general to specific. This means that from general considerations resulting from the literature review on the paradigms the level of specificity narrows down, first at the general level of Dutch farmers, finally at the specific level of the case farm. The general part reflects the theoretical issue, meaning the operationalization of the different paradigms (Output 1) and the transition pathways based on the theoretical results, since it focuses on the economic system on a broader level. On the contrary, the specific part addresses the practical problem of alternative weeding methods (Output 3), that focuses exclusively on the farm level. Halfway between the theoretical and the practical problem, or in between the general and the specific, there's the farmers' self-assessment tool. It is halfway because it follows up the theoretical results of the paradigms table to provide guidelines and criteria for the development of a self-assessment tool for the potential practical implementation of alternative farming techniques, and because it is meant to be used by farmers in general. Hence, it exploits theoretical concepts to stimulate the finding of practical solutions for the broader category of Dutch farmers. A graphic representation of the general to specific rationale used for this report can be found in Figure 1.1

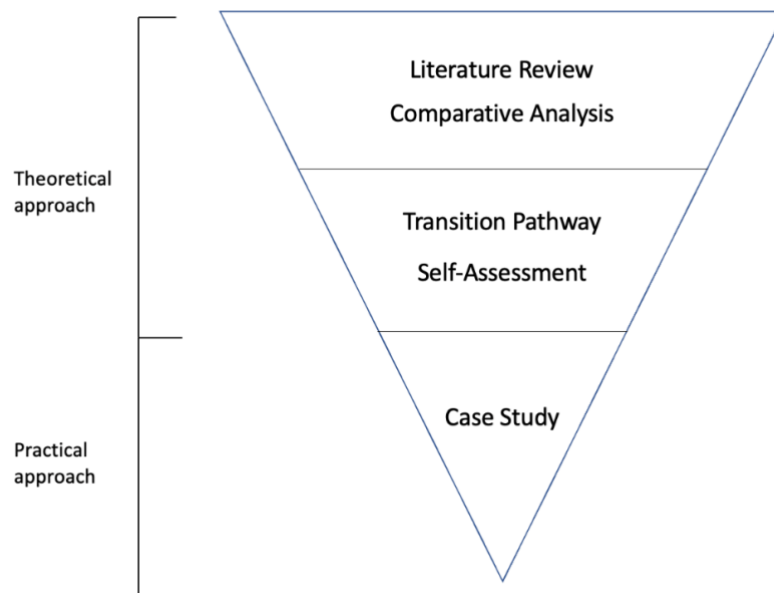


Figure 1.1. Top-down deductive structure

1.1. METHODOLOGY

The methodology used was predominantly based on literature reviews related to the current state of Dutch agriculture and the three paradigms explored in this report. The purpose of such literature review on green growth, degrowth, and agrowth was to spark a discussion among the team members so that common points and differences between the three would be evident. Beyond a literature review, we also reached out to relevant people and organizations working on sustainable agriculture and food systems, mainly to get insight on alternative weeding practices relevant to our case study. For each of our outputs, the methodology used are explained below:

Comparative Analysis

To compare the three economic paradigms, differences, and common points that refer to broader semantic fields are ultimately broken down into indicators. The macro indicators cover a wide range of dimensions that are too large to be adequately operationalized and quantified alone. The micro indicators hence were chosen as different facets of the broader dimension that can point out specific differences or common points between the three paradigms.

Following a thorough literature review, our initial brainstorming session highlighted prominent and distinct differences among the paradigms. Notably, these disparities revolved around the level of market orientation in farming practices (economic dimension), the intensity of material usage in agricultural activities (ecological dimension), and the concept and utilization of labour (social dimension). We also consider various existing discourses on sustainable development, particularly within the agriculture sector. For example: Sustainable Development Goals (SDGs) indicators in the context of agriculture, OECD's green growth indicators, Kate Raworth's Doughnut Economy theory, and EU's Pathway regarding sustainable food system.

These considerations were furtherly enriched with dominant principles and underlying assumptions that we identified underpinning the different paradigms. Examples of such principles and assumption are the notion of efficiency and sufficiency, the rebound effect (also known as Jevon's paradox), ownership and commoning, and the concept of food security. Details on this assumption of indicators can be found in Section 3.1. Operationalization.

Transition Pathway

The transition pathways were based on our literature review of the different paradigms; however, we were also looking into relevant and current literature to develop the building-blocks of our transition pathway. We used four building blocks—technology, market, policy, and value chain—for each of the proposed economic paradigms to formulate the transition pathway. We utilized the EU's transition pathways for legume production (van Ruitenbeek et al., 2022) to determine these essential elements because they are pertinent to the agricultural practices used in The Netherlands today. The definition of these building blocks can be found in Section 3.3 Transition Pathways.

Self-Assessment Tool

The self-assessment tool for the farmers is based on the indicators defined on the comparative analysis and the general information of individual farmers (e.g. type of farm, scale, kind of practice, etc). We created questions and guidelines specifically designed to classify farmers by which economic paradigm best serves their objectives. Based on the size and kind of production of the farms, clusters are created, and a unique self-assessment instrument is produced for the category the farm we're in contact with belongs.

To ensure a thorough assessment, the questions touch on topics such as labour use, ecosystem services, market orientation, material throughput, and contribution to food security, all of these are based on the indicators we come up with in the comparative analysis. Farmers' agreement or

disagreement is measured using statements or Likert scales, and questions are phrased to avoid bias by specifically excluding any reference of the paradigms. This approach fosters a customized roadmap for sustainable farming practices by enabling a detailed knowledge of farmers' perspectives.

Case Study Implementation

In the context of applying operationalization of different paradigm to the case study of organic farmer in Drenthe, Netherlands. We did a combination of desk study and series of interviews with experts. To learn about alternate weeding techniques, we reached out to non-governmental organizations focused on agrifood systems. To gain information into alternate weeding strategies' efficacy, environmental impact, and adoption issues, we posed a set of questions. The inquiries centred on identifying practices for an alternative economic paradigm—such as green growth, agrowth, and degrowth—that are in line with sustainable agriculture paradigms. The two main questions were how to reduce reliance on fossil fuels and reduce manual labour for weed control.

1.2. LIMITATIONS

It is necessary to recognize and openly address some of the limitations that come with our research as we examine the results of our study. To appropriately interpret the findings and offer a full understanding of the scope and implications of our project, we recognized several limitations from our study:

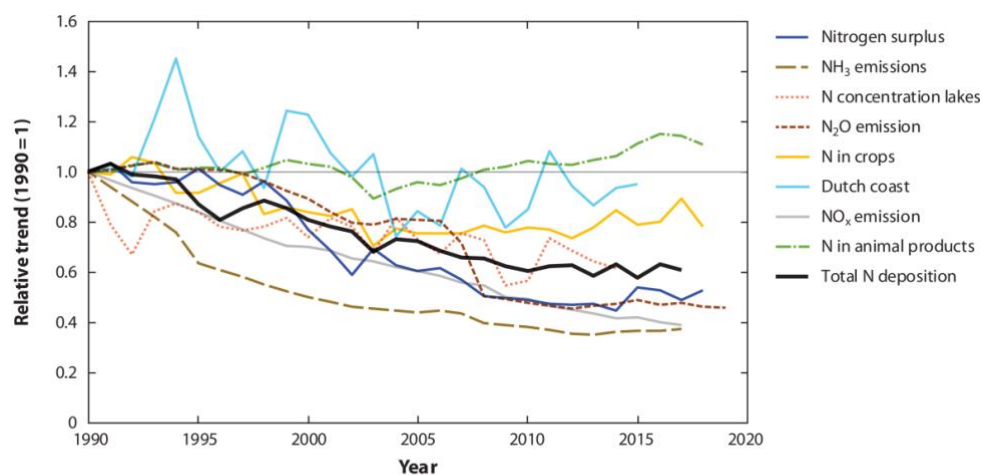
- Compared to green-growth, discourses on post-growth, including degrowth and agrowth have primarily existed at a conceptual and abstract level, lacking the development of concrete and coherent strategies (Frontiers, n.d). This poses a notable challenge on our comparative analysis and transition pathway that seeks to operationalize these three paradigms under different economic, ecological, and social indicators. The limitations of the existing strategic frameworks (and/or for agrowth case; still lack of theoretical base) could affect our study's granularity and depth.
- The self-assessment tool for farmers has limitations related to dynamic issues, such as shifting challenges, different types of soil, and other elements that may make farmer clustering more difficult. Furthermore, it's possible that the threshold of 10 hectares that defines smallholders does not quite fit the Dutch environment, so it's worth looking into alternative thresholds. This distinction is important since the management of smallholder farms frequently varies greatly from that of bigger farms. Additionally, the interpretation of the results must consider the subjectivity introduced by potential biases in the responses, such as protest answers and social desirability.
- Stakeholder analysis in this project was conducted based on desk-study, utilizing sources such as press releases or relevant paper and not based on a thorough analysis involving the actual actors (e.g. interviews, focus group discussion) due to limited time and human resources. In further study, a combination of these two methods could increase the reliability of the stakeholder analysis.
- Our team's knowledge is another constraint because we do not have any agronomy specialists on staff.
- None of the team members is from the Netherlands, so our knowledge of local context and language is limited.

2. LITERATURE REVIEW

2.1. DUTCH AGRICULTURE

The Dutch agricultural sector is the most productive and efficient agricultural sector of the EU per unit of land (van Grinsven et al., 2019). Specifically Dutch horticulture, which is one of the most intensive production systems globally, has been characterized by intensification since the 1950s, by adopting a model of increased inputs of fertilizers, pesticides, and energy (Ahovi et al., 2021). The high economic efficiency of the Dutch agricultural sector came as a result of high amounts of these inputs and other supplements such as imports of animal feed. Despite the fact that many GHGs were on the decrease, there was an overall stagnation due to an increase in methane emissions by the growth of dairy livestock and dairy production (van Grinsven et al., 2019). Due to the intensity of dairy farming, the Netherlands has the highest surplus of nitrogen (N) per hectare of agricultural land in the EU and Dutch cows have the highest N emissions per cow (Zhu & Oude Lansink, 2022). Environmental pressures are increased in the Netherlands because of the imports from other countries, which are driven by Dutch consumption and production of agricultural goods (Figure 2.1) (Donati & Tukker, 2022).

The Dutch nitrogen crisis has come as a consequence of high animal densities and of high fertilization levels that led to percolation of N into the ground and water. NH_3 emissions from agriculture in 2018 had the dominant share of 87% of total emissions among including other fields, with a minor share on NO_x at 17%. Moreover, the emissions of N_2O from agriculture reached the 74% and the losses of N in groundwater and surface water the 55% (de Vries et al., 2022). Farmers' strong representation in lobbies had as a result the limitation of policies that aimed to nitrogen levels reduction, but also increased costs for them. Especially the MINAS directive made farmers realise that there is an overuse of nutrients and an economic loss for them, but the fear of another hunger winter after World War II discouraged policies that reduce food production, with farmers promoting slogans like "no farmers, no food" (Galloway et al., 2021). Even though the Netherlands reduced the ammonia emissions by 60% over the past 3 decades, the ruling of the European court in 2018 required further reduction of N_x emissions and the State Council of the Netherlands characterised the Dutch nitrogen policy as ineffective (Erisman, 2021). The reduction that was observed on the emissions from ammonia came as a result of the reduction of fertilizer inputs and of the implementation of low-input fertilization techniques (Galloway et al., 2021).



Galloway JN, et al. 2021
Annu. Rev. Environ. Resour. 46:255–88

Figure 2.1 Trend in Nr pollution indicators in the Netherlands relative to 1990. Data from the Environmental Data Compendium (71) (Galloway et al., 2021)

With high amounts of exports to other countries, the Netherlands is the second largest exporter of agricultural products globally, after only the US, with an agricultural export of EUR 95.6 billion (over 10% of GDP) (Donati & Tukker, 2022). In 2019, the Dutch trade surplus exceeded 30 billion euros for the first time, with the total value exceeding by 45% the value of 2008. Most exports ended up in neighbour countries (Germany, Belgium, United Kingdom, France), with the most exported products being ornamentals, meat, dairy and eggs, vegetables, and fruit, reaching 43% of total exports, resulting in a trade surplus. Therefore, Dutch agricultural industry imports are mostly agricultural services related to the processing or alternation of goods (Jukema et al.,2020). As a result of the intensified agricultural trade, Dutch agriculture broadens its environmental impact even outside the national borders, with adverse effects being impacts on the environment and on biodiversity (Verburg et al.,2022). Studies have shown that there has been an immense biodiversity loss due to the land that is used for agricultural production. More specifically, 86% of at-risk species are endangered by agriculture, which points out the disruption occurred to the environment by the agricultural sector (Donati & Tukker, 2022).

Depletion of fossil fuels constitutes one of the most pressing sustainability issues (van Grinsven et al., 2019). Agriculture contributes to the consumption of fossil fuels and therefore to the rise of CO2 emissions (Bos et al., 2014). More specifically, Dutch horticulture contributes to the total national GHG emissions at 14% (Los et al., 2021). It has also been measured that energy inputs constitute a large share of the total inputs, which results in the 20% of the total production cost (Los et al., 2021). To comply with the Paris Climate Agreement, the agricultural sector needs to reduce emissions by 3.5 M tons by 2030, with the relative target about GHG emissions to reach 11% (van Grinsven et al., 2019). The goal is to reduce the GHG emissions by 49% by 2030 and by 95% by 2050, compared to the levels of 1990, but there is no strict regulation that forces Dutch glasshouse horticulture producers to quit using gas in production on the short term (Los et al.,2021). Figure 2.2 illustrates the proportion of greenhouse gas (GHG) emissions attributed to Dutch agriculture.

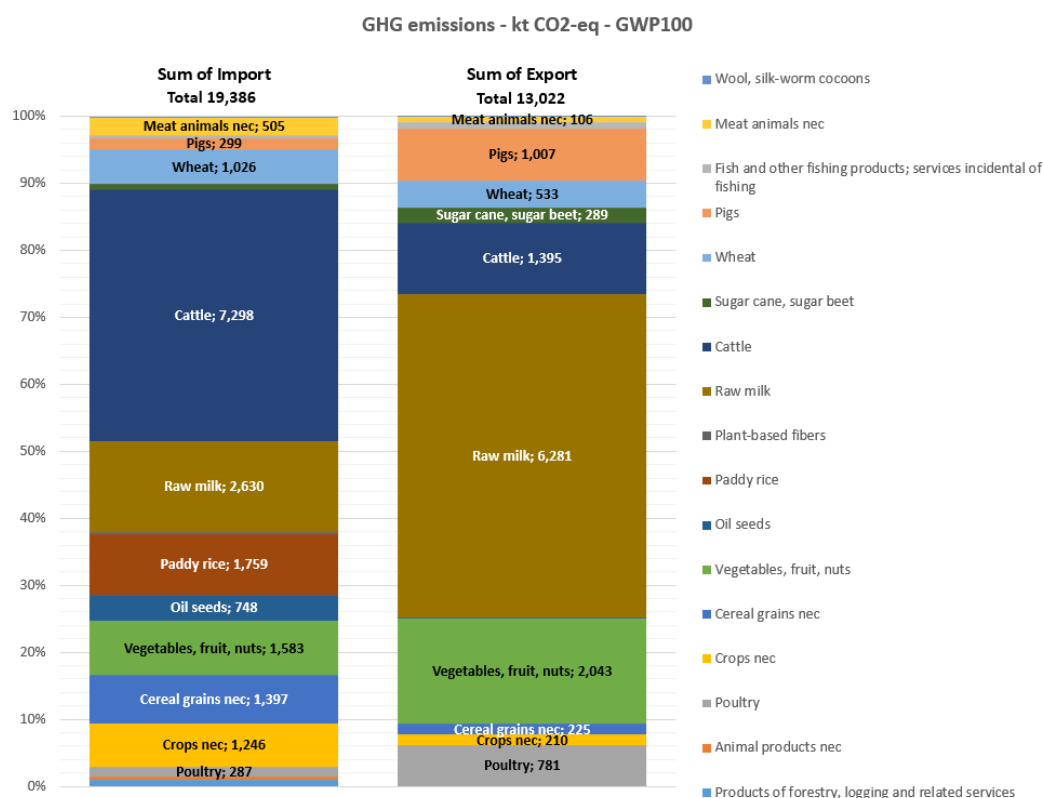


Figure 2.2. Agricultural share for GHG emissions in agricultural exports and imports in the Netherlands (Data: EXIOBASE V3 year 2011) (Donati & Tukker, 2022)

Even though energy use per unit of milk in dairy was 25% lower in Dutch organic dairy rather than in conventional. However, this is not the case for organic crop production. More specifically, in organic arable farming the percentages of energy usage reach 10%-30% and in organic vegetable farming 40%-50% more than the conventional (Bos et al., 2014). Many steps have been taken to achieve a more sustainable agriculture system, as many Dutch horticulture firms have invested in energy saving technologies such as heat storage, co-generators, and energy screens. The combined heat and power (CHP) has also been widely adopted in Dutch horticulture, so that heat that is generated is not lost, but used for other purposes (Los et al., 2021).

Meerburg et al. (2009) say, "From the end of the 1970's, environmental problems became increasingly evident in the Netherlands: pollution of drinking water with nitrate, saturation of soils with phosphate, loss of biodiversity, and radical changes in traditional anthropogenic Dutch landscapes." Since it became necessary for Dutch farmers to prioritize efficiency and increase the size of their farm, while minimizing the labor used per hectare, a majority of Dutch society gradually lost connection with agricultural production (Meerburg et al., 2009). In the 1980s, the presence of adverse environmental impacts emerged the introduction of policies to prevent and mitigate the impacts. Many Dutch policies aimed to reduce water and air pollution (van Grinsven et al., 2019). Despite the commitment of the Dutch government in the last decades to create a more sustainable agricultural system, several technical inefficiencies have been reported. More specifically, there have been recorded considerable inefficiencies in the use of variable inputs among Dutch indoor vegetable farms, with the highest scores in pesticides (Ahovi et al., 2021).

It is also worth mentioning that Dutch agricultural sector is also characterised by the co-existence of small family farms and large industrial farms with a more distinct organizational structure. There are also different categories depending on the quality of the final product, as some of them target more niche markets and others aim to produce standard products, at the lowest possible cost (Los et al., 2021). Moreover, innovation plays an important role which led to high tech greenhouses that enabled Dutch businesses to better serve local wishes and requirements (Jukema et al., 2020). At the same time, a difference in the farm payments deriving from Common Agricultural Policy (CAP) was presented, as farm payments per type ranged from 90 euros per hectare on horticulture farms to 610 euros per hectare on starch potato farms. The payments differed also among dairy production farms (Helming & Peerlings, 2014).

2.2. ECONOMIC PARADIGMS

2.2.1. THE NEOLIBERAL ECONOMIC PARADIGM

Since the 1970's, production, gross domestic product (GDP), and material throughput have grown exponentially (Wiedmann et al., 2020). There are varying views on whether this growth is the key to our prosperity or is in fact detrimental to our social and ecological balance (Hickel & Sta, 2019). A vast and unequal accumulation of wealth has brought on a process of global social and ecological deterioration (Wiedmann et al., 2020). The main criticism of the current neoliberal capitalist system is that it has allowed businesses to produce at rates that far exceed the planet's carrying capacity. By being reliant on continuous growth, the economic system accelerates the depletion of resources and, as a result, increases carbon emissions (Kallis et al., 2018).

Neoliberalism has a major role in the continuation of global warming and the urgent need for radical alternatives to neoliberalism to prevent global warming disasters (Klein, 2014; Aronoff, 2021). According to Fremstad & Paul (2022), neoliberalism has hindered attempts to tackle environmental problems by using ideological justifications such as:

1. *Decentralized democracy*: neoliberal scholars subjected governments to the same economic forces as businesses and people, exacerbated the problem of climate change. The decentralization of democracy has weakened action on climate change by placing the burden

of public goods onto smaller jurisdictions that lack the financial capacity and regulatory resources. This can be problematic since the global nature of the climate crisis requires action at the global or at least nation-state scale (Ostrom et al, 1999).

2. *Defund public investment:* Neoliberals rejects the notion that the state plays a vital role in supplying public goods and regulating the economy. Investments made by the government are seen as costly and inefficient, which discourages public spending and encourages private investment.
3. *Deregulate the economy:* Neoliberalism undercuts the role of government regulation by characterizing rules as unnecessary "red tape." Neoliberals argue that restrictions undermine the economy and drive up costs for businesses, rather than serving as instruments for shaping markets.

Unsustainable commodity consumption stems from globalization under neoliberal capitalism, which is propelled by the relentless pursuit of economic growth and has detrimental effects on the environment and society (Latouche 2009; Lawrence & Smith, 2020). In the agricultural and food system context, evidence for this criticism includes the rise in undernourishment worldwide, the effect of climate change on food production, and the projected doubling of food waste by (FAO/OECD, 2012). A primary cause of environmental problems, agriculture also has to deal with problems including deforestation, substantial greenhouse gas emissions from animal supply chains, harm from climate change, and the economic effects of droughts (Carolan, 2012).

One major reason why many people and politicians are reluctant to genuinely embrace climate policy is the fear that strict regulations will impede future economic growth (van den Bergh, 2017). Many ecological economists believe that uncontrolled economic growth, rather than neoliberalism alone, is the primary cause of climate change and environmental damage (Fremstad & Paul, 2022). Proponents of a different economic paradigm based on degrowth argue that it is necessary to break away from the idea of constant growth (Li, 2020), while some propose pathways allowing for growth while constraining global warming to under 2°C (Arias et al., 2021). These different views about growth are diverse among scholars, reflecting a spectrum of perspectives on the intersection of economic growth and environmental sustainability. In the next sections, we will explore these different viewpoints in more detail.

2.2.2. GREEN GROWTH

Green growth is seen as an ecologically sustainable approach to GDP growth which incentivises using renewable energy and energy efficiency, all the while increasing productivity (D'Alessandro et al., 2020). This approach strives for infinite GDP growth and believes that it can solve welfare and other societal problems (Wiedmann et al., 2020), while being fully in line with the ecology of our planet (Hickel & Kallis, 2020). This is done through private sector investments, state-imposed policies that support energy efficiency, and discontinuing fossil fuel subsidies (Obama, 2017). The theory has been internationally recognised -differing marginally- by the World Bank, OECD, and UNEP, and is a part of the Sustainable Development Goals (Hickel & Kallis, 2020; OECD, 2011; UNEP, 2011, World Bank, 2012). Proponents of green growth believe that we can continue to increase GDP growth and prosper by adopting sustainable policies (UNEP, 2011). In other words, that we can decouple economic growth from environmentally destructive activities, like GHG emissions (Obama, 2017).

Martinez-Fernandes et al. (2013) note the Netherlands, along with Belgium and Luxembourg, are expected to have good opportunities for making breakthroughs in green technology and innovation due to a well-educated workforce, although high labour costs hinder them. The constant threat of sea-level rise can also be a driving force towards innovation (Martinez-Fernandez et al., 2013). On the national scale, the Netherlands have experienced partial decoupling in terms of GHG, material use, consumption, and energy efficiency, but production has in some cases moved off-shore, leading to higher GHG numbers abroad, detrimental to global green growth (Belde et al., 2011). Material

and energy “environmental productivity” has increased only moderately when taking international flow of goods and CO₂ into account (Belde et al., 2011). Despite all this, the Netherlands measured in 5th place overall in terms of green growth out of 46 countries measured in 2015 (OECD, 2017). This can widely be credited to high material productivity, CO₂ productivity, and low income inequality compared to the countries (OECD, 2017). It is noted that the Netherlands, in terms of *land consumption* and *environmentally adjusted multifactor productivity growth*, fared way worse (OECD, 2017), being lower than some of the overall bottom five countries in this regard.

In agriculture, green growth can help modernise agricultural practices and level the prosperity of rural farmers (Huang & Xiong, 2022). Low fuel prices and current agricultural subsidies reassure the short-term profitability of conventional farming, which hinders the profitability of green growth and green energy (Bouma & Berkhout, 2015; Obama, 2017). Green growth can improve input efficiency and management of resources, increasing farmers’ revenues (Stevens, 2011). In terms of efficiency however, the elephant in the room within the agrifood system is meat production. The production of meat, especially red meat, widely uses feed fit for human consumption, such as grains or soy, with the conversion rate for a kg of grain to a kg of beef can be up to 21,7:1 (Cassidy et al., 2013). A 70% increase in food calories available for human consumption is expected if crops were only grown for that purpose (Cassidy et al., 2013). It should therefore be in green growth’s interest to reduce beef consumption, for the sake of efficiency. In their green growth indicator report, the OECD (2017) mentions possible gains in a changed diet, with red meat as one example, but nothing on how and why. But this is on a regional or global level.

If we go back to the farm and field level, a change of the management of farm resources might come with a cost in the short term, but for the long term it gives better economic returns (Stevens, 2011). Improved management of land should improve the water retention and nutrient content of the soil, reduce crop losses due to polluted water, erosion, and pesticide resistant pests (Stevens, 2011). Sequestering soil organic carbon has increased yields and productivities of farms (Stevens, 2011). Conserving biodiversity, and consequently genetic diversity, can keep open the possibility of new breeds (Stevens, 2011). Conserving this agricultural biodiversity can yield better productivity, soil nutrient contents, pollination of crops, and hydrological functioning (Stevens, 2011). These are all prime indicators reminiscent of Daily’s (1997) outlining of ecosystem services.

Small and medium-sized farms need income from other sources as a supplement to their livelihoods (Stevens, 2011). The report claims “structural disadvantages” to small- and medium-sized farming (Stevens, 2011), such as the economy of scale, when compared to larger farms. Stevens (2011) presses that income diversification *should* take place, which can be done through investing in goods and services such as organic food, renewable energy, and eco-tourism, potentially creating green jobs. For a Dutch example, the government wants dairy farmers to generate electricity (Ministrie van Economische Zaken en Klimaat (MEZK), 2020) This proposed operational model according to green growth presented in Table 2.1.

Table 2.1. Differences between Conventional Agriculture and New (Green Growth) Agriculture

	Conventional Agriculture	New Agriculture
Driving forces	Population growth & food demand Economies of scale Productivity increases	Market liberalization Environmental protection Consumer preferences
Products	Food Feed Fiber	Renewable energy Eco-services High value-added chemicals
Organization	Intensive Large-scale Labor-saving Yield-enhancing	Extensive Smaller-scale Labor-intensive Quality orientation
Practices	Land tillage Chemical inputs Animal hormones	Organic farming Nutrient balancing Precision farming
Technologies	Mechanization Agrochemicals Enhanced seeds and breeds	Biotechnology Information technology Integrated technologies

Source: Stevens (2011) p.35.

If this new agricultural system is to be realized, re-training of farm workers must take place (Piao et al., 2021; Stevens, 2011). Stevens (2011) suggests that trade tariffs be reduced or abolished, to further increase technological spread and sustainable agriculture, that is more specialised to their respective climate. There are other ways to reduce pressure on farm resources, such as buying farmland to conserve it, or paying farmers to disincentivise commercial production, as is practiced by the WTO (Stevens, 2011). So does incentivising farm restructuring towards more environmentally friendly practices (Stevens, 2011). Public and private investors have already gotten their money's worth by investing in water management (Stevens, 2011). It is also within green growth ideology to give payments to farmers for providing ecosystem services (Stevens, 2011). With good management via green growth ideas, rural economies will thrive, and social welfare of farm families will increase, as social welfare and environmental protections are intrinsically linked in a way that the ecosystem services benefit rural communities (Stevens, 2011). Stevens (2011) presses that a change in government subsidies should take place in order to better support small-medium sized farms. To move away from subsidies based on input and output levels, in order to increase equality among farms' income and reduce pressure on the environment. Otherwise, the larger farms will continue to outcompete the smaller ones. Other ways to increase feasibility of smaller, greener farms is with eco-labelling (Stevens, 2011).

To measure the success of green growth, the OECD has made indicators, first developed in the 1990's (OECD, 2017). They have since been updated and expanded and are, as of 2017, a total of 51 indicators, covering social, economic, and environmental categories (OECD, 2017). However, not all of them fit within the framework of Dutch agriculture. Some can be used, such as: soil resources, land resources, water productivity, material productivity, and CO2 productivity. These indicators will then be further explained in chapter 3.1.

Green growth in agriculture has been tried with various success. In Brazil, an ambitious plan was made in 2010 to reduce GHG emissions in agriculture with technological solutions (Piao et al., 2021). But it "...did not address the main components of the literature of green growth policies..." (Piao et al., 2021). The plan also had a lack of training personnel and lack of imbursement for implementing

the sustainable agricultural systems (Piao et al., 2021). This was a top-down prerogative, since localities did not take part in the creation of the plan (Piao et al., 2021).

In the Dutch agricultural sector, Belde et al. (2011) note that absolute decoupling has taken place in terms of two OECD indicators back towards 1990's levels: water usage and "agricultural nutrient surpluses". However, commercial fertiliser use in agriculture has not decreased enough, according to OECD's (2017) newest report on Green Growth indicators, and other indicators are also lacking. In 2020, OECD released a report titled *Beyond Growth*, suggesting alternatives to the Green Growth. Two alternatives will be presented in the next two chapters.

2.2.3. AGROWTH

Agrowth advocates focusing on sound environmental, social, and economic policies regardless of how they affect economic growth, and even suggesting that GDP be ignored or even "abolished" as a welfare and progress measure. To have an agrowth mindset is to be "agnostic" or indifferent to economic growth (van den Bergh, 2011), as outlined in Raworth's (2017) book of *Doughnut Economics*.

The agrowth paradigm has been critical about the GDP indicator, stating that it does not effectively capture social welfare. First, GDP is only an estimate of the costs and not the benefits of market-related activities while it excludes informal or non-market activities. Second, economic theory does not offer any support for GDP as a measure of social welfare (van den Bergh, 2009). Third, based on the studies on subjective well-being, most economically developed nations saw a consistent pace of GDP growth in 1950 – 1980, but the increase in mean welfare stagnated or even reversed into a negative trend during the same period (Layard, 2005). Fourth, a wide range of circumstances affect a person's happiness or well-being. These include the demand for basic commodities and services as well as development in social standing, comparatively constant income, and efficient adaptability to both economic and physical changes. Therefore, it is unlikely that GDP, which is the cumulative of incomes, will be a reliable estimate of social welfare. Fifth, the use of natural resources and the environment is a significant subcategory of unpriced consequences of growth, indicating that GDP does not adequately account for its social and environmental welfare implications (van den Bergh, 2009).

Agrowth, in line with disregarding GDP as an indicator, will increase the acceptability of policy approaches on the pressing issues of the present. Policies that respond to the risks of peak oil and climate change by implementing an extensive switch from fossil fuel to renewable energy sources (van den Bergh, 2009). According to Hueting (2010), the process of transitioning to new resources will entail a decrease in both energy concentration and productivity, which will ultimately lead to a decrease in the overall productivity of the economy. In fact, most of the current growth is being produced by relatively unclean activities that consume a lot of material and energy resources and produce a disproportionate amount of pollution (Hueting, 2010).

POSSIBLE CHALLENGE OF IMPLEMENTATION

Within the traditional growth paradigm, realizing environmental and resource sustainability is very challenging since it entails sacrificing growth and productivity (van den Bergh, 2011). This obstacle is eliminated by an agrowth stance since growth without limits no longer affects a stricter environmental regulation. The agrowth perspective holds that strict environmental regulations won't significantly impair wellbeing because wealthier countries' growth seldom ever increases it (van den Bergh, 2011).

However, it will be challenging to shift to an agrowth paradigm because the traditional growth paradigm is dogmatic in character (van den Bergh, 2011). The politics of today are typified by tense

responses to slow GDP growth. The false notion that growth is required or even sufficient to address significant societal issues is repeatedly propagated in the media and in academia, which feeds into the obsession with GDP growth (van den Bergh, 2011). It has also been demonstrated that more economic growth makes it more likely for political leaders to hold office for longer (Burke, 2011). Therefore, there is unfortunately still a lot of pressure on politicians to follow the path of unlimited economic growth.

Agrowth favours a top-down approach meaning that environmental policies should be designed and imposed by the state to ensure that we remain within safe ecological constraints (Raworth, 2017). With the assumption that GDP is a poor indicator of social welfare, it should be irrelevant whether such policies lead to GDP growth or not. The agrowth aim implies that we should be content with slower growth and should give more consideration to other factors such as social well-being and ecological impacts. (Victor, 2008).

FAVOURABILITY

Based on the survey by Koskimäki (2023) on “post-growth” pathways, nearly 80% of sustainability scholars are in favour of “post-growth” pathways for high-income countries. The “post-growth” term in this survey includes “degrowth” and “agrowth” systems that aim for a steady state economy. Degrowth is characterized as a socially sustainable decrease in society's material throughput until a steady and sustainable level is attained (Hickel, 2021). More details about degrowth can be found in subsequent chapters.

Looking at the “post-growth” pathways in more detail, the growth agnostic pathway had the largest amount of support for both high-income (56%) and upper-middle-income countries (51%) (Koskimäki, 2023). This conclusion may be explained by the fact that high-income countries bear the bulk of the world's environmental burdens and already have enough wealth to meet their social needs (Dorninger et al., 2021; Oxfam & SEI, 2020; Teixido-Figueras, et al., 2016; Wiedmann et al., 2020). Notably, this implies that for a sustainable future, countries—including the Netherlands as an example of higher-income countries (World Bank, n.d) —might find it advantageous to adopt an agnostic attitude toward growth.

A similar survey by King et,al (2023) shows that 27% respondents were in favour of green growth position, 45% in favour of agrowth position, and 28% holds a degrowth position. Participants in the sample represent a wide range of academic fields from the social sciences to natural sciences and engineering, came from 78 different countries of origin in addition to 73 countries of residence. The study divided respondents into groups according to their attitudes on growth versus environment by including a short three-question questionnaire in the survey: the relationship between economic growth and development space, environmental protection, and life satisfaction.

DUTCH AGRICULTURAL CONTEXT

Although the Netherlands' position on agrowth is still unclear, there are indications that lean towards endorsing a growth-agnostic strategy. In the context of agriculture, the Ministry of Agriculture, Nature, and Food Quality has a plan to embrace a circular agriculture, as outlined in their declaration in 2019. The document articulates a vision that signifies a paradigm shift away from growth solely in production volumes and cost reductions. Instead, the focus is on optimizing resource utilization and fostering food production in harmony with nature (Ministry of Agriculture, Nature, and Food Quality, 2019). This commitment to a more sustainable and balanced approach suggests a trajectory in line with the agrowth perspective.

The OECD's perspective on agrowth is summarized in their recent publication, “Beyond Growth” (2020). The concept of going ‘beyond growth’ in this context doesn't entail abandoning growth as an objective; rather, it involves a shift in the composition and structure of economic activity to attain the multifaceted goals integral to a more comprehensive vision of economic and social progress.

Given that the Netherlands is part of the OECD, it's worth looking into whether the country fully agrees with the ideas presented in this publication and implementing the necessary policy in the agricultural sector.

2.2.4. DEGROWTH

Jason Hickel (2020) defines degrowth as, “a planned reduction of energy and resource use designed to bring the economy back into balance with the living world in a way that reduces inequality and improves human well-being” (p. 1). Degrowth is a *planned and targeted* reduction of material throughput in certain industries and places, it is not a monolithic idea to degrowth everything (D’Alisa et al. 2014; Hickel, 2020; Martínez-Alier et al., 2010). Over-consuming countries are to reduce their material throughput in order to give more space for the Global South to increase consumption required to meet their social needs (Georgescu-Roegen, 1975; Martínez-Alier et al., 2010). It challenges many assumptions embedded within our current neoliberal economic paradigm. Researchers note that recognising the limitations of the current economic paradigm is paramount for imagining alternative systems where social and ecological justice can be realised (D’Alisa et al. 2014; Hickel, 2020; Martínez-Alier et al., 2010).

Degrowth goes one step further than agrowth by recognising that the traditional neoliberal paradigm is deeply flawed and acknowledging the intrinsic link between material use and GDP growth. It is widely accepted among degrowth scholars that a reduction in material throughput will most likely lead to a simultaneous reduction in GDP (Kallis, 2011; Martínez-Alier et al., 2010). Degrowth proposes a change in the system itself, so this planned reduction will not have negative consequences on social well-being. In fact, it is seen as a necessity based on a synthesis of two critiques of the neoliberal paradigm: the critique of growth and the critique of development (Kallis, 2011).

THE CRITIQUE OF GROWTH

The critique of growth states that the neoliberal system is fuelled by an imperative to grow, and that growth itself is the problem as it is intrinsically linked with material throughput (Gerber, 2020; Martínez-Alier et al., 2010). This was brought to popular attention in the Meadows et al.’s (1972) report titled *Limits to Growth*. Meadows et al. (1972) argue that if we continue down the same path of growth, we will eventually destabilise the planetary systems for which we rely on for (re)production. This has been reiterated by many academics such as Georgescu-Roegen (1977) and Latouche (Kerschner, 2010) where they described it as ‘growth mania’ and the ‘tyranny of growth’, respectively. The neoliberal view fails to consider the ecological system, or ‘externalities’, in which the economic system is embedded (Fremstad & Paul, 2022). Table 2.2 shows how degrowth breaks down these principles, offering a radical alternative which focuses on distribution, regeneration, and care as opposed to accumulation, extraction, and control (McGreevy et al., 2022). Latouche (2009) similarly discussed the transition from capital accumulation, competition, and extraction under the growth imperative to a society whose focus is on equity, cooperation, and well-being. If some are calling for a halt to growth as it is destructive, why do others persist on striving for it?

Table 2.2 Principles by which growth and post-growth metabolisms operate arranged by category

	Economic principles	Social-ecological principles	Allocative principles	Institutional principles	Relational principles
Growth metabolism	Efficiency	Extraction	Accumulation	Private ownership	Control
Post-growth metabolism	Sufficiency	Regeneration	Distribution	Commons	Care

Source: McGreevy et al. (2022) p.1012.

THE CRITIQUE OF DEVELOPMENT

The critique of development brings into question the assumption that more economic growth is needed in order to increase human well-being. Martínez-Alier et al. (2010) describe the “neoliberal ‘mantra’” (p. 1) as the belief that markets create efficiency gains, leading to increased well-being. This understanding then fuels the growth imperative as it sees economic growth as the only path to ‘development’. By questioning this assumption, degrowth opens a world of possibilities where social well-being can be improved through alternative means such as redistribution and a revaluation of ‘well-being’ itself (Gerber, 2020).

DEGROWTH AND AGRIFOOD SYSTEMS

When assessing the potential implications of the degrowth paradigm shift on the agricultural sector it is important to note that degrowth is an umbrella term which represents a wide variety of beliefs and strategy (Eversberg & Schmelzer, 2018). This new economic paradigm is based upon two pillars. Firstly, that economic growth is destructive, therefore there must be a reduction in material wealth, particularly in the Global North (D’Alisa et al., 2014; Georgescu-Roegen, 1975; Hickel, 2020; Kallis, 2011; Martínez-Alier et al., 2010). Secondly, that this transition must be done peacefully, democratically, and in an emancipatory manner in order to achieve social and ecological justice (D’Alisa et al., 2014; Eversberg & Schmelzer, 2018; Hickel, 2020; Martínez-Alier et al., 2010). The former is essentially a critique of decoupling. It thus contradicts green growth’s assumption that we can have infinite sustainable growth. The latter then implies that social well-being can be met without growth. This then also challenges green growth’s belief in ‘development’, where social well-being can only be improved by increasing economic wealth (Martínez-Alier et al. 2010). Beyond these two pillars, degrowth is a heterogeneous field which Eversberg & Schmelzer (2018) describe as a spectrum. Based on local context and perspective, it can thus materialise in many different ways (Lara et al., 2023; McGreevy et al. 2022)

Common proposals by degrowth scholars include changes such as more equitable distribution of labour through reduced working hours, adopting convivial technology, transition to more plant-based diets, and shorter supply-chains (D’Alisa et al., 2014; Gomiero, 2018; Martínez-Alier et al., 2010; Latouche, 2009). It must be stressed that degrowth’s main goal is not a reduction in economic growth, but in material throughput. Reduced GDP is just anticipated based on the assumption that material throughput and economic growth are intrinsically related. It is uncertain how proposals such as reduced working hours and changes in technology use will impact the agricultural sector, thus further research is required (Gomiero, 2018).

Convivial technology means that workers are able to autonomously choose which technologies they deem to be socially beneficial (Gerber, 2020; Illich, 1973). This would likely lead to more organic and agro-ecological farming methods as technologies such as herbicides and pesticides are known to be damaging to the ecosystem in the long-term (Gerber, 2020; Gomiero, 2018). Woodhouse (2010) shows that organic agriculture can have improved energy efficiency, although it comes at the cost of labour efficiency and earnings (see also: Gerber 2020). Animal agriculture has been proven to be one of the most destructive forms of agriculture, as well as not necessary for a healthy and balanced diet (Poore & Nemecek, 2018; Springmann et al., 2018; Willett et al., 2019). Shorter supply chains with more local food production, seasonal eating, and a reduction in animal products could have a drastic reduction in material throughput while continuing to provide the same social benefits and nutrition (Cassidy et al., 2013; Gomiero, 2018; McGreevy et al, 2022; Springmann et al. 2019; Willett et al. 2019).

Degrowth also proposes structural changes that indirectly impact the agricultural industry which can help the aforementioned changes survive in a post-neoliberal world (Gerber, 2020; Gomiero, 2018; Harvey, 2015; McGreevy et al., 2022). These proposals are meant to reorganise society in order for a post-neoliberal system to be able to thrive (Gomiero, 2018). They target systems such as land ownership and debt which are strong drivers of the neoliberal growth imperative (Gerber, 2014,

2020; Lara et al., 2023). An increase in practices outside of capitalist markets such as commoning and community supported agriculture (CSA) can help take off the pressure from the farmers to continuously grow their operations.

2.3. TRANSITION THEORIES

Transition theories represent a field of research that focuses on long-term societal change, pointing out enabling and constraining factors to such change, with great focus on sustainability transitions (Markard et al. 2012). Adloff (2019) identifies three main trajectories for social change. The first is labelled as “modernization”, which represents incremental change and stand as opposite to “transformation”. The latter represents a deeper change reflecting a more rapid switch also in moral values and beliefs. This was defined by Dinesh et al. (2021) within the agricultural sector as “a change in at least 1/3 of the inputs or outputs/outcomes of food system within 25 years or less”. The third trajectory is defined by Adloff (2019) as “control” and reflects potential for social transition to be steered in a top-down manner, rather than as the result of the interaction of social and economic dynamics that ultimately result in either incremental or transformational change following a bottom-up direction (Adloff, 2019).

With reference to the “control” trajectory of social change, Markard and colleagues (2012) identify different frameworks for sustainable transitions. One of them is “transition management”, a practice that became common in Dutch public administration that relies on “meta-governance”, meaning the attempt at steering multiple actors with their activities in a coordinated way towards a desired outcome (Loorbach & Rotmans, 2010). This approach received criticism to the extent that sustainable transition cannot be easily managed in a controlling sense (Kemp & Loorbach, 2003). Moreover, according to Markard and colleagues (2012), frameworks like the “strategic niche management” and the “multi-level perspective on sociotechnical transitions” reflect the nature of sustainable transitions as being a “long-term, multidimensional fundamental processes in which a broad range of actors work in a coordinated way”. While the former framework focuses specifically on niches’ creation and on how to scale them up, the latter entails more of a system perspective on the issue (Markard et al. 2012). More specifically, Elsner and colleagues (2023) point out that the niche is the level in which novelties are generated and protected by the socio-technical regime (the set of written and unwritten rules that structures social groups and interactions). The niche can be ultimately constrained or spread depending on the exogenous context, or the “socio technical landscape” like climate change or rapid shocks like pandemics and wars. Niche, regime, and landscape are hence three levels whose interaction defines the societal change (Elsner et al., 2023). A last framework for social change within the sustainability context is the “technological innovation system” (Markard et al., 2012) that focuses on the “institutional and organizational changes” that are required to occur in parallel with technological advancements.

Finally, Dinesh and colleagues (2021) identified key areas of intervention in promoting sustainable transitions within the food system. The following are the ones used as a reference for the main elements considered in building the transition pathways in Section 3.3:

- “Strong farmer organizations and networking”, reflecting the value chain facet of sustainable transitions, meaning the creation of monetary value within the food supply chain.
- “Climate resilient and low emissions practices and technologies”, reflecting the technology facet of sustainable transitions.
- “Expanded private sector activity and public-private partnerships”, reflecting the market facet of sustainable transitions, meaning the place where supply and demand meet.
- “Capacity and enabling policy and institutions”, reflecting the policy facet of sustainable transitions.

All the three paradigms presented in the previous sections attempt to reach a common goal, meaning a more fair and sustainable society. What differ are the underlying assumptions underpinning each

paradigm that ultimately produces different outcomes in terms of how the transition pathways towards a common goal are carried out. For example, being green growth a paradigm that follows the “growth imperative”, as opposite to degrowth, the transition pathway within green growth would entail some form of more intense market expansion when compared to agrowth and degrowth.

3. OUTPUTS

3.1. OPERATIONALIZATION

Operationalization is the procedure to specify exactly how a concept will be measured in a research. It entails determining the research procedure to employ and collect information about our notions (DeCarlo, 2018). In this project we define three dimensions of the alternative economic paradigms to be operationalized (economic, ecological, and social). The indicators are then described under the three different paradigms for comparative analysis. Our interpretation of these indicators is guided by underlying assumptions throughout this process, acknowledging that they are particular aspects of the larger economic, ecological, and social paradigms that we are trying to investigate. The visual representation of this concept is shown in Figure 3.1.

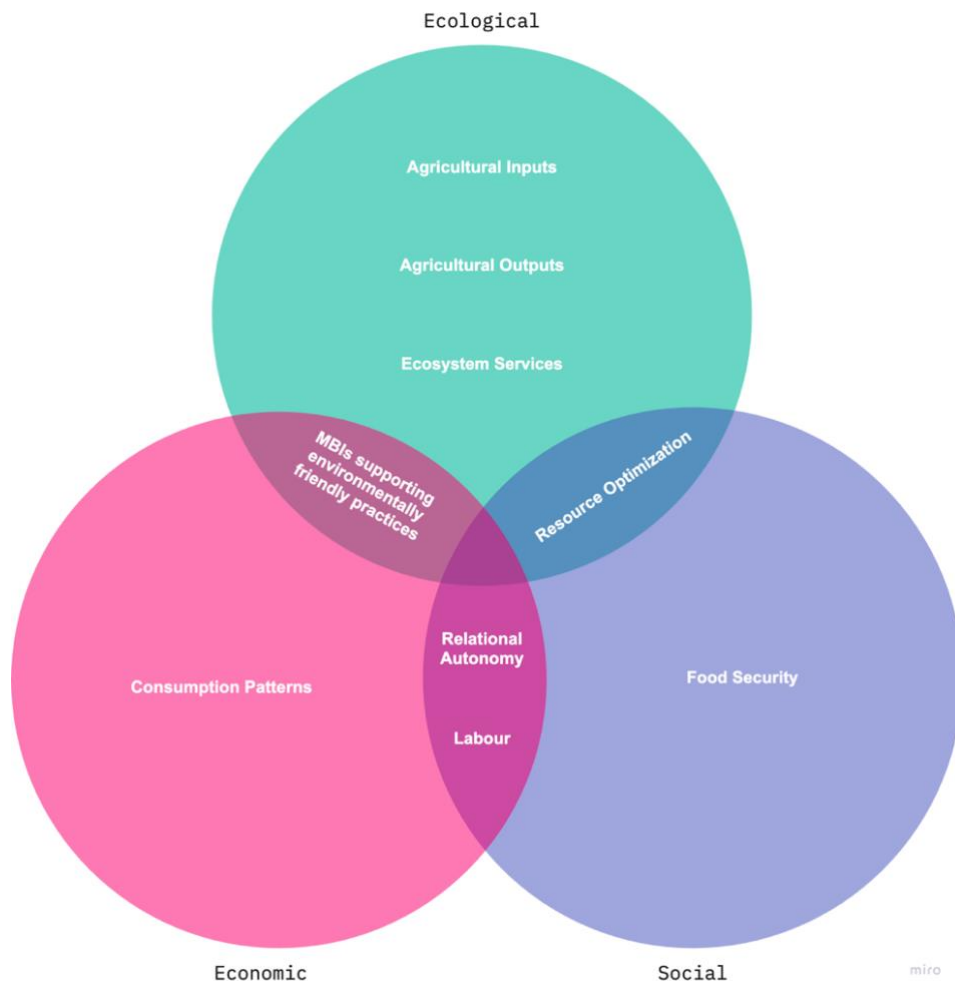


Figure 3.1 Visual representation of the indicators under three different dimensions

3.1.1. ECONOMIC DIMENSION

MARKET ORIENTATION

A market-oriented agricultural practice centres on aligning with market demands and optimizing economic returns. Within such system, choices regarding crop selection, production methods, and resource allocation are guided by a drive to enhance profitability and adapting to prevailing market conditions. A conventional market-oriented and profit maximization mindset are essentially the current practices under the neoliberal economic paradigm (Kallis et al., 2018). Therefore, the transition towards a more social and environmentally conscious agricultural practices is needed. Within this macro-indicator, several micro-indicators are defined for a comprehensive understanding of the market-orientation agricultural practices:

- *Autonomy*: Examining elements including contracting practices, commodification of land, direct selling, commoning strategies, and financing provides insights on the process of becoming autonomous. The level of independence and decision-making power that farmers possess in their dealings with the market is reflected in their autonomy.
- *Consumption patterns*: Analysing eco-labelling, diet seasonality, protein source in the diet and trade practices offers insights into how farm management is influenced by consumers' decisions.
- *Market-based instruments to promote environmentally friendly practices*: This indicator evaluates the uptake of market-driven tools to promote eco-friendly practices. It involves implementing certification schemes, market incentives, and other tools that are based on the market and targets at encouraging ecologically friendly practices in agricultural systems.

Within these indicators, underlying assumptions are made and shown in Table 3.1.

Table 3.1. Underlying assumptions for market orientation

Micro-indicator	Underlying assumptions
Autonomy	• Farmers signing contracts may have reduced autonomy as they commit to fulfilling specific agreements. • Farmers owning land are assumed to have more autonomy, while those renting may face decisions influenced by the need to generate consistent profits. • Direct selling implies short supply chains and less environmental impact. • Commoning as a sharing practice points out an approach that doesn't follow the "profitability imperative" • Farmers requiring credit may prioritize the most profitable crops to repay debts, potentially compromising environmentally friendly choices.
Consumption patterns	• Farmers implement eco-labelling procedures in response to consumer demand for products that are environmentally sustainable. • Consumer preferences influencing seasonal crop demand can impact environmental sustainability. • Consumer choices between animal and plant-based proteins affect livestock numbers and environmental impact • Farmers modify their crop plans in response to exporting procedures and changes in the worldwide market dynamics caused by consumer demand.
Market-based instruments to promote environmentally friendly practices	Assumes farmers' readiness and capacity to adopt these instruments as a sign of a market orientation toward sustainability, emphasizing the relationship between financial incentives and eco-friendly practices.

3.1.2. ECOLOGICAL DIMENSION

MATERIAL THROUGHPUT

Thinking about sustainable ecological scale involves thinking about the amount of physical material moving through the global economy. This notion of “material throughput” helps us connect the physical size of the global economy and the following externalities on the ecosystems. Each time we purchase a good or service we set in motion a chain of activities that has an impact on the physical world. Whether it is extracting resources from the earth, manipulating those resources in a production process, using the goods produced, or the eventual disposal of those goods as waste, physical material is being used and depleted, energy is being expended and dissipated, and ecosystems are being degraded. There is little recognition that economic activity is impossible without some ecological impact. Sustainable scale raises the question as to how much material throughput is possible while sustaining the ecosystem services that make economic and other important human activities possible.

Ecosystem services are a range of natural processes and conditions that benefit and sustain our species’ survival (Daily, 1997). Services such as pollination of crops, flood/drought mitigation, and stimulating the mind with aesthetic and learning environments (Daily, 1997). These services have been further expanded and defined into dozens more of services. Agriculture has an important role in providing and preserving many of those ecosystem services (Hardelin & Lankoski, 2018). Zhang et al. (2007) have figured which of those services are most relevant to agriculture and how to sustain them at the field level to the regional level. They are: soil retention, pollination, pest control, water (provision & purification), soil fertility, soil formation, nutrient cycling, genetic diversity, & climate regulation. These services can be partially grouped and used as indicators for a healthy soil, watershed, and living environment. In Dutch agriculture, the ecosystem services of pollination (of crops), soil fertility/nutrient cycling, and water purification, and to a certain extent –with certain crops–, pest control, remain the most relevant. Most of all, nitrogen plays the biggest role, mainly through agricultural run-off, in terms of nutrient balance, acidification of soil/water, and eutrophication of waters down the watershed, impacting biodiversity and ecosystem functioning (J. Schaper, lecture, March 2023). Soil health can be measured through soil organic carbon, pH, soil fauna, nitrogen & phosphorous balance. Pollination can be measured with pollinator abundance, and pest control can be measured by predator abundance or pest abundance. As part of the material throughput indicator, the underlying assumption for each of the micro-indicators are as follows:

Table 3.2. Underlying assumptions for material throughput

Micro-indicators	Underlying assumptions
Agricultural inputs & outputs	They function as an easy way to record the entire material flow in agricultural systems.
Resource optimization	Examines how different paradigms streamline inputs and outputs through two important elements: innovation and circularity. The foundation of innovation is the belief that a farmer's commitment to maximizing input utilization is demonstrated by their greater investment in novel practices or inputs, such as high-yield seeds, environmentally friendly technology, or alternative farming methods.
Ecosystem services	The more ecosystem services are considered when managing a farm, the more foresight a farmer has in dealing with possible problems like soil health and water quality. Additionally, the Doughnut Economy theory (2017) outer edge is represented by ecosystem services, which stand for the "ecological ceiling" that defines the bounds of human activity with respect to planetary boundaries.

3.1.3. SOCIAL DIMENSION

According to Rogers (2014), social sustainability is the ability of societies to continually meet the physical, social, and emotional needs of people. In this situation, attaining social sustainability depends heavily on equity and equality. In the framework of our analysis, social sustainability covers essential elements like labour in the agriculture sector and food security. When we look at alternative economic paradigm, we see that equity and well-being are just as important as the economic and ecological dimensions.

FOOD SECURITY

Food security, as defined by the World Bank, has four categories: availability, access, utilisation, and stability (FAO, 2008). Availability refers to the production of food, stock, and trade of food goods. In other words, does the required food exist? Access refers to the social capability of individual households to acquire food which is influenced by pricing and income. Utilisation refers to the required energy and nutrient content of the food available. Factors such as sanitary food storage, food preparation, and a balanced diet are important to achieve proper food utilization. Lastly, stability requires that the three previous indicators are stable throughout time. To be determined as 'food secure' all four categories must be simultaneously achieved (FAO, 2008).

LABOUR

On the more socio-economic side of the indicators, the *labour* indicator focuses on employment within the agricultural context. It has three categories: workforce purchasing power, employment, & skills. This is further broken down into: if living wages can supplement the agricultural workers ability to buy goods and services (workforce purchase power); rate of people that have farming as the main source of income; rate of skilled workers in the share of the national agricultural employment. These sub-indicators can paint a picture of the role of labour within the three economic paradigms. Table 3.3. provide the underlying assumption for the social dimensions macro-indicators:

Table 3.3. Underlying assumptions for social dimension

Micro-indicators	Underlying assumptions
Food security	Agricultural practices under different paradigms are thought to have an impact on the amount and type of food produced, how easily accessible the market is, how properly food is used, and how stable these aspects are over time.
Labour	It is assumed that the income, employment prospects, and skill mix of the agricultural workers are directly impacted by economic paradigm and agricultural practices.

3.2. COMPARATIVE ANALYSIS

Green growth, agrowth, and degrowth all have the same goal in mind, sustainable agriculture. Where they differ is rooted in their assumptions. The two main differences refer to their views on decoupling and development, quickly summarised in Figure 3.2.

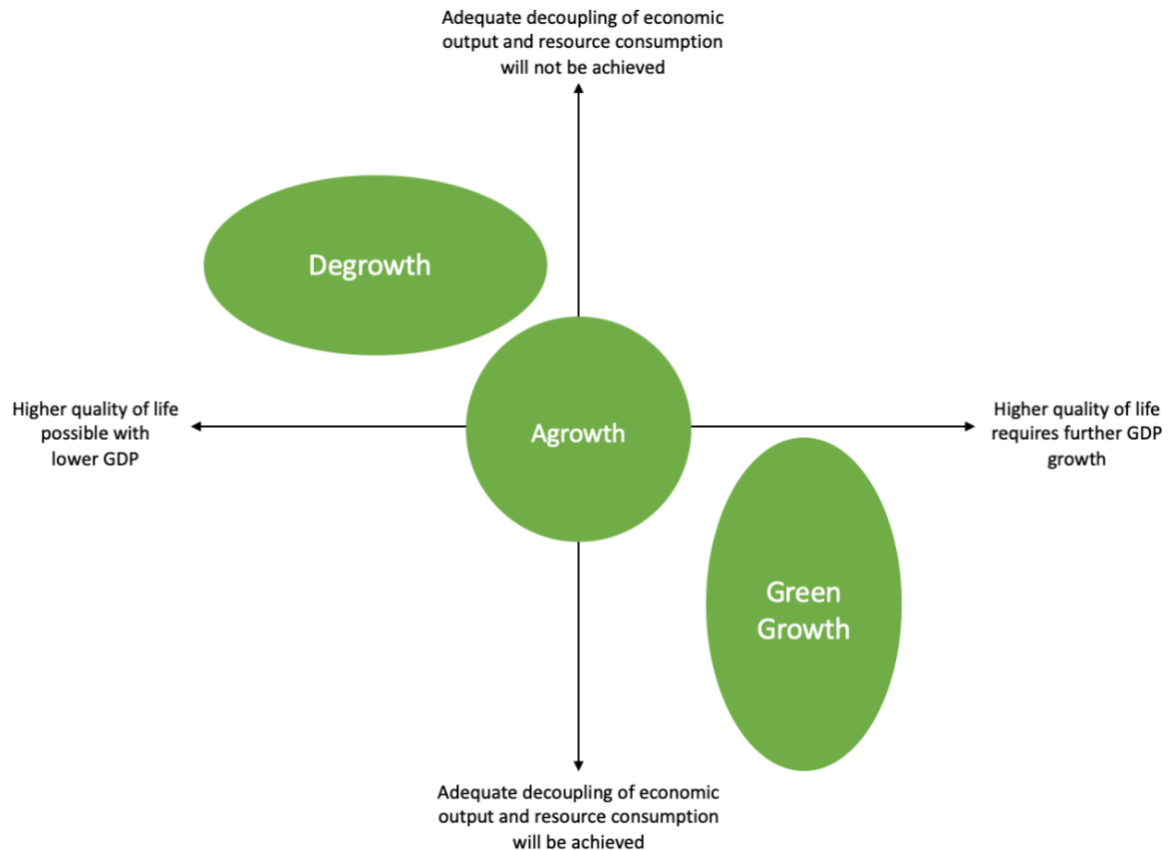


Figure 3.2. Different Strategies of Post Growth, Agrowth, Degrowth, and Green Growth.
Source: Modified from Lange, S. (2020).

Green growth scholars believe that decoupling is possible through innovations leading to more efficient technologies, leading to less materials required to produce the same outputs. If absolute decoupling can be achieved, then society can continue to grow infinitely while decreasing overall material throughput. On the other end of the spectrum, degrowth believes that this is not possible, at least not at the speed and scale required to avoid surpassing ecological tipping points. This is based on the fact that there is no empirical evidence of absolute decoupling of material throughput when taking trade into account (Gerber, 2020; Hickel & Kallis, 2019) apart from specific sectors (Martinez-Fernandez et al., 2013), and that GDP and material use are intrinsically linked (Wiedmann et al., 2020; Kallis et al., 2018). Then, degrowth scholars also point out the rebound effect which states that efficiency gains lead to increased consumptions of material as they become cheaper and more widely adopted (Giampietro & Mayumi, 2018). This leads to an endless cycle of growth on a finite planet. Agrowth finds itself somewhere in between. It is uncertain about the possibilities of decoupling (Wiedmann et al., 2020; van den Bergh, 2017). Therefore, it argues that we should not carelessly pursue growth but make decisions based on social well-being regardless of the economic consequences. OECD (2017) themselves have noted that not enough decoupling has taken place within the OECD: productivity has increased, although material input is still high. This further supports that total decoupling is unlikely. Hickel & Kallis (2020) note that "...absolute decoupling from carbon emission is highly unlikely to be achieved at a rate rapid enough to prevent global warming over 1.5°C or 2°C...".

The assumption of development refers to how the different theories believe society can increase social well-being. For green growth, infinite growth is needed as social well-being is directly related to wealth. From this perspective, GDP must increase to improve the standard of living. Agrowth is critical of this and states that we do not need to pursue growth to increase well-being. We should instead focus on activities that are expected to increase well-being, regardless of their relation to economic growth. Degrowth and agrowth both share the goal of focusing our decisions based on well-being as opposed to economic growth, but degrowth acknowledges that the required reduction in material throughput will more than likely lead to reduced GDP (Martínez-Alier et al., 2010; Kallis 2011). Degrowth takes this one step further and claims that growth has a negative impact on overall well-being, and we must reduce material throughput which will also lead to decreasing GDP. This is related not only to the negative ecological impacts of growth, but also on the lifestyle that infinite growth creates. This has been described by David Graeber (2018) in 'Bullshit Jobs' where over half of our jobs in our current society exist only to create more value. These jobs exist for the sole purpose of creating more value, at the expense of the workers negative mental health in a world where our self-worth is so closely connected to our productivity and work ethic. Degrowth thus posits that to increase well-being we must focus on equitable redistribution of resources as well as a reassessment on societal values. How this is done is a mix of top-down and bottom-up actions, while agrowth and green growth focus almost exclusively on a top-down policy approach. On the similarities of agrowth and degrowth, Kallis (2011) discusses that if van den Bergh (2011) talks about 'restructuring' to focus on welfare instead of GDP as agrowth, then they are talking about the same thing. Some degrowth researchers have also chosen to distance themselves from explicitly mentioning a reduction in GDP (Hickel, 2021).

Stevens' (2011) idea on removing trade barriers on agricultural products and thus further specialisation of production zones around the world, can lead to monoculture farming practices (because of efficiency, and the economy of scale), based on the respective growing conditions (Klasen et al., 2016; Feintrenie et al., 2010). This should not be a problem if global food trade is good (Stevens, 2011), but it leaves local communities vulnerable to disruptions in the distribution chain. Also, monocultures are less disease/insect resistant than intercropping systems or more diverse systems, leaving them vulnerable to those perils.

Other differences, similarities, and limitations can be viewed in an extensive table in Appendix 3.

3.3. TRANSITION PATHWAYS

To formulate the transition pathway, we use four core components for each of the proposed economic paradigms: technology, market, policy, and value chain. In deciding these core components, we refer to the transition pathways of legume production in the EU (van Ruitenbeek et.al, 2022), as it is contextually relevant to current agricultural practices in The Netherlands. Each of the core components are described below in Table 3.4.

Table 3.4. Core components of transition pathways

Technology	Market
The utilization of agricultural technology under alternative economic paradigms. Instead of conforming to conventional pro-growth model, we are looking into technological adoption that are aligned with each of the paradigm's outlook.	This building block is looking into important market and consumer trends. To differ from the "Value Chain" building block, "Market" is looking into drivers and barriers for supply and demand on agricultural production under alternative economic paradigm.
Policy	Value Chain
Under alternative economic paradigms, agricultural policies are formulated by developing and implementing rules and regulations that deviate from traditional growth-centric approaches.	Value chains cover the range of agricultural operations, from of crop cultivation to processing, distribution, and retail. We are looking into the value chains that link producers and consumers in a complex network under alternative economic paradigm.

These transition pathways can be a helpful tool for strategic planning among a variety of stakeholders. It is important to point out that these pathways represent potential courses of action for adapting each alternative paradigm with the ultimate goal of achieving sustainable agriculture in The Netherlands. However, they are not a prediction of future events.

3.3.1. GREEN GROWTH

Technology		Market	
Transition Pathway	Limitations	Transition pathway	Limitations
Find new technologies that will increase efficiency, that will reduce strains on the environment (reduced input use and reduced pollution) (Stevens, 2011; OECD, 2017).	Rebound effect, leading to overall increased production/input use (Giampietro & Mayumi, 2018). Specialised equipment, not readily available/fixable.	Consumers will become aware of environmental impacts (Eco-labelling) (Stevens, 2011). Trade tariffs of agr. Products reduced or abolished to facilitate trade (Stevens, 2011).	Subsidised conventional agriculture (Stevens, 2011; OECD, 2017). No trade tariffs lead to global competition and specialisation, (most likely) monoculture farming (Klasen et al., 2016; Feintrenie et al., 2010), detrimental to food security and biodiversity.
Policy		Value Chain	
Transition Pathway	Limitations	Transition pathway	Limitations
Invest in research and development (domestic & foreign)(Stevens, 2011; OECD, 2017). Environmental regulations (Stevens, 2011). Subsidy reform (Obama, 2017) away from production levels and towards environmental practices (Stevens, 2011)	Political contestation. Regulations can slow growth in the short term (Stevens, 2011). Agribusiness opposition.	Global trade of agricultural products (Stevens, 2011). Income diversification of farms (Stevens, 2011). More efficient transportation & processing (Stevens, 2011).	Reliance on global trade has a negative impact on self-sufficiency. Can leave communities vulnerable to disruptions in the value chain.

3.3.2. AGROWTH

Technology		Markets	
Transition Pathway	Limitations	Transition pathway	Limitations
The government is prioritizing sustainable technology for reducing environmental effect of agriculture (e.g., precision farming techniques, agroecological practices, organic farming). Emphasizing ecological resilience and long-term viability over conventional production factor like yield.	Yield reduction in the short term as opposed to conventional production method since the focus on sustainable technology may require a transitional phase for optimization and adaptation.	Stricter policy on sourcing locally leads to growing consumer demand for local and sustainable products. Responding to the policy, the market for organic and regenerative agriculture is also growing, as farmers start adopting sustainable practices	The transition period required for farmers to adopt new practices may pose issues in meeting immediate consumer demand, potentially resulting in temporary shortages of supply.
Policy		Value Chains	
Transition Pathway	Limitations	Transition pathway	Limitations
Stricter environmental regulations are imposed nationally to maintain or achieve sustainable agriculture. For current practice, the government might want to address the pressing matter of ecological impact of nitrogen. The state would be indifferent about whether this leads to GDP growth.	Given that the main goal is usually to pursue economic growth, an agrowth plan that imposing stricter agricultural policy is likely to be viewed as unusual and in the current political environment. Refusal might arise from stakeholders.	The government is assisting farmers in several ways: Investigating the conditions for circular farming, promoting equitable profit sharing in supply chains, enabling farmers to work together against demands that don't raise prices, and improving food chain transparency through monitoring. (Ministry of Agriculture, Nature, and Food Quality, 2019)	The length of time it takes for these actions to have a noticeable effect would postpone farmers' immediate gains.

3.3.3. DEGROWTH

Technology		Markets	
Transition Pathway	Limitations	Transition pathway	Limitations
Farmers have autonomy to choose which technologies that they employ (Gomiero, 2018). Decisions are based on the social benefits that they provide (Faye, 2023; Gomiero, 2018). Efficiency gains are seen as beneficial, although only part of the solution and must not result in a rebound effect.	Research is not clear as to whether farming methods, such as agroecological or organic farming, have the capacity to feed the world (Gomiero et al., 2011; Müller et al., 2017). Therefore, the theory may not translate to practice.	As profits are not a motive, food will be grown based on self-sufficiency, local cultural diet, and growing conditions. Self-sufficiency influences both production and consumption trends to adopt a food system more in balance with ecological regeneration.	This transition will be slow and experience resistance due to the cultural change required. People may not be willing to change their eating habits to exclude imported or animal-based foods.
Policy		Value Chains	
Transition Pathway	Limitations	Transition pathway	Limitations
Policy, described as 'non-reform reforms' can play part of a role, but this must be done in collaboration with other change pathways such as interstitial and building counter-hegemony (Schmelzer et al., 2022). Some in the degrowth movement reject the role of the state and will disagree with top-down policies (Gerber, 2020; AKC Collective). Degrowth relies more on grassroots and cultural change.	As there is not a consensus within degrowth, there are disagreements on whether to work on policy change (Schmelzer, 2018). Large cultural change is slow and uncertain as people are comfortable with the status quo.	Farming practices are based on care, self-sufficiency, and 're-localisation of markets' (Faye, 2023; Gomiero, 2018). Each actor in the value chain will be focused on improving social and ecological regeneration. This combined with a shift to a more plant-based diet will lead to significant reduction in pressures on the ecological boundaries (Gomiero, 2018).	The 'agrarian myth' romanticising rural living and expecting the population to embrace such radical change may not be reasonable (Gerber, 2020). This must be taken into consideration when planning to transition to smaller farms. Global markets must be taken into consideration to ensure equitable food distribution. It is important that this does not lead to exclusive nationalised markets at the expense of other countries (Gomiero, 2018).

3.4. FARMERS' SELF-ASSESSMENT TOOL FOR FOSSIL FUEL REDUCTION

This section presents a set of guidelines to set the foundation for the development of a self-assessment tool for farmers, intended to support them in identifying which trajectory better suits their needs, with reference to the three economic paradigms. In addition to this, we provide in the appendix an example of a self-assessment tool for farmers specifically tailored to the farm we're in contact with, The case farm. In general, the set of guidelines and questions follows a systems' perspective, meaning that it builds on the three dimensions of sustainability that grasp society in all its components (economic, environmental, and social) and attempts to appraise how farmers perceive themselves in terms of role and capacity in addressing climate change-related issues.

Collecting general information of farm size and on the main type of production is essential in providing a fitting self-assessment tool. For example, questions or statements to be agreed upon change significantly based on whether a farm is more livestock-intensive or simply grows vegetables. A question like "would you switch from livestock to crops if the government compensates you for potential economic losses?" only makes sense if addressed to livestock farmers. Dividing the population of farmers into clusters according to the farm size (whether it is larger or not than 10 hectares, the FAO threshold for the definition of smallholders) and the main type of production gives the possibility to develop more specific questions/statements, and to collect more precise and potentially more insightful information.

The distinction of farmers according to farm size and specialization creates four clusters in the first place, as it follows:

- Farm size: farms larger and smaller than 10 hectares (according to FAO threshold for smallholders)
- Farm specialization: arable (farms only growing crops including vegetables, cereals and fruit and farmers only dealing with livestock, including dairy) and diversified (a mix between crops and livestock)

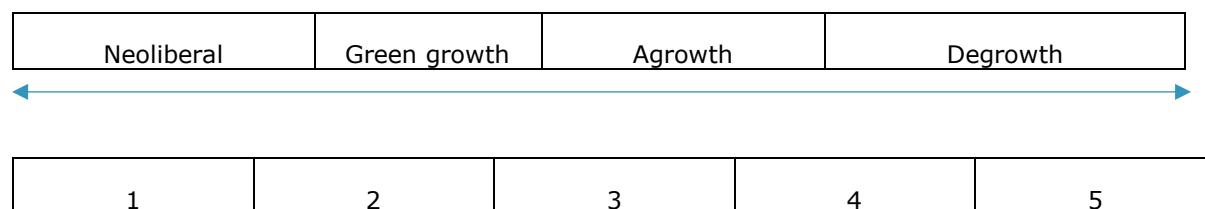
Further, the combination of farm size and farm specialization creates eight definitive clusters as it follows:

- Livestock farms (only livestock) smaller than 10 ha
- Arable farms (only crops) smaller than 10 ha
- Livestock farms (only livestock) larger than 10 ha
- Arable farms (only crops) larger than 10 ha
- Diversified farms (more livestock than crops) smaller than 10 ha
- Diversified farms (more crops than livestock) smaller than 10 ha
- Diversified farms (more livestock than crops) larger than 10 ha
- Diversified farms (more crops than livestock) larger than 10 ha

This subdivision of farmers into clusters points out the necessity to develop a tailored self-assessment tool for each category. If developed with an online software, each farmer would have the possibility to be redirected to the fitting self-assessment questionnaire according to the general information provided about farm size and type of production.

The self-assessment tool can be carried out with different formats. A first possibility is to develop a flowchart, meaning a set of yes/no questions in the form of a decision tree that ultimately directs the farmer to the "more fitting paradigm", stating with a brief description his/her potential trajectory for future farming decisions. A second option is a Likert scale measuring the importance for the farmer of specific facets relatively to sustainability, the paradigms, or even specific issues such as fossil fuel reduction or nitrogen emissions. The Likert scale gives the possibility to quantify results that can build up a weighted index giving an idea on to what extent a farmer better fits under which paradigm. Moreover, it creates room to infer results on a regional/national scale for Dutch agriculture if specific degrees of intensities of the answers are matched with specific paradigms. With reference

to the Likert scale, another option is the development of a set of statements against which the farmer should indicate the extent of which he/she agrees or disagrees with. The same considerations for the potential index development apply in this case. The only difference is that a Likert scale with questions would include 7 degrees of intensity, while the statements format would include 5 degrees of intensity (strongly disagree, disagree, neutral, agree, strongly agree).



In this graphic example, the numbers 1 to 5 represent the degree of agreement or disagreement with the statement. The final score is calculated as an average value of all the answers between 1 and 5 (with 1 being “strongly disagree” and 5 being “strongly agree”), suggesting the extent to which a farmer matches a paradigm. Questions and statements need hence to be formulated so that the degree of intensity/agreement or disagreement reflects the perspective on the question/statement according to the paradigms, so that an index can be developed. The sequence of the paradigms as represented in the visual above is based on the results of the literature review: degrowth is a more radical paradigm when compared to the status quo (neoliberal paradigm), so they’re opposites. Green growth is closer to the neoliberal paradigm in the sense that believes in absolute decoupling without challenging existing market and economic dynamics, since it’s precisely from market dynamics that high tech solutions for decoupling start advancing through investments, for example. Agrowth relies more on the principles of sufficiency typical of degrowth and follows as an imperative the carrying out of human activities within the planetary boundaries. Hence, the “growth imperative” in the agrowth is more subject to exogenous conditions. If, for example, food production is already sufficient to meet the availability and accessibility conditions for food security, growth is something not to be pursued.

With reference to the type of questions/statements provided to farmers, these can be developed building on the three dimensions of sustainability, more specifically with reference to the indicators provided in output 1. In this sense, questions can assess the level of a farm’s market orientation, material throughput, approach to the ecosystem services, contribution to food security and use of labour. Despite the indicators are assigned to a specific dimension, they do not fit exclusively within one. The potential overlap between economic, environmental, and social dimensions must be taken into account, by combining the dimensions in the formulation of the statements or questions. Another possibility is developing questions/statements according to the paradigms themselves. In this sense, questions or statements can be used to check whether a farmer has internalized more the principles, values and beliefs of green growth, agrowth or degrowth (the example provided in the appendix follows this logic). In this case, it is important not to directly mention the paradigms in order to avoid bias in the answers (“protest” answers”), since the paradigms entail to some extent specific political arrangements and ideals that can provoke “protest answers”, namely answers provided on the basis of political contestation. To add another level of specificity, questions and statements can include – or entirely be based on – specific issues such as fossil fuel reduction and nitrogen emissions. Nitrogen emissions-based Likert scales can be a viable possibility for livestock farms, both larger and smaller than 10 ha. In this case, the specific issue needs to be internalized within the different paradigms, meaning that the statement should reflect how the issue is perceived and addressed according to each paradigm.

In order to provide a practical example of a self-assessment tool and the format through which it can be spread among farmers according to which cluster they belong, a simplified Likert scale with statements to be agreed/disagreed upon can be found in the appendix, specifically designed for the farm for which we propose alternative weeding methods for fossil fuel reduction in this report. Hence, the Likert scale is tailored for arable farms (only crops including vegetables, cereals and fruit) larger than 10 hectares.

3.5. CASE STUDY

3.5.1. INTRODUCTION TO THE CASE STUDY

Our research included the adaptation of the economic paradigms on a farm in Drenthe, the Netherlands. To gain a comprehensive understanding of the case study, we conducted observation during a meeting between the farm owner and farm manager held for another project. Additionally, our on-site visit to the farm involved an interview with the farm owner and the manager, accompanied by a guided tour in some of the plots. Furthermore, we utilized additional data that were provided to us at the start of the project, such as information of crops grown in previous years.

The farm has been running organic for the last 20 years. The total size of the farm is 75 ha, of which 10% is owned and the rest is rented long term based on a verbal agreement. Therefore, they mentioned that they plan to reduce their land for next year, since the organic market is shrinking. According to the owner of the farm, the inspiration to alter from conventional to organic farming came from the idea that the conventional method is not beneficial for people nor for the environment. They are also interested in progressing to biological regenerative/ biodynamic agriculture, as they believe that the moon can strongly contribute to the growth of the crops, and because it is seen as an evolution for them. Their ambitions revolve around becoming more leguminous, expanding to nut cultivation, reducing fossil fuel use by producing their own energy and with the use of electric agricultural machinery, and autonomous robots in arable farming. They are taking action towards their goals, with the owner of the farm having taken a biodynamic agriculture course at Kraaybekerhof, and with designing their own equipment in collaboration with a local blacksmith. They have also started producing their own energy by placing solar panels in the roof of the house to produce energy that is currently used for an electric vehicle and for an electric lawn mower. Until now it has been a family business, now in a transition period as it will be handed over to an outsider of the family, the current farm manager.

The focus of this case study is the sustainable transition to reduce fossil fuel usage by 25% over the next four years. It has been proven that organic agriculture uses less fossil fuels than conventional farming (Bos et al., 2014). This, however, cannot be applied to organic crop production, since it is characterized by high intensity levels of crop rotation, organic fertilizer use, and mechanical weeding practices that require the use of heavy machinery (Bos et al., 2014), rather than spraying herbicides. With that said, alternative solutions in weeding are a central solution towards reducing the farm's fossil fuel use. The soil of the region is characterized as sandy. Consequently, the soil of the farm contains a lot of humus, which increases the weed pressure compared to the clay soil. A side effect of the sandy soil on the farm is increased water percolation, thus more water is needed to wet the sandy soil compared to siltier ones or clay soils in other regions. On the farm visit, the farm manager mentioned that the irrigation system was powered by fuel and consumes a significant amount of it (10liters/hour of pumping). This is an avenue worth exploring to reduce fossil fuel usage of the farm, albeit not related to the farmer's concern of weeds or labour. An example would be to increase the renewable energy share of the energy that powers the water pump, or somehow reduce the water usage. In the interview with Timo Sprangers, it was underlined that there is a high possibility that water usage in the region is not allowed during summertime.

The farm is quite large, consisting of scattered plots totaling 75 ha, which intensifies these activities. As a result, it needs a lot of tractor usage and a lot of labor. For some crops, and especially within the crop rows, hand labor is the only weeding method that can be applied in order to not damage the crop. The farm also collaborates with neighbor farmers, including a chicken farmer, and other farmers for a crop rotation system between their fields. By using machines in collaboration with the other farmers, costs are shared amongst the group making organic cultivation a lot more accessible and economically sustainable, all the while giving a stronger sense of community.

According to the farm manager, weeding itself is not a difficult process, but it's expensive due to the labour and fuel costs, and it takes up a lot of time. The aim of the farm manager and of the owner

is to reduce the use of fossil fuels, by using alternative weed control techniques. They are practicing a variety of techniques like burning, hoeing, harrowing, chopping, finger weeding and false seed beds. Something that the farm manager mentioned was that if you keep growing organic for a long time, in the end a soil balance is accomplished. In order to be able to achieve the same yield without increasing the dose of fertilizers, they aim to increase the nitrogen soil capacity by further building organic material and by stimulating soil biodiversity. Other measures include spreading bokashi, growing a dormant crop like grass clover, and further adding leguminous plants to the rotation. Problems such as the carrot fly are avoided by delaying planting until the first generation of flies has died. They deal with some fungus problems, but according to them it differs each year depending on rainfall and temperatures.

The farm produces according to the demand of the market. This means that they do not follow a planned crop rotation. Their activities revolve around summer crops. Some crops are cultivated for seed production, such as pumpkins. The plots that are investigated within the case study are currently cultivated with chicory, carrots, and herbs. Chicory is sold directly to the customers. For the distribution of carrots, they are collaborating with a contractor, due to additional procedures that should be done before the distribution of the final product in the market which requires special equipment. Moreover, the weeding of carrots within the rows is done by hand, as mechanical weeding only works between the rows. Concerning the herb production, they are selling the final product directly to the customers and the process from cultivation to packaging is fully organic. They have partnered with other organic farmers in the region who share machines for different steps such as cleaning, processing, and packaging. One of the herbs is *Plantago* (nl. weegbree) for medicinal purposes (Figure 3.3). This plant is considered a weed by some farmers according to the farm manager.



Figure 3.3. A *Plantago* (nl. weegbree) field being cultivated by the farm. Picture was taken during a visit to the farm. A strip of green manure is seen in the background.

For reducing the use of fossil fuels, they are not interested in solutions that require the increase of labor, as the management of the workers is a challenging task. Most of the workers come from countries like Romania, Poland, and Ukraine, starting with a group of 8-9 early in the season and increasing up to 30-40 at the peak of the season. This makes management of the workers complicated. Also, as they work seasonally, there is high worker turnover and new workers need to be trained each season. There are significant amounts of time required by the farm owner or the farm manager for their training and supervision, as well as labor making up a significant proportion of the cost. Another problem that occurs with manual weed control is that they cannot harvest poisonous weeds, like black nightshade and *Datura sp.*, which started appearing in recent years. Agroforestry has been considered at some point, but they quit the idea as there are a lot of restrictions concerning the growing time of the crops. Animals also are not considered, as it would only bring extra work. The farm manager also expressed his interest in the solution of mulching with bioplastic cover but is hesitant due to the possibility of residues left behind after they decompose. Moreover, a winter crop rotation does not seem appealing to them, as during that season they are occupied with other activities.

3.5.2. ALTERNATIVE WEEDING CONTROL APPROACHES AND NETWORKING SOLUTIONS

The following alternative weeding control approaches can be used as proposals for further investigation and potential implementation in the farm of the case study and any other farm that cultivates organically and aims to reduce the use of fossil fuels for weeding. For the purposes of this section of the report, we conducted an interview with Timo Sprangers, who is a researcher at Open Teelten Proefboerderij. During the interview, alternative weeding control solutions were discussed, varying in terms of practices and level of technology used. This interview operated as a starting point for further research on alternative weeding and for further investigation on the practices that were mentioned. There is a wide range of alternative weeding practices, varying from frugal innovations like intercropping to more technologically advanced, as lately a lot of companies try to automatize weeding practices by using mechanical weeding, by using lighter tractors to implementing robotics, precision farming, and AI technology. These alternatives then fit differently into the economic paradigms mentioned in the report. These solutions are explained in subsequent section and are summarised in Table 3.6 (p. 35).

What should be taken into consideration while investigating alternative weeding techniques for farms in sandy soils is that as soon as the soil gets disturbed, new weeds start emerging. Especially for the case study, it was highlighted by Timo that when it comes to the weeding practices for carrots and chicory, things can get challenging when they are grown organically. Therefore, if there is a way to prevent them from growing, there is no need to tackle them later.

INTERCROPPING

Intercropping can potentially resolve the weeding problem by reducing the resources available for weeds and optimizing the resource management for the crops (Stefan et al., 2021). During the interview with Sprangers it was mentioned that intercropping has been proved beneficial for combining beans and pumpkins, which are both cultivated on the farm, and it could potentially also work with herbs (Interview). However, intercropping may be hard to realize on this farm if individual crops are grown side by side. As mentioned during the farm visit, the farmers were concerned with intercropping in such a way that the workers would have to distinguish between not just one crop from other weeds, but one crop from another, and then from the weeds. This complication could lead to a loss of yield or at least more staff training according to the farm manager. And it is true that intercropping can be more labour intensive, but if one uses legumes within the intercropping, one can save some money by using less N-fertiliser (Lithourgidis et al., 2011). A simpler method would be to intercrop in alternate strips, in so the farmers need not change their seeding and weeding efforts remarkably, can still use their machinery, and the benefits of mixed intercropping can be experienced on the edges of the strips (Yu et al., 2015).

Stefan et al. (2021) suggest that including cereals can play a crucial role in reducing weed pressure. Intercropping with smothering plants is also an option for the farm, such as *Plantago* (nl. Weegbree) which the farm grows already. Intercropping with species that suppress weeds via allelopathy can also be an option (Liebman & Dyck, 1993). Examples of allelopathic crops relevant to the farm's past crops include oats, buckwheat, and wheat, other crops being e.g. using clovers or vetch (*Vicia* sp.) (Frick & Johnson, 2002) which can additionally lessen N-input needed on borders of the main crop. Crops that utilize resources that the weeds do not use -so the crops grow despite weed pressure- is also an option (Liebman & Dyck, 1993) but a full inventory of weed species would then need to be provided.

Strip intercropping research has taken place in the Netherlands with varying results. On sandy loam soil with onions, carrots have been seen to give no different yield (Song, 2020) or significantly less yield, unless the carrots were in 24m wide strips (Zhang, 2019). Potatoes have been shown to have the best yield in 12m strips (Zhang, 2019). Another form of strip cropping is relay intercropping. It is essentially growing crops alternately in succession, so that the crops' growing interlaps for some time. Doing so can increase the land equivalent ratio (LER) compared to monoculture farming (Yu et al., 2015) The dos and don'ts of relay intercropping can be summarized in Table 3.5.

Table 3.5. Probable- and improbable crops to grow side by side in a relay intercropping system based on a case study in the Netherlands. Copied from Juventia et al. (2022). Top row crops are grown first. An example of interpretation is that one can grow cabbages before planting potatoes as the intercrop, but not the other way around.

Preceding	Grass-clover	Parsnip	Pumpkin	Wheat	Potato	Bean	Cabbage	Chicory	Celeriac	Onion	Pea	Winter spelt	Sugar beet
Following													
Grass-clover	X ₁	0	0	0	0	X ₄	0	0	0	0	X ₄	0	0
Parsnip	0	X ₁	0	0	X _{2,3}	X ₂	0	X ₂	0	X ₂	0	0	X ₂
Pumpkin	0	0	X ₁	0	0	X ₅	0	X ₂	X ₃	0	0	0	0
Wheat	0	0	0	X ₁	0	0	0	0	0	0	0	X ₃	0
Potato	0	0	0	0	X ₁	0	0	0	0	0	0	0	X ₄
Bean	X ₄	X ₂	0	0	0	X ₁	0	X ₃	X ₃	0	X _{2,3,4}	0	X _{2,4}
Cabbage	0	X _{2,4}	0	0	X _{2,4}	0	X ₁	0	X _{3,4}	0	X _{2,3,4}	0	X ₂
Chicory	0	0	0	0	X ₄	0	0	X ₁	0	0	0	0	X _{2,4}
Celeriac	X ₃	0	0	0	0	0	X _{3,4}	0	X ₁	X ₂	0	0	X ₄
Onion	X ₃	0	0	0	X ₂	0	X ₄	0	0	X ₁	X _{2,3}	0	X ₄
Pea	X ₄	0	0	0	0	X _{2,3,4}	0	X ₂	0	0	X ₁	0	0
Winter spelt	X _{3,4,5}	0	X ₅	X ₃	0	0	0	0	0	0	0	X ₁	0
Sugar beet	0	X ₂	0	X ₅	X ₄	X ₃	0	0	0	0	0	0	X ₁

0 = the succession is allowed; X₁ = not allowed because of same species; X₂ = not allowed because of plant-parasitic nematodes; X₃ = not allowed because of shared pest, disease and weeds; X₄ = not allowed because of inefficient resource use or intensive soil use; X₅ = not allowed because period between successive crops is considered too short or long.

Biofoil and mulch layering

In the start of the project, we got informed that the farm manager had expressed an interest on the use of biofoil, after visiting the Bejo Open Days. There, a machine from the company Forigo was displayed, Forigo Modula Jet, that has the capability to place biofoil tarp and sow under it. The farm manager was also interested in the biodegradability of the biofoil itself, produced by Oerlemans Plastics. On their website, it is mentioned that it complies with EN 17033, which states that it is clearly biodegradable and that it doesn't leave harmful residue in the soil (de Beaurepaire, 2018). It is also mentioned that it complies with EN 13431, according to which 90% or more of the plastic material will be converted to CO₂ and the remaining part is converted to valuable compost (European Bioplastics, 2016). Even though it is ensured that there are no harmful residues for the soil, it is not clearly stated whether there would be residues on the crops. In general, biofoil is categorized with the mulching techniques. As an alternative to biofoil, it was suggested to use just organic material as a mulching layer. One possible solution alternatively could be compost, like the bokashi that is made at the farm with inputs from the green manure grown on some fields. A "winter-killed cover crop" can also form part of the mulch (Frick & Johnson, 2002). Other solutions could be using hay or straw, which both have their qualities and limitations, with hay prone to germinate grasses from the hay (Shirish et al., 2013), and straw hard to find in such quantities at an affordable price in the Netherlands according to the farm manager. But this increased price stemming from straw can reduce price in terms of labour, with less weeding needed due to the straw shading the weed seeds,

and from less water usage, since a good layer of straw can help retain moisture (Döring et al., 2005; Shirish et al., 2013) along with significantly reduced erosion (Döring et al., 2005), which is both an important quality during droughts, and on the farm's porous, sandy soil. This less water usage also means that the water pump would not need to be active as much, saving fuel. What was mentioned during the interview is that mulching works best for onions and not as well for carrots. It also works well for potatoes during warm, dry summers (Döring et al., 2005).

Reduced Tilling

No tilling is usually combined with a mulch or straw layer and can have several benefits. Abdalla et al. (2016) noted that sandy tilled soils lose most soil organic carbon over time and emit the most CO₂ compared to untilled soils. It is beneficial to soil organisms (Zhu et al., 2010).

Shallower tilling is a readily available method for the farm. Sprangers (personal communication, 1.12.2023) mentioned that shallower tilling does not replenish the weed seed bank as much as deeper tilling. As most of the weeds germinate from the top layer of the soil, it has been observed that if tillage happens only at 2cm deep from the ground, an isolation layer is created which brings the transportation roots to the atmosphere (Sprangers, personal communication, 1.12.2023). So, with every year of a shallow till of 2-5cm, the weed pressure should lessen, contrary to tilling deep, where an older seed bank is brought again to the surface. There is a downside to this on hard-setting soils, where the soil under the shallow tilled area can compact and reduce aeration and thus reduce rooting potential of crops (Kadžienė et al., 2011). The same can likely be said about no tillage on hard-setting soils. So lighter machinery might come in handy.

ROBOTIC SOLUTIONS

Adoption of new weeding technologies requires high efficacy, reliability, and economic suitability. Some examples of such technologies are thermal weed control, that uses electricity, steam, hot foam or laser technology to freeze or heat the weeds, and mechanical weed control options. Both came as a result of rapid developments in sensing, vision and computational efficiencies (Coleman et al., 2018). What should be taken into consideration in using robotics and machinery on the fields is that the farmers should follow some sort of training, in order to learn how to use the new tools, and also that there must be some kind of supervision in the field. Both require some level of effort and a specific number of working hours that will be removed from other activities. In addition, there are possibilities of connection with organizations, companies and institutions that are specializing in the automation of weed control and provide guidance to farmers that would like to adapt new means in their farming processes.

A fact that was highlighted during the interview is that only a few robots are used in the Netherlands for weeding purposes, with the first ones appearing just two years ago. The following robotic devices were suggested. Ekobot is a Swedish company that has started commercializing also in the Netherlands and develops robots that not only remove weeds, but also collect data about the crops, allowing cost reduction for the farmers up to 20%. The Ekobot robot system WEAI combines front-end technology in areas of AI, robotics and electromobility with traditional knowledge of agricultural production. It uses electric power and has the capacity to cover up to 10 hectares and 4-8 rows. It works with electric power and every charge lasts for 10-12 hours per day. It is suitable for crops, including carrots whose weeding techniques are quite limited due to distance restrictions, are specifically mentioned on the website. In 2023, they also conducted a series of demos in the Netherlands (Ekobot WEAI, n.d.).

Moreover, Pixelfarming Robotics has introduced Robot One, a solar powered robot that is suited for large scale and biodiverse environments. Its various tools are adjustable in row width and working depth, which allows specific crop treatment and chemical free weed control. Also, several jobs can take place at the same time, as a hoe, a streamer, a rotor harrow, an L-Bow or a CO₂ laser can be

adjusted accordingly. In Pixelfarming Academy, Robot One users can be trained in a community inspired environment. In Farmer Studio, the specific working area for farmers, they learn to manage the script based on which the working route of Robot One will be determined. Pixelfarming Academy is also open for experimentation purposes and to provide connections with the academic world. Therefore, contacting them as a farmer could be proved beneficial for introducing robotics in weeding (Pixelfarming Robotics, 2022).

Another robotic device for weeding is FarmDroid FD20. It is a solar powered field robot that can do both seeding and weeding and performs inter-row and intra-row weed control, by marking the position of each plant at seeding. According to the manufacturer, it offers increased operational stability since it uses high precision GPS technology. It has the capacity to cover 6,5 ha daily, with 2-12 rows and row spacing starting from 22,5 cm. It is fully powered by solar energy, which gives CO2 neutral operation, and has four solar panels on top. The company has stated that it has operated successfully for a variety of crops, including carrots, chicory and various herbs (FarmDroid, n.d.). During the interview with Timo Sprangers, it was specifically mentioned that in Germany, around 100 of such robots are operating and that is widely used for the weeding of carrot and chicory.

NETWORKING

There are also companies and organisations that support farmers in alternative weeding processes and introduce them in several funding and experimental programs. Groeikracht Cosun is a partnership that was introduced to us during the interview. Their goal is to provide support to farmers in topics that concern them. They are conducting several projects, like Inspiratieboerderijen, in which they are the latest techniques that are ready to show in arable farming, Sneller Meer Mechanische Onkruidbeheersing (SMMO), which aims in encouraging the use of modern precision equipment and making chicory cultivation more future proof and also purchase support according to eligibility criteria, and Toekomstgerichte onkruidbeheersing, which supports the development of techniques such as weeding, hoeing and robotization. As part of the last program, they are also conducting practical tests and experiments with mechanical weeding control in several regions in the Netherlands, by also taking into account the regional challenges. They also share stories about innovative cultivation solutions and organising meetings, so that farmers can exchange knowledge. In one of those stories, the case of a chicory farm that is located in Liesel. They developed in one of the largest contracting companies in chicory cultivation, with a focus on chicory and beet roots (Groeikracht Cosun, n.d.).

The EU is funding the project Robs4Crops, which *"aspires to deliver a labor saving, fully autonomous robotic system for spraying and mechanical weeding, together with a supporting ecosystem, ready for wide-scale adoption"*. At the moment, through this program, robotic farming is being demonstrated in large scale pilots in four countries in Europe, among which is also Netherlands, with the LSP4, about Crop Rotation in Potato Farming (Robs4Crops,n.d.). The project coordination is executed from the Department of Agrosystems from Wageningen University and Research (WUR), and according to Dr. Frits van Evert, Senior Scientist at WUR, Robs4Crops will revitalize the European food and farm industry and will accelerate the adoption of high-tech robotics and automated technologies in agriculture. It started running in January 2021 and is still in progress, until December 2024 (WUR, 2021).

Table 3.6. An overview of alternative weeding approaches for the farm.

Alternative weeding approaches	Methods and Tools	Advantages	Limitations
Intercropping			
Intercropping: Growing crops side by side or alternately	Modification of current tools, or new sowing tools needed	Crop health benefits -> yield	Crop choice, hard on a large scale. Makes hand weeding more laborious (must now discern 2 crops from weeds)
Strip cropping: Growing crops in rows or strips alternately	No additional tools needed	Easily adapted. Beneficial effects on borders.	A little more intricate crop rotation planning
Biofoil and Mulch layering			
Biofoil: A tarp made of biodegradable material (usually cellulose). Crops/seeds can be planted/sown into the tarp.	A machine that aerates the soil and lays a tarp simultaneously. Biofoil tarp. A machine/extension that sows/drills the seeds into the tarp.	The tarp suppresses weeds, can be laid before planting.	Unsure about the residues left behind from biofoil Investment for machine
Mulch layering: compost	Expansion of current Bokashi methods	Nutritious for crops	Amount of mulch needed to cover/stop weeds from growing
Hay layering	Grown on farm or bought	Water retention, Suppresses weed growth	Grasses from hay can germinate. If grown on farm, land is removed from crop cultivation
Straw layering	Grown on farm or bought	Water retention Suppresses weed growth	Expensive/hard to find in NL for such a large farm

Reduced Tilling			
Plowing or harrowing only top 5cm of the soil	Harrower or a shallower plough	Depletes weed seed bank. Good in combination with mulch or a winter cover crop (e.g. Buckwheat)	Compacting of soil layer under tilled layer. Will need lighter machinery?
Robotics			
Ekobot Removes weeds and collects data for the crops.	System WEAI: combines front- end technology in areas of AI, robotics and electromobility with traditional knowledge of agricultural production	Uses electric power. Allows cost reduction by 20% It is also suitable for carrots	Farmers should follow some short of training to get familiar with the robots. There should be supervision while robots are working on the field. The farmers should ensure that they can afford such investment or if there are eligibility criteria for funding.
Robot One Performs weeding and other activities at the same time	Includes a hoe, a streamer, a rotor harrow, an L-Bow or a CO2 laser that can be adjusted accordingly	Solar powered Consists of adjustable tools Suited for large scale and biodiverse environments Farmers can be trained for using the robot by Pixelfarming Academy	
FarmDroid FD20 Performs inter-row and intra-row weeding, by marking the position of each plant during seeding	Use of high precision GPS technology that offers operational stability	Solar powered The row spacing can start from 22.5 cm Suitable for carrots, chicory and various herbs	

Networking			
Groeikracht Cosun Partnership that supports farmers in alternative weeding processes	Creates networking opportunities for farmers and introduces them in several farming and experimental programs	Inspiratieboerderijen Project: latest techniques of arable farming are showed SMMO Project: encourages the use of modern precision equipment, aims to make chicory cultivation more future proof, purchases support according to eligibility criteria Toekomstgerichte onkruidbeheersing: conducting experimental tests with mechanical weeding control in several regions in the Netherlands	A farm might not be eligible to participate at the projects.
Robs4Crops Promotes robotic farming solutions for spraying and mechanical weeding in large scale pilots in four European countries	The program is demonstrated into large scale in 4 European countries	Aims at reducing the amount of labor needed Wageningen University & Research is running the project coordination. The project is running in the Netherlands, LSP4 - Crop Rotation in Potato Farming	The project is confined to potato farming at the moment

3.5.3. IMPLEMENTATION OF THE ECONOMIC PARADIGMS TO THE CASE STUDY

The farm object of this case study represents a curious example of the complexity in implementing alternative economic paradigms. The farm demonstrates a strong commitment in practicing more sustainable agriculture, and this is clear not only from the decision to undergo an organic approach nearly 20 years ago, but also from their proactive approach in seeking new solutions such as agroforestry and biodynamic farming. The farm includes some elements of all the paradigms that have been explored and presented in Chapter 2. It exhibits green growth features, such as short-term crop planning based on market prices, and interest expressed in weed control with high-tech robotics stating that if the investment can be recovered in 5-10 years, that would be considered a potentially feasible alternative. It shows elements of the agrowth and degrowth approaches when talking about the commitment to organic practices in the face of a shrinking market. This shows that the organic approach is an imperative that is not likely to be abandoned and demonstrates underlying values and morals that go beyond the profitability orientation. The economic dimension is subordinated to the ecological dimension. Moreover, the convivial relationship with some neighboring farmers resembles to some limited extent a form of “commoning”. This is practiced through the sharing of equipment and land with neighboring farmers. A limitation of this practice is the fact that ownership over the land and equipment is still evident, whereas commoning as a practice overcomes the notion of private property altogether. That being said, the farm we’re in contact with is taking practical steps towards a more convivial agriculture. Farmers’ networking practices and private-public partnerships are precisely what Dinesh et al. (2021) stressed as an important key intervention area to promote sustainable transitions.

The fact that the case farm entails to some extent elements of all the paradigms (efficiency gains for green growth, social considerations for agrowth, and sharing of resources for degrowth), points out the high complexity in implementing these paradigms, along with the potential tradeoffs and limitations of each of them. Similarly, as with the indicators, the case study shows that the paradigms do not behave as mutually exclusive clusters, but rather overlap in certain cases. For example, degrowth doesn’t necessarily state that robotics is something not to be pursued. The social and ecological values underpinning degrowth can embrace certain high-tech solutions typical of green growth if they are believed to be beneficial. The major difference is that green growth accepts existing market dynamics, while degrowth challenges them. This means that in a pathway towards fossil fuels reduction, a green growth approach would be limited to seek more efficient fuel usage through innovations such as electric powered tractors and robotic machineries, a degrowth pathway may entail a transition of agricultural practices via social change and the adoption of convivial technologies, leading to an overall reduction of arable land. This could then convert arable land to natural areas for rewilding and leisure, creating both social and ecological benefits while reducing fossil fuel usage and sequestering carbon emissions. In this way, fossil fuels are not only reduced by “efficiency” means, but also through changes in practices and nature-based solutions, a solution that highlights the prioritization of social and ecological well-being over economic growth.

A major difference between the paradigms is also the relation with labor. Hi-tech solutions typical of green growth offer the possibility to reduce workforce, while degrowth stresses the importance of a less intensive agricultural inputs usage, which ultimately would require more manual labor to compensate this reduction. The difference, again, is in the underlying assumptions. Degrowth doesn’t reject high-tech solutions, but their avoidance is rather a consequence of the material throughput reduction imperative. Hi-tech solutions are hence to be employed only if they lead to a reduction in material throughput. Conversely, in green growth hi-tech solutions are to be employed if they lead to gains in efficiency, which doesn’t imply a reduction in material throughput due to the rebound effect. Most of the solutions provided are not mutually exclusive within a single paradigm, but the underlying motives or reason for a solution choice can differ vastly. If the underlying motive is increasing efficiency for increased production and profits, it can be seen as a green growth approach. If the underlying motive for increasing efficiency is to provide food security for a local community, it can be seen as a degrowth approach. In conclusion, an economic paradigm can be identified as implemented only by appraising what drives a farmer to do what they do.

4. STAKEHOLDERS AND ETHICAL CONCERN

4.1. STAKEHOLDER ANALYSIS

Food systems and agriculture integrate technical, environmental, and human elements into the ecosystems of places. They are complex social-ecological systems that primarily rely on human management and are shaped and maintained by farming methods (Fairweather, 2010). Integrating stakeholders is a way of accommodating conflict points and claims. When inclusivity is a goal, a broad view of stakeholders is required. However, a classical criticism of a broad view and definition of stakeholder is that “virtually anyone and anything can ‘affect or be affected’ by the decisions”, arguing that “expansive views of relevant stakeholders tend to become so broad as to be meaningless” (Orts & Strudler, 2002). This valid criticism leads us into focusing on the most pertinent stakeholders in this project. Table 4.1 presents the different stakeholder’s “interests” and “influence” on this project:

Table 4.1. Different interest and influence of stakeholders

Actor	Interest	Influence
Dutch Ministry of Agriculture, Nature, and Food Quality (LNV)	The Dutch government is committed in achieving “a circular economy for the Netherlands by 2050” (MVW, 2023). This means that the LNV ministry promotes and supports projects in exploring alternatives that can have an impact on the achievement of the circular economy goal. The interest hence does not only rely on the knowledge that can be created through such projects that can inform the ministry to implement tailored policies, but also on the effect of such paradigms on the main professional categories the ministry deals with such as farmers, food industry professionals, and academics.	Provides funding for projects and defines overarching goals. They support the achievement of governmental objectives and set ministerial ones.
Dutch ministry of economy and climate (MEZK)	The Dutch government plans to reduce CO2 emissions 49% reduction in greenhouse gas emissions by 2030, compared to 1990 levels, and be CO2 neutral by 2050 (MEZK, 2020).	Defines goals for municipalities and provinces to follow.
Organic farmers	Alternative weeding methods that use less fuel in the operations are of great importance for the whole category of organic farmers. Mechanical weed control is known as the most effective alternatives to herbicides. Organic farmers represent an important stakeholder as results in the alternative weeding methods can be applied in more farms, expanding the potential for fossil fuel reductions. The interest in the results from the paradigm exploration is given on the one hand by the different idea of agriculture and the relation with nature and ecosystem services the paradigms entail (for example on the	Organic farmers’ influence relies on their agency, meaning on the acceptance or rejection of the alternative weeding methods or of the values, ideals, beliefs and morals of the different paradigms. Accepting alternative weeding methods creates room for further exploration of organic farm practices through their implementation. If they accept them, it suggests that they consider them to be feasible. Conversely, if rejected that suggests that they don’t consider them feasible, halting the wider adoption of such practices. Same considerations apply for the

	material throughput, that ultimately has an effect on the overall farm practices and finance), on the other hand by the effect these paradigms have on the overall economic dynamics, external but influencing for example the type of crops to be grown.	paradigms. Hence, organic farmers influence, since they represent a “niche”, have the power to make advance transitions in this process of knowledge creation.
Conventional horticulture farmers	Despite not being organic farmers, results from the alternative weeding methods can be of interest also for conventional farmers. Using herbicides creates detrimental effects for the environment like groundwater pollution to name one, that in the long run can undermine the farm productivity. Adopting alternative weeding methods is something that conventional farmers might be required, either from the “ecological demand” or from state command-and-control measures. If for example at the EU level phasing out pesticide is discussed, phasing out herbicides is not a remote possibility, despite the recent developments on the glyphosate case (EU Commission, 2023).	Conventional farmers might have influence on a political scale, meaning that if it were to be followed in the Netherlands a degrowth trajectory which would require radical changes in agricultural practices they could resist to some top-down policies meant to reach a more sustainable agriculture, as the 2021 farmers’ protest and 2023 BBB outbreak as a consequence of the nitrogen crisis highlighted.
WUR	Wageningen University and Research comprises and supports a wide range of projects that have an interest both on exploring what do these paradigms entail (the core purpose of this project) and on the implementation of new technologies in agriculture such as robotics. The interest is hence mostly based on the knowledge these projects advance and its relevance for WUR’s partners that fund such projects.	WUR represents the “implementer” of projects supported and funded by the LNV ministry. Its influence is pragmatic in the sense that it is WUR’s responsibility to carry out projects: define the overarching purpose in practical terms, defining the method and collecting data, analysing, processing and presenting results to the stakeholders. The WUR’s influence is hence more on the potential results of such projects and their disclosure.
Agricultural equipment suppliers	The potential feasibility of the implementation of robotics in weed control management provides additional examples of potential market expansion. If this solution is not only feasible but also possible to be scaled up, agricultural equipment suppliers might find themselves in the situation of scaling up agricultural robotics production. In addition to this, these companies might have an interest in experimenting new models that aren’t launched on the market yet. Moreover, results from the paradigms’ exploration might inform on potential new partnerships with farmers or other food industry stakeholders for new market opportunities. The flip side of this is that transitions to alternative economic	Potential networking with farmers for experimenting new models of machineries and new horizons for partnerships with both the government (interested in new hi-tech solutions in farming) and the farmers themselves. Private partnerships represent a mode of governance capable of informing policy in a bottom-up manner. Equipment suppliers can also resist changes and put pressure on farmers to adopt their machinery. This can be done through advertising, government lobbying, and funding research at academic institutions.

	practices may reduce farmers reliance on heavy machinery causing a reduction in sales for suppliers.	
Dutch organizations on sustainable food systems	Both the operationalization of new economic paradigms and the alternative weed control methods can be insightful for such organizations like SlowFood Netherlands and Toekomst Boeren. These organisations are socially and ecologically oriented and have an interest in the paradigms' exploration. Results will provide information that can be used as leverage points in political arenas and inform agricultural practices. Alternative weeding methods also constitute a factor of interest since these organizations have also farmers as members.	Similarly, to conventional farmers, such organization can have an influence on a political level. Influence on a political scale means the possibility of scaling-up or halting both alternative weeding control methods and ideals, morals and beliefs resulting from the paradigms.
Banks	Hi-tech solutions such as robotics implementation are hard to adopt by farmers due to the high initial costs. In this sense, bank credits to farmers willing to undertake a hi-tech trajectory (either in weeding control methods or other activities) will play an important role in supporting a sustainable transition. The feasibility of the adoption of such hi-tech solution would hence constitute a "market" opportunity for creditors.	Banks influence the availability of credit for farmers and interest rates. This has effects on the overall farm management configuration, from what to grow (the most profitable), to how to grow it (less costs is better) and to whom to sell it (to whom pays the most).
Supermarkets	Large scale distribution companies usually deliver reports that state the status of scope 1, 2 and 3 emissions (Directorate General FISMA, 2023). Scope 3 refers to indirect emissions, including those carried out by suppliers. This means that potentially large-scale distribution companies have an interest in supporting the reduction of fossil fuel usage in the first step of the food supply chain (namely cultivation), for reporting purposes (Klimaatrapportage, n.d.). Expanding private partnerships with farmers or other food industry actors represent a potential future trajectory that can create room for win-win solutions (for example, the large-scale distribution decreasing scope 3 emissions thanks to the supplying farmers reducing their emissions).	Large scale distribution companies have the potential to financially support supplying farmers in reducing fuel consumption in order to reduce scope 3 emissions. Not only farmers, but also food industries that get supplied by farmers and supply supermarkets. Influence here operates through the power balances throughout the value chain.

4.2. ETHICAL CONSIDERATIONS

Each stakeholder in this project is guided in their actions by distinct interests and influences and it is important to consider ethical implications of our research. The implications of the findings in this research will have different implications for each of the stakeholders involved. It is critical that we reflect on such implications and consider potential ethical concerns that may arise. By reflecting on

these potential implications, we will be better able to address them and work with stakeholders to reduce any negative impacts. The project highlights the importance of sustainable and ethical agricultural approach, and it calls on stakeholder involved to adjust their actions in different ways according to the various paradigms. Table 4.2. outlines possible ethical concerns of each of the stakeholders.

When discussing a potential transformation of agricultural systems, the impact on farmers can be particularly contentious. This was highlighted by the farmers protests in the Netherlands following the Dutch government's plans to reduce the size of its animal agriculture industry. When proposing changes that impact the livelihoods of workers they must be included in the conversation. Plans for retraining, infrastructure conversion, etc. will need to be addressed in any alongside any proposals.

Table 4.2. Ethical concerns

Stakeholder	Ethical concern
Government Ministries: - Dutch Ministry of Agriculture, Nature, and Food Quality (LNV) - Dutch Ministry of Economy and Climate (MEZK)	• Increased opposition of proposed plans • Could undermine the previous works of the ministries
Organic farmers	• Increased competition caused by wider adoption of organic agriculture • Certain paradigms undermine their profit incentive
Conventional horticulture farmers	• Certain paradigms undermine profit incentive. All do it in the short term. • Pressure to change practices to more sustainable forms of agriculture
Wageningen University and Research	• Reducing the relevance of certain departments that research and perpetuate industrial agricultural methods
Agricultural equipment suppliers	• Reduced demand in the case certain paradigms less reliant on industrial machinery are adopted
Dutch organizations on sustainable food systems	• Reassess their sustainability and growth assumptions impacting their recommendations and practices
Bank (investment and financing)	• Certain paradigms can lead to a shrinking market and reduced profits due to less reliance on industrial machinery and promotion of sharing and decommodification
Supermarkets/food industry	• Potential changes in supply chain requiring reconfiguration of logistics

5. CONCLUSION

We started this report by outlining two research questions which at times align, differ greatly in scope and timescale that they address. On a general level, the different economic paradigms can be operationalized within the context of Dutch agriculture by breaking down the three dimensions of sustainability into different but overlapping facets that make evident the differences between them. All the paradigms look for the same goal – sustainability – but the difference relies on how the problem is understood and how the goal is achieved. In this sense, green growth entails a stronger market orientation and top-down policies, with market orientation reflecting the economic dimension. Degrowth challenges existing market dynamics while increasing social and ecological considerations. Agrowth relies on existing market dynamics but with a greater state top-down interventions on the market.

Market orientation can be further broken down into three main aspects in order to have more detailed insights: relational autonomy with stakeholders, consumption patterns, and the adoption of market-based instruments in support of environmentally friendly practices. Each of these indicators of market orientation (reflecting the economic dimension of sustainability) are constituted by measurable facets either quantitatively or qualitatively: contracting practice, commodification of land, direct selling, commoning, and financing provide more detailed differences that ultimately give an idea of how autonomous farmers can be in their decisions within the different paradigms. Consumption patterns are broken down into eco-labelling, diet seasonality, protein source in the diet, and trade, each of which gives an idea on to what extent consumption necessities in terms of consumer preferences steers agricultural production. Market based instruments are an indicator of to what extent financial compensation is important for farmers to adopt environmentally friendly practices. In this domain, only the eco labelling, contracting practice, and commoning can be qualitatively appraised.

Degrowth is characterized by a less intense material throughput (macro-indicator reflecting the environmental dimension), since its conception of the role of agriculture in society is based on the concept of sufficiency, thus leaning more on providing social well-being instead of income accumulation, when compared to green growth. This has an effect for instance on the prioritization given to maximizing yields and profits: if this is detrimental to environment but beneficial for income, the environment is to be prioritized for degrowth since environmental negative externalities have a greater effect on social well-being. In this sense, green growth attempts to balance negative environmental effects through increasing resource optimization, while degrowth advocates for an absolute reduction in material throughput. For example, a greater accent is put on seasonal production in degrowth, with strong effects on the amount of energy to be required as input, and on the health of the surrounding ecosystem. Material throughput refers to the rate of production that keeps into consideration not only the life cycle of agricultural inputs and equipment used in agriculture, but also focuses of the agricultural outputs in terms of negative environmental externalities. It is hence a broad concept that was broken down into distinct clusters but that are highly interrelated: agricultural inputs, agricultural outputs, resource optimization and ecosystem services. Aggregating the results from these indicators have the potential to provide a better picture on how the role of agriculture in society is conceived within the paradigms.

With reference to social sustainability, also the conception of the role of labour outlines the different shape agriculture would take under the different paradigms. The accent put in green growth on efficient (high and low-tech) solutions and diversification of jobs away from traditional farm jobs raises important ethical considerations about how to take care of those people who will be replaced by more efficient methods and don't have technical and specific skills to be applied, by either providing a universal basic income (degrowth) or providing training (all alternative paradigms). In order not to limit the social dimension to the conception of labour within agriculture (operationalized in terms on employment rate of agriculture, workforce purchasing power and level of skills), this dimension was enriched with the food security indicator. The four pillars of food security represent insightful operationalization possibilities because they address the social value of agriculture

explicitly. In this case, pillars like utilization may not be quantifiable but provide insights on the role of knowledge in meeting the social foundation of human activity.

The self-assessment tool for farmers builds up on the insights provided by these indicators. Dividing farmers into clusters relating to the farm specialization and size have the potential to collect more precise information on the extent to which the paradigms are rejected or internalized. Moreover, setting the questions and statements of the Likert scale according to a specific problem like fossil fuel reduction can provide information both on the willingness and on the farmers' capacity in addressing it.

With reference to the practical research question, that addresses the narrowest level of specificity, alternative weeding control practices can be carried out in different forms. It is important here to point out that the solutions outlined in section 3.5 are not mutually exclusive. Since the farm is characterized by scattered plots, different solutions can be applied in different plots according to the specific necessities of the farmer within each plot. For instance, what consumes fuel in addition to the weeding practice is carrying heavy machinery to the plot where weeds need to be controlled. Giving this, a rational combination of solution to reduce fuel consumption would be to exploit agronomic practices or the least fuel-intensive solutions (intercropping, no tilling, biofoil or mulch layering) in the most distant plots from where the tractor is stored and exploiting machineries-based solutions on the closest plots to reduce fuel consumption due to transportation. Apart from the weeding process, the watering process can be further explored on the farm to reduce fuel consumption, through alternative energy sources and water-retaining mulch layering.

5.1 RECOMMENDATIONS

New economic paradigms and their implications for Dutch agriculture is a highly under-researched field of study. In order to advance knowledge in this domain it can be beneficial to dive deep into the proposed indicators, either individually or by grouping the overlapping ones, and measure them. This is still a necessary but not sufficient condition to advance knowledge in this field. Since its not only a matter of what happens, but why it happens, to complete the picture is imperative to ease the emergence and interaction of implicit and explicit assumptions, beliefs and values that ultimately define whether a specific paradigm trajectory is undertaken, in order to better understand them and their mutual interaction. This shouldn't be done exclusively within the professional category of farmers. Academics, activists, food industry professionals, workers, local politicians and citizens all carry with them different framing processes on the paradigms object of this report. A potentially beneficial format for this to happen is the dialogue, a form of multi-stakeholder engagement that sets a comfortable forum to share ideas and beliefs in order to promote mutual understanding and knowledge advancements, especially in the underlying assumptions underpinning the paradigms. Wageningen University offers the possibility to organize dialogues and being supported in doing so. At a farm level, the team recommendation is to start keeping track of fossil fuel consumption in a detailed manner. This would create room for potential scenarios development with concrete estimations of fuel consumption and reduction referring to different alternative weeding practices.

5.2 FINAL REMARKS

Depending on which solution is to be carried out, or on what configuration of solutions is to be adopted, different paradigms are implemented. Again, it is important to stress that even the paradigms do not stand as mutually exclusive blocks, but rather overlap, interact and enrich each other with assumptions, beliefs and prescriptions. Degrowth for example doesn't explicitly state its rejection of high-tech solutions, but differentiates itself from green growth and agrowth depending on whether a fully automated weeding robot is purchased individually by a farmer (maybe through a bank loan), collectively by a group of farmers (commoning), or even through an incentive scheme implemented by the government (resembling more agrowth). Conversely, green growth doesn't fully reject low-tech solutions as long as they induct gains in efficiency but differentiates itself from degrowth since the latter might adopt low-tech solutions because they imply more manual labour,

guaranteeing in this way a living wage to more people. Here, in fact, the difference is in the underlying rationale, in degrowth more concerned on people's well-being, and in green growth more concerned on resource optimization for the sake of increasing income.

Weed management can hence take different forms, depending not only on the availability of high-tech solutions that can be combined with existing practices (and their costs), but most importantly on the dominant beliefs and values of the interested farmer. Paradigms have an influence on how economic activities are carried out by people, but ironically even people's activities over time define the underlying rationale, beliefs and values that characterize an economic paradigm.

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APPENDICES

APPENDIX 1. SELF-ASSESSMENT TOOL FOR FARMERS

In order to provide a practical example of a self-assessment tool and the format through which it can be spread among farmers we have created an example of a Likert scale. This can be used by farmers to indicate which economic paradigm best applies to their needs. In practice, multiple such self-assessment tools can be created which are each relevant to certain farming practices. This example has been created as an example that can be applied to The case farm, our case study, which is an organic horticulture farm. The farmer can use the Likert scale statements to plot whether they agree or disagree with statements related to fossil fuel reduction in this report. Hence, the following Likert scale is tailored for organic horticulture farms larger than 10 hectares.

Statements are built according to the paradigms, meaning that each of the 4 statements represents a paradigm. Hence, strongly agreeing with one statement means to fully embrace a paradigm, while strongly disagreeing would mean to reject one. Middle answers can be inferred according to the paradigms' spectrum provided as a graphic example in the self-assessment tool section. Statement 1 represents the neoliberal paradigm; statement 2 represents green growth; statement 3 represent agrowth, and statement 4 represent degrowth. In order to develop a potential weighted index, instead of providing different statements reflecting different paradigms (like in this example), it would be better to develop all statements reflecting one paradigm, to accrue the extent to which an individual farmer embraces or rejects a paradigms' assumptions and prescriptions.

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1. Fossil fuel consumption is not a concern for me. As long as it helps me produce sufficient yields with greater profit margins than otherwise, I won't consider it something I should reduce.	1	2	3	4	5
2. I prefer to keep the same fuel-intense crop and invest in more efficient machinery rather than looking for less fuel-exigent crops but that would be paid less on the market or require more labour.	1	2	3	4	5
3. Increasing yields to increase profit is not imperative for me if I have to consume too much fossil fuels. Rather, it would be more beneficial to plan my future crops according to social and ecological considerations.	1	2	3	4	5
4. If there was the possibility to develop an energy community with neighbouring farmers to produce the energy we need for our farms (biogas, electricity), I would definitively consider it.	1	2	3	4	5

APPENDIX 2. INTERVIEWS

INTERVIEW WITH TIMO SPRANGERS FROM OPEN TEELTEN PROEFBOERDERIJ, 01-12-2023

Weed management on farms:

- Mechanical weeding: a lot of companies try to automatize
- Farmers have started using lighter tractors
- Different types of techniques are currently used, introducing robotics and AI technology on the fields
- Carrots & chickery: difficult weed control especially in organic agriculture and when slowly grown
- Study on energy inputs that are required for any weeding solutions. The paper "Using energy requirements to compare the suitability of alternative methods for broadcast and site-specific weed control " is suggested, as a study on energy inputs that any weeding solution requires
- Agricultural inputs: farmers should pay attention to their nutritional value, as adding more inputs for the crops can also result in more weeds

Examples of robotics for weeding control:

- Robots arrived in the Netherlands only two years ago
- If the farmers decide to use them, they should spend some amount of time in training and to supervise the field later on.
- Classic mechanical operations linked with ai : Ekobot from Denmark (plant specific)
- Thermal weed control: with electricity, steam, hot foam, laser technology/ Restriction: Lazer technology comes under guns law in some countries
- Lazer technology: requires a lot of energy inputs, for weed control not that much
- Concentrated light does not disturb the soil and should reduce weed pressure
- Farmdroid: suggested as a good solution, used for carrot and chicory,
- Machinery & robots are expensive, labor as well
- Initiatives and subsidies can help farmers to introduce robotics in their weeding processes

Intercropping

- Combination of weed control : leek & celery is a combination that has been proved to work well
- Sandy soils have the difficulty that as soon as you disturb the soil you have new weeds emerging
- The amounts of weeds you have in the fields can be controlled: if you can stop them from germinated you don't have to tackle them.
- Intercropping with pumpkins and beans also works well.
- Intercropping could potentially work with herbs

Plowing

- Co2 emissions from soil can be reduced

Biofoli:

- Use just organic material as a mulching layer is suggested : compost has been proven to work good with onions, but doesn't work that well in carrots. In the farm they are currently using bokashi
- Chicory and sugar beats are related

- Loose sand can be used as mulch

Water Usage tips:

- Probably not allowed to use water in summer times in the region of Drente
- Methods like mulching and covering the soil help evaporation.
- Tillage only 2cm deep isolates the layer, breaking the transportation roots to the atmosphere. Most weeds germinate from the top layer of the soil, so by using this technique it is not that easy for them to grow. The farmers should start with good preparation of the soil.
- 2cm tillage has been practice by Brabant farmer for weed control and water retention

VISIT OF THE FARM IN DRENTHE AND INTERVIEW WITH THE FARM MANAGER, 17-11-2023

Things they want to improve in weeding practices:

- Reduce labor
- Reduce fuel consumption

General information about the farm:

- The farm has been running organic for the last 20 years. Their inspiration to switch from conventional to organic came from the fact that conventional farming is not good for people nor for the environment.
- Organic farm: they drive more times than on a conventional farm, constantly busy with a tractor. Weeding itself is not a difficult process
- No spraying is used
- When you grow organic for a long time, a balance can be achieved/ ex. A lot of useful insects (they only have some carrot fly)
- The soil of the region is not an easy soil, it needs a lot of work with tractor and human labor
- High temperatures combined with a lot of rain can result in fungus (depends on the year)
- A lot of hummus and topsoil compared to clay, thus more water needed as it percolates through the course soil. This creates ideal conditions for weeds as well.
- Harvest earlier than in Clay soil (e.g. the cabbage grows faster (but are a bit spindlier) on his sandy soils than on clay soils)
- The region has the ideal climate for crops, as well as for weeds

Labor:

- Usually, 3 people work there in standard
- Labor is expensive, with the payments of the workers increasing even more each year (succeeds crop selling price)
- Workers come mostly from abroad (Romania, Poland, Ukraine) and they are hired in collaboration with a contractor
- It is mostly demanded in 3rd/4th week of May until the end of August
- 8-40 people, the number downsides again until the end of the season
- They have to spend a lot of time supervising the workers.

Cultivation Plots on the farm:

- Pumpkins: grown for seed production, manual gemination/ pollination depending on variety. Thus 3 types of pollination. For one it is picking the male flowers, find the flowers that will open the next day (manual pollination). They have F1 hybrids and a very old

variety, for which they take out the seeds and plant them. Harvesting the seeds, the percentage of difference of seeds should be below 5%.

- Plots that are the focus of the case study: chicory, carrots, herbs
- No same crop rotation: they produce according to the demands of the market
- Herbs: they are fully organic from cultivation to packaging
- They are collaborating with a chicken farmer, sharing land with other farmers and sometimes switching fields
- Combining machines with other farmers enables them to preserve a 100% organic company
- Currently, there is a row of flowers along 1-2 sides of each field. They are a mixture of (mostly?) wildflowers. Supposedly good for pollinators. They are replanted each year.
- Weegbree: according to the farm manager it is considered as a weed for other farmers

Distribution of the final products:

- Organic market is shrinking
- Chicory, herbs, seeds: sales via direct contact with the customers
- Carrots: they need special preparation before sale, so they are collaborating with a contractor
- Beans: the use conventional seeds, organic ones are not available in the market
- Chickery: direct contact with the customers
- They are only working with contracts, otherwise in case of damage it would be hard for them to cover it.

Weeding practices:

- Chicory, maize: easier with the tractor, done 90% by tractor
- Carrots: mostly need labor, because the distance between the rows is only 40cm, so there is not much space

Agroforestry as weeding solution:

The farm manager got interested , there are some fields that are not on the right space and it could be practiced in space that cannot be harvested

Concerns:

- 1st year: very costly, in the space between you have to plant something
- 3rd-4th year: not possible
- If they move to trees, they don't have much expertise

Biofoil as weeding solution:

- They would be interested trying it if there are no residues

Solar power

- located in the farm, there are space for more

Fossil Fuel consumption:

- They use 3,000 liters volume diesel tank; they refill it 3 to 4 times a year
- 10 liter diesel per hour used for irrigation only

- Not sure how much the average use is for the tractors, but during the growing season, a tractor goes 2-4 times a week across the fields to rip up weeds.

INTERVIEW WITH REPRESENTATIVE OF SLOW FOOD, 21-11-2023

The representative works as a volunteer. He is focused on the political and advocacy aspects of Slow Food. He is also a wine importer who works with small-scale farmers.

They introduced the SF slogan “Good, clean, and fair food for all” (he mentions SF is global and thus this applies not only in the western countries)

He describes SF as not only a green movement, but also as a social movement. He stressed that we cannot forget that when we talk about changing an agriculture system, we also must consider the environmental and social implications.

SF rep. then asks us for our working definitions of the three alternative economic paradigms. Arni and Ian describe the three from their background knowledge (as we started literature review the same day thus we did not have working definitions).

- The basic ideas described were that green growth works with only minor adjustments to the current system. It focuses on improvements in efficiency through technical solutions. A key belief in green growth is that decoupling economic growth from ecological impact is possible, and that economic growth is required to improve social well-being.
- Agrowth is then growth ‘agnostic’, whereby it wants to improve social well-being and reduce ecological impacts regardless of the impact on growth. The decisions should be made without regard for economic growth measured in GDP.
- Degrowth starts with a belief that decoupling economic growth from ecological impact (measured in material throughput) is not possible. Thus, the inverse of this is that to reduce material throughput, there will inevitably be a reduction in GDP.

SF rep. responds to these definitions by clarifying that Slow Food operates around the world and will therefore have a diverse opinion on growth depending on local context saying, “It does matter what country we are talking about.”

In other continents economic growth can be appreciated, what are the circumstances in any reason. For the Netherlands this may not be necessary

Ian then clarifies that the definition of degrowth is a planned reduction in material throughput in certain sectors and geographic regions, thus degrowth does not oppose this statement. The planned reduction in certain areas is meant to reduce ecological pressures so that other areas can in fact grow and meet their social needs. Degrowth does take into account social and ecological justice.

Federico asks: What does it mean to be slow in farming?

SF rep. explains: It means farming with attention and care, taking your time for doing right things for human, nature, and environment.

Slow agriculture: take care of the land, soil, animals, use of pesticides (as SF includes non-organic), take your time to reflect on decision making, always open for feedback, feel responsible for more than just your case.

We ask for the role of the current economic system:

SF rep. recommends that cities and villages should take more care of the neighborhood.

For example: What kind of food is available close to schools? If there is a McDonalds, then children are more likely to eat this. Is it possible to improve the food options? To have healthy food available in schools?

We ask: How do farmers interact within trade when working in a sustainable way and at a slow pace?

SF rep.: It is profitable, but working in a slow way needs a long-term vision. In the Netherlands, many are not able because they are pressed by the industry.

“Water quality problems will be the next nitrogen crisis”

We ask about measurable indicators such as biodiversity, soil quality, water quality, etc.

SF rep. responds saying that we must also take into account the economic and social indicators. Sustainability should include ecological, social, and financial dimensions. SF is an inclusive network, meaning that they focus both on the production and consumption aspects.

We ask about transition pathways for future farmers.

SF rep.: The SF movement in the Netherlands is not so big. This is beyond their scope. We are working on creating a professional community for SF members. Larger NGO's are more likely to have these large goals, SF mostly support other initiatives. SF is inclusive meaning it is open for consumers and producers. Big agribusiness are welcome, but not very willing to be included.

We ask about alternative weed management.

SF rep. says he is not a specialist in these technical issues. Being “slow” means to plan with a long-term perspective rather than with a short-term (like in conventional farming where farmers have contracts with the food industry that pressures them to stick to what is included in the contract); being slow is about taking care of rather than exploiting. In this sense what does it mean for a farmer to plan in the long vs. planning in the short term?

MEETING BETWEEN RESEARCHER FROM WUR AND THE MANAGER FROM THE CASE FARM, 14-11-2023

Meeting Minutes

(our transcriber started translating in real time, but this was not feasible throughout the interview)

Researcher: Introduces herself. Worked in the organic sector: mainly pesticides and weed control. Asked by Margriet (Exploring Alternatives commissioner) to have a conversation. Asks the farm manager to introduce himself.

The farm manager: Introduces his farm. Works with the farm owner, who is unable to join the meeting. They started the farm in 2003 in Drenthe, with a 4ha organic farm, mainly fresh vegetables. Over the years it has grown to its current size of 85ha. He is now less focused on fresh vegetables, but more on, conserved vegetables (carrot and green bean), seed multiplication; pompoen, courgette, and started a herb-corporation in collaboration with others where they grow multiple varieties for medicinal use such as valerian and weegbree.

Mainly directly to the seller except conserves through intermediary. Working together with an organic poultry farm, collaborating through exchanging machinery and/or land. The poultry farm only grows wheat and corn for feed. They sometimes share land to rotate crops. The case farm also work together with 2 organic dairy farms, exchanging manure and similar land sharing agreements as with the poultry farm.

The case farm gewassen:

- 10/15ha waspeen
- 10/15ha cichorei
- 5ha pompoen
- 6ha kruiden, valeriaan
- 15ha sperziebonen
- 10ha zaaizaad teelt
- 10ha graan

Researcher: What about spinach, buckwheat?

The farm manager: Spinazie en boekweit, kleine aandelen. Spinazie alleen voor zaaizaad. Boekweit is misschien ten einde. Wheat goes to chickens but the rest is pretty much running a loss.

Researcher: What kind of soil?

The farm manager: Hoge zandgrond, oude restgrond. Goed voor bio maar grote onkruiddruk. Daarom zijn ze hier. Als je kosten wil besparen, heb je daar het meeste te halen.

Researcher: Gebruiken het vaakst onkruidbestrijding veldgroenten.

The farm manager: Zijn met zijn 2 en nu ook stageloper werken/leren. Alleen in het seizoen, niet in de winter. Eind mei, beginnen met hand wieden, cichorei is eerste gewas met de hand tot ongeveer eind augustus/begin september. Groepje van 8 of 9, loopt op richting de 30/40 mensen in de piek. Ook door de bolster met de handbestuiving. Halve dag en daarna weer verder in het onkruid.

Researcher: Jullie werken vooral met wieden?

The farm manager: 2 wieden, gebruiken ze het liefst zo weinig mogelijk. Vooral waspeen. Cichorei hangt er vanaf, branden ze terug en daarna is de vraag hoe snel dat terugkomt. Of het zin heeft om het wieden te gebruiken, en anders lopen ze het met de hak door. Anders zelfs een stukje met de knie, anders is wieden niet efficiënt als je rijen hebt waarbij eentje veel te doen heeft en de ander niet. Beter op de knieën doen.

Researcher: Is het onkruiddruk of zijn het ook specifieke onkruiden die zorgen geven?

The farm manager: Vooral onkruiddruk. Wat ze nu ook zien is giftige onkruiden die doorzetten, zwarte nachtschade, lastig te wieden met de hand, vaak blijft wortel in de grond. De laatste jaren ook de doornappel. Het begon 3 jaar geleden sporadisch, maar is afgelopen jaren erg gegroeid. We weten niet waarom. Misschien toch uit de mest of compost.

Researcher: Bemesten vooral met mest van andere bedrijven?

The farm manager: Ja. Rundvee-mest. Laag fosfaatgehalte. Geen problemen met stikstofnorm, onder 100kg/ha maar fosfaten zit vrij snel vol. Rijden op alle gewassen 25 kuub drijfmest uit. Behalve boekweit (niet bemest) en kruiden (35 kuub) omdat ze in dec/januari gerooid worden. Soms strooien ze bij als het nodig is (bladverkleuring zichtbaar), verenmeel of patentkali.

Researcher: Komt er nog wat van kippen binnen?

The farm manager: Nee. Van kippen komt veel fosfaat. Dus die doen ze niet. Als er ruimte over is, dan compost om te ruimte te benutten. 200/300 ton compost per jaar. Bokashibult opgezet, ook ivm onkruid. Kruidenresidu onderzoek voordat ze planten, zit ook residu in.

Researcher: Compost maken jullie ook aan?

The farm manager: Nee, kopen we aan. Is biocompost. Zit blijkbaar toch residu in.

Researcher: Komt uit natuurgebied, maken jullie op het bedrijf?

The farm manager: Ja

Researcher: Kijkt naar rotatie. Veel veldgroentes. Ook grasklaver. Hoe ziet de rotatie eruit?

The farm manager: Geen vast bouwplan. Waar ze streng op zijn is wortel, zaad altijd 1 op 8, misschien 1 op 10. Daarom ruilen ze met veehouder voor verse grond voor wortels. Verder 1 op 6 gemiddeld. Sperziebonen kunnen sneller achter elkaar. Ligt ook aan wat de markt vraagt. Dat is een beetje het bouwplan. Grasklaver was grond in omschakeling, konden ze ruilen met veehouder.

Researcher: Het gaat om onkruiddruk en vermindering van brandstoffen. Wat zijn verder doelen voor het bedrijf?

The farm manager: Komend jaar iets grond wegdoen, omdat de markt aan het krimpen is. De bedoeling is dat de eigenaar van de boerderij wat rustiger aan kan doen, The farm manager wat meer. Voor mezelf het doel om rond de 70/75ha, als ik het daarmee rondkrijg dan vind ik het genoeg. Het liefst minder handarbeid. Groep van 40 man is grote kostenpost, plus het is een speciaal soort mens, soms lastig met gastarbeiders. Als je dat kan vervangen, dan liever de trekker 1x extra dan de mensen 1 week langer. E.v.t robottechnologie in de toekomst. Nu mark stagneert blijven de prijzen gelijk. Uitzendbureau gaat ieder jaar 1 a 2 euro omhoog per uur. Opbrengst kun je niet met 10% ophogen, en de vraag is of je dat moet willen. Is de balans.

Researcher: Meer vlinderbloemigen. Is dat vanwege stikstof of waarom interesse?

The farm manager: Is iets aangepast. Vrij veel sperziebonen, dat telt al. Met de huidige situatie moeten we kiezen wat financieel rendabel is.

Researcher: Heb je vragen/verwachtingen?

The farm manager: Hoe wij de bestrijding nu doen.

Wij ploegen wanneer het land bekwaam is. En dan maken we 2x een voorveld schoffelbank voorop en iets achterop om vocht in grond te houden. Soms 3x. Met cichorei branden in 4-brand stadium alles terug. Bij wortels branden we voor opkomst (5e 6e dag). Verder veel schoffelen 1x in de week, eggen minstens 1x in de week. Ook wat vingerwieders in sperziebonen en kruiden, is goed bevallen dus ook met cichorei proberen. Torsiewieders voor geplant materiaal. En dan met de hand de laatste onkruiden weghalen. Bij de waspeen is dat op een bed van 1.5m moet 40cm met de hand.

Researcher: Best wel intensief. Branden, schoffelen, eggen, hakken, vingerwieden, valse zaadbedden. Dus jullie zitten er bovenop.

Researcher: Mbt open veldgewassen. Wat doen jullie in de winter? Komt er een groenbemester?

The farm manager: Dit jaar na het graan wel. Afweging gemaakt tussen hoe het perceel er na de graan uitkwam, als het binnen een week veel onkruid stond dan geen groenmest. Soms schone grond, daar dan groenbemester ingezet. Andere percelen hou ik zwart om het onkruid aan te pakken.

Researcher: Rotatie met graangewassen. Zijn dat zomergranen of wintergranen?

The farm manager: Voornamelijk zomer.

Researcher: Open voor wintergraan?

The farm manager: Ligt eraan welk perceel. Sommige niet zo geschikt. Pluimveehouder heeft wat wintertarwe, dus als het kan dan doet hij dat wel. Over het algemeen toch zonde.

Researcher: Dingen als bodembedekking, plastic of mulch? Zou dat werken?

The farm manager: Vraag is uitgezet bij Howard. Daar stond een machine die kon zaaien onder bioplastic. Vraag gesteld wat is dit bioplastic? Haal ik daar geen residu mee binnen? Op het moment dat dat natuurlijk materiaal is wat geen kwaad kan, dan willen ze het wel proberen.

Researcher: En andere typen? Stro, snippers?

The farm manager: Nog nooit geprobeerd. Maar onderschat niet de onkruiddruk hier. Is ook waar ze tegenaan lopen met machines. Allemaal kleigrond, dat is hier anders.

Researcher: Ook hier met robots veel getest. Praktisch gezien nog niet ontwikkeld genoeg. Wel potentie maar dat duurt nog lang. Voor bio-boeren niet specifiek genoeg.

Researcher: Wil kijken wat er aan bodembedekking mogelijk is. Erg zomer rotatie. Eerste gedachten zijn als er mogelijkheden zijn voor wintergewas, of gebruik van grasklaver voor 2 jaar, breekt de cyclus van veel onkruiden. Combinatie met melkboer of andere boeren, is misschien ruimte voor. Wintergranen of perennials in de rotatie.

The farm manager: Bewuste keuze het niet te doen. De eigenaar van de boerderij doet veel in het buitenland, vooral in het winter. The farm manager werkt ook in de winter nog voor een ander bedrijf. Zo'n drukke zomer dat ze de winter meer rust willen.

Researcher: En de meerjarige optie om rotatie te onderbreken?

The farm manager: Zou kunnen. Het is meer dat we een aantal gewassen hebben waar we aan verdienen.

Researcher: Jullie zijn vrij circulair bezig. Of geduld hebben tot zaadbank is uitgeput, of kijken wat ze structureel kunnen veranderen om op die manier het patroon te doorbreken. Grasklaver is niet zo moeilijk maar brengt weinig op. Of een andere meerjarige die ongeveer hetzelfde kan doen maar met lagere investering en hogere opbrengst. De cyclus moet onderbroken worden (1-jarige zomerkruiden).

The farm manager: Grasklaver zou je kunnen ruilen met de veehouder.

Researcher: Andere dingen zijn er al: afdekken, rotatie openbreken en moet nog even denken over gewassen die dat kunnen doen.

The farm manager: Biofolie verhaal, als dat geschikt is, dan kun je ook nog wat andere gewassen telen. Hebben wel 5 vaste afnemers, maar dan kun je experimenteren. Bijvoorbeeld prei, maar ui is daar familie van maar daar kun je niet aan beginnen. Stel je kunt dit onder folie zaaien, dan wel. Dan verbreed je je markt ook tegelijkertijd. We zoeken gewassen die hier goed willen en die ze op klei liever niet telen.

Researcher: We hebben vlinderbloemigen al gehad. Maar wat mbt erwten of lupines?

The farm manager: Ik ken iemand die dat doet i.c.m. gerst, want die gewassen willen hier goed tot augustus, en dan laten ze blad vallen en duurt het nog een maand voordat ze rijp zijn. Je wil niet weten wat er in de maand daaronder groeit. Winterveldbonen is De eigenaar van de boerderij mee gestopt, kun je het onkruid niet weghouden.

Researcher: Sommige boeren combineren graan met vlinderbloemingen of graan met klaveronderzaad.

The farm manager: Zou je de klaver er niet uit eggen?

Researcher: Soms.

The farm manager: 2 jaar boekweit geteeld, mag je ook niks mee doen, maar je moet wel geluk hebben wil die boekweit sneller groeien dan het onkruid. Niet-eg gewas is wel spannend. De lupine en gerst kun je wel eggen.

Researcher: Heb onderzaad van klaver wel gezien maar de effecten zijn variabel.

The farm manager: Melders etc. bij boekweit bijvoorbeeld prikken daar wel doorheen.

The farm manager: Kijkt naar strokenteelt, en de invloed die dit heeft. Hierbinnen ook kijken naar robots. Ook onderzoek naar hoe robots onderscheid maken tussen verschillende soorten onkruid en gewas.

Researcher: Iedere beroering van de grond veroorzaakt ook weer nieuw onkruid.

The farm manager: Concluding, robots, type of crop to interrupt cycle, soil coverage.

Researcher: Solar panels at farm? Create own energy?

The farm manager: Yes. On roof of house. Electric vehicle, electric lawn mower for the home. But there are more roofs that could be used.

APPENDIX 3. COMPARATIVE TABLE ON THE ECONOMIC PARADIGMS

Disclaimer: For categories that are left blank, we were not able to find sufficient literature to make any claims. We have included some assumptions where we felt confident in our response based on our literature review. Unfortunately, these do not have direct sources.

Indicator	Sub-Indicators	Operationalization	Measurement	Scale	Green Growth	Agrowth	Degrowth
Market Orientation							
Relational autonomy		Autonomy produced in global market relations or in local/regional relations	Quantitative	Single farm level			
	Contracting practice	Power balance between farms and industry determines the outcome of the contracts	Qualitative	Single farm level	Competition reduces crop options for farmers, as a result of freer trade of agricultural products.		Alternative models such as community supported agriculture and social enterprises will greatly decrease power imbalances between the producer and consumer (McGreevy et al., 2022).
	Commodification of land	Ratio between owned land and rented land	Quantitative	Single farm level	Wants to empower small farms with subsidies/innovation, but has no land reforms (OECD, 2017; Stevens, 2011)		Land reform resulting in 're-commoning' will reduce both privately owned and rented land. (McGreevy et al., 2022) Community owned land will increase the autonomy of local actors leading to 'food-democracy' (Bornemann & Weiland, 2019).
	Direct selling	Ratio between amount of production for direct selling (to end customers) and amount of production sold to traders/food industry	Quantitative	Single farm level	Values global production chains, due to specialisation of production based on biophysical conditions or local skill ("comparative advantage" (Stevens, 2011))		Shorter supply chains and local food production will lead to significantly more local food production and consumption habits (McGreevy et al., 2022).
	Commoning	Appraisal of competition and collaborativeness	Qualitative	Single farm level	A freer market can ease the sharing of technologies (Stevens, 2011).	Commoning is encouraged since it promotes collective resource management, promoting local resilience	Commoning is a central practice in agricultural activities (McGreevy et al., 2022). Collaboration and

		among neighboring farmers			<i>Nothing mentioned about sharing resources/land/equipment</i>		community involvement are integral.
	Loan-Financing	Debt to equity ratio (should not be >1)	Quantitative	Single farm level	Does not support unconstrained credit... (OECD, 2017; Stevens, 2011) Wants to create a farm revenue irrespective of input/output (Stevens, 2011)		Financing is done using alternative methods whereby farms are not indebted to one large creditor. Practices such as CSA's, crowd funding, and commoning increase local autonomy (McGreevy et al., 2022).
Consumption patterns		The ways in which resources are consumed or utilized within agricultural practices (producer and consumer)	Quantitative	National level	Consumers preferences being a driving force (Stevens, 2011) Tends to benefit larger producers. <i>Mentions (one sentence OECD, 2017) that gains can be made from changing consumption patterns.</i>		
	Eco-labeling	Consumer perception on eco-labelled products	Qualitative	Single consumer level	Food labels are made via regulations. Beneficial to farmers, can increase value (Stevens, 2011).	Government subsidies for eco-labeled products enhance consumer favorability and contribute to increased competitiveness in the market.	Eco-labelling is not discussed in the literature as the focus is on changing the markets themselves. In a degrowth scenario, eco-labelling would be redundant as all goods would be produced with ecological considerations.
	Diet seasonality	Share of food in the diet of a single consumer that is produced in another climatic zone or in a local greenhouse	Quantitative	Single consumer level	Gives in to consumers demand of year-round available products. This can be done through international trade, as mentioned above. <i>Mentions (one sentence OECD, 2017) that gains can be made from "seasonal and local produce"</i>		A return to seasonal diets occurs due to the shorter supply chains and decreased alienation between the consumer and producer.
	Protein source in the diet	Share of animal derived proteins compared to	Quantitative	Single consumer level			Significantly reduced consumption of animal products as they are an

		vegetable derived proteins in the diet in a specific population					environmentally destructive means of producing protein (Poore & Nemecek, 2018). Animal agriculture requires significantly more inputs, such as land and water, and produces significantly more pollution, such as nitrogen and methane (Willeit et al., 2019).
	Trade	Share of exported product at farm level on the overall production	Quantitative	Single farm to global level	End goal is much more export oriented, due to specialisation between regions in the name of efficiency, which can lead to monocultures (Klasen et al., 2016; Feintrenie et al., 2010) Lowering trade barriers can reduce production in countries with high fertiliser/pesticide inputs (Stevens, 2011). Environmental goods should still be protected (Stevens, 2011), giving farmers opportunities for income diversification.	Reduced reliance on international market and minimized exported product due to concern of environmental impact	Export, which is commonly pursued for economic growth, is not a focus of food production. With a focus on local production the extractive nature of the agricultural industry will lower pressures on the growing of cash crops for export markets. This will create (bio)physical space for local agricultural production.
Market-based instruments supporting environmentally friendly practices		Share of farmers falling under financing schemes for environmentally friendly practices on the overall number of farms	Quantitative	Regional to national level	Reformed government subsidies, environmental regulations, trade measures (free(r) trade of agricultural products), money towards R&D and foreign development. Payments for Ecosystem Services	Market-based instruments and policy interventions rewarding sustainable farming are enforced to stimulate transition. Government incentives for sustainability practices are scaled up.	Market-based instruments are one of many practices for promoting change. Grassroots movements and citizens initiatives will simultaneously create pressure from outside of the state and corporate markets to create democratic change.
Material Throughput							
Agricultural Inputs		The intensity of inputs used in agricultural production	Quantitative	Single farm to national level	Aims to use less inputs, increase efficiency, increase share of renewables in agricultural practices, while increasing production.	Aims to use less inputs, increase efficiency, or shift into renewables in agricultural practices.	

						Indifferent about the effect on production.	
	Water	Value added per unit of water consumed, measured in irrigation water per hectare irrigated (OECD, 2017)	Quantitative	Single farm to national level	Does not support unconstrained water use, employs water charges (Stevens, 2011). Measures water use in terms of productivity (OECD, 2017). It thus wants more efficiency.	Promote methods to increase water efficiency through regulatory approach	Guided by agroecological principles, practices are adopted to increase water retention and reduce polluting inputs (Gerber, 2020; Nelson & Edwards, 2020).
	Land	Percentage of variation of agricultural land use per total amount of agricultural production	Quantitative	Single farm to national level	Wants more extensive farming via subsidy reform and environmental protections. Is okay with intensive farming if it avoids "inappropriate cultivation and irrigation techniques or overuse of chemical inputs" (Stevens, 2011). ->can be summarised as: Does not take a certain position in the "share vs. spare" debate.	Promote methods to increase land efficiency through regulatory approach	Decrease in the size of farms and increase in diversity within farms. Plant-based diets are promoted which have significantly less strain on land use (Cassidy et al., 2013; Poore & Nemecek, 2018; Willett et al., 2019)
	Chemicals and fertilizers	Value added per unit of chemical/fertilizer consumed	Quantitative	Single farm to national level	Wants fewer chemicals, promotes integrated pest management (practices that benefit predators of pests, lower disease rate, but can also include some chemical controls) (Stevens, 2011). Does not support unconstrained use of fertilisers.	Promote methods to use less fertilizer or even to phase out chemical use (organic) efficiency through regulatory approach	Significant reductions in the use of agrochemicals, following principles of agroecology to preserve ecological integrity (Gerber, 2020; Nelson & Edwards, 2020).
	Energy use	Value added per unit of fuel consumed (OECD, 2017)	Quantitative	Single farm to national level	Pushes for renewable energy (e.g. biofuel, wind) use along with more efficient fuel use. Regulations on diesel fuel.	Promote transition from fossil fuels to renewable energy in agricultural practices through regulatory approach	
	Machineries	Types of machinery are relied upon to complete farming activities.	Qualitative	Single farm to national level	Supports engineering innovation and renewable energy-run machines (Stevens, 2011).		Following Illich's (1973) convivial technology, farmers can autonomously choose which machines they deem to add social benefits. Being critical of

							techno-optimism, high-tech machinery may play a role, but is not seen as a silver bullet solution. Ecological and social considerations have to be made when deciding whether or not to use machinery which requires large quantities of fossil fuels, although Gerber (2020) warns that it is important to not overly romanticise rural living and succumb to the 'agrarian myth'.
Agricultural outputs		The intensity of outputs in agricultural production	Quantitative	Single farm to national level	Aims to emit less and increase efficiency in agricultural practices, while simultaneously pursuing growth of production (OECD, 2017; Stevens, 2011).	Aims to emit less and increase efficiency in agricultural practices. Indifferent about the effect on production.	
	NOx Pollution	Nitrogen emitted per unit of production	Quantitative	Single farm to national level	Wants reduction through technological innovation, health and safety standards (Stevens, 2011)	Promote methods to reduce nitrogen-based emission through regulatory approach. Pollution monitoring are carried out by the government.	Increased focus on seasonal production and plant-based protein will lead to a reduction in NOx emissions which is traditionally emitted by gas used to heat greenhouses and animal agriculture.
	CO2 Pollution	CO2 emitted per unit of production	Quantitative	Single farm to national level	Does not support unconstrained fuel usage. Reduced fuel usage through more efficient technology and machines powered by green energy. Biofuel production, carbon sequestration projects (reforestation, small-scale green energy generation). Regulations on diesel fuel.	Promote methods to reduce carbon emission through regulatory approach. Pollution monitoring are carried out by the government.	With a reduced reliance on industrial agriculture, heavy machinery, and chemical fertilisers CO2 emissions will be significantly reduced.
Resource optimization		Appraisal of farm's practices to efficiently	Qualitative	Single farm to national level	Paramount.		

		manage and utilize resources for maximum output and sustainability			Technological innovation should increase efficiency.		
	Innovation	Share of farm income spent on innovation (research and development)	Quantitative and qualitative	Single farm level	Technological innovation should increase efficiency. Supports income diversification on farms		The role of innovation is not instrumental as degrowth aims to reduce material throughput through other means.
	Circularity	Types and number of byproducts of agricultural activities that are re-used in other agricultural practices in the same farm	Quantitative and qualitative	Single farm level	Strives for circularity, being increased efficiency of resource use at all life stages (from extraction to disposal). Government incentives.		Practices of care are extended to more-than-human where circularity and sufficiency are embraced as methods to reduce negative ecological impacts (Faye, 2023).
Ecosystem services		Illustrates how anticipatory the paradigms are towards ecosystem services provision in the future	Qualitative	Field to national level	Deemed important. Payment schemes for Ecosystem Services (private & state)(Stevens, 2011).		Care and reproduction of the ecosystem are central to the degrowth food system (Faye, 2023).
	Purification of water, water provision	Water quality (measured in pH/nutrients in farm ditches and watershed levels)	Quantitative	Single farm to national level	Water management is deemed important. Preserved through agricultural biodiversity and support schemes (Stevens, 2011).		A reduction in the use of agrochemicals and animal agriculture will lead to reduced water use and pollution.
	Pollination	Abundance of pollinators at farm level	Quantitative	Field to national level	Preserved through agricultural biodiversity		
	Biodiversity	Biodiversity index	Quantitative	Single farm to national level	An all-round do-it-all indicator that improves productivity, soil nutrition, hydrological functions, and pollination.		
	Soil health	The balance between the nutrients entering the farming system and the nutrient outputs leaving the system. Also: pH, soil biodiversity, water/wind erosion	Quantitative	Field to national level	Soil erosion: done via support schemes Soil biodiversity: <i>Not a word on how to combat soil acidification, but acknowledges the problem.</i>		

	Carbon sequestration	Carbon sequestration (soil organic carbon change in soil)	Quantitative	Field to national level	One of the contributions of agriculture towards green growth (Stevens, 2011).		
	Nitrogen and phosphorous balance	N concentration P concentration	Quantitative	Field to national level	Wants to keep the balance. Decoupling should reduce N/P load.		
Social Dimension							
Food Security		How the paradigms differ in terms of providing enough food for everybody	Qualitative	Single farm to national level	Through unhindered global trade of agricultural products (Stevens, 2011). Can lower food security in the short term (Stevens, 2011).	As a critique to GDP, agrowth perspective strive for supplemental indicator of well-being. Food security is highly managed through regional and national policy actions. (King et al., 2023)	More equitable production and distribution of food will increase overall food security (McGreevy et al., 2022). Critiques the current agrifood system for being based on a system of extraction which focuses on the growing of cash crops for profit (Faye, 2023).
	Availability	Ratio between amount of food consumed and amount of food produced not including trade (self-sufficiency index)	Quantitative	Regional and national level	Highly dependent on imports of food for a nutritious diet, since local food will only consist of a few well-adapted species (grown with a "comparative advantage" (Stevens, 2011)).		
	Accessibility	Minimum income required to access a nutritious diet Percentage of population that doesn't reach it	Quantitative and qualitative	Regional and national level			With the focus on food systems on social well-being and equitable distribution, food will be accessible to all. Certain policies such as universal basic income and universal basic services help make sure all basic needs such as food and housing are provided for (Fitzpatrick et al., 2022).
	Utilization	Appraisal of knowledge of food storage and processing techniques	Qualitative				

		basic principles of nutrition and childcare					
	Consistence	Stability over time of nutrients intake	Qualitative	Regional and national level	Vulnerable to disruptions of the supply chain/trade networks, being so specialised.		
Labour		How do the paradigms differ in terms of labor employment in agricultural context	Qualitative	Regional and national level	More (bullshit) jobs = more work opportunity. (Graeber, 2018) A shift away from purely agricultural products towards services (e.g. eco-tourism) and environmental goods (biofuels, timber, organic produce) New green jobs		Proposes reforms such as work time reductions and redistribution of labour (Fitzpatrick et al., 2022). It is uncertain how this will impact the agricultural sector.
	Workforce purchasing power	Living wages of agricultural workers translated into their ability to buy goods and services	Quantitative	Regional and national level	Reliant on subsidies and/or income diversification to increase wages, especially small-medium sized farms (Stevens, 2011)		A focus on social equity and distribution of resources ensures living wages for all (Fitpatrick et al., 2022)
	Employment	Rate of people having farming as the main source of income	Quantitative	Regional and national level	Income diversification, green jobs (e.g. organic farming and biomass production), eco-tourism (Stevens, 2011). Unclear if this will rise due to shift towards these alternate income streams (services & green jobs)		With a focus on small-scale and less intensive forms of farming there will likely be a need for an increase in agricultural labourers (McGreevy et al., 2022). Gerber (2020) warns degrowth not to fall a victim to the agrarian myth, making it unclear how this will be done.
	Skills	Rate of skilled workers in the share national agricultural employment	Quantitative	National level	Re-skilling needed for green jobs (Piao et al., 2021; Stevens, 2011).		Based on agroecological principles and place-based knowledge, the farming system will rely on local knowledge, skills and, context (Faye, 2023; McGreevy et al., 2022).