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Sustainability in agriculture: a qualitative study of how agtech startups in Norway contribute

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Declaration

I, Pernille Christine Frimann Bügel, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

Signature.....PCFB.....

Date.....JUNE 1, 2020.....

Abstract

The purpose of this study is to analyse the contributions to sustainable agriculture from the agtech companies on the rise in Norway. Agtech is a growing sector in agriculture focusing on innovative technology to improve agricultural efficiency and applicability. Agriculture is still one of the sectors worldwide that has not implemented newly developed technology to a large extent. Thus, this study aims to shed light on the huge potential in this industry that can mitigate the challenges of climate change, and meeting criteria for food security globally. The goal of this study is to look more closely at sustainability contributions by Norwegian agtech companies and products, through the lens of degrowth and ecomodernist theory in a sustainability perspective. Interviews with agtech companies were undertaken to assess their sustainability impact. Sustainability can be difficult to define, as was made clear during research, however the data collected demonstrated a willingness to be sustainable throughout their business strategies. I discovered a trend that the products they develop are part of improved efficiency in agriculture, which in turn may lead to sustainability on multiple levels. This entails using advanced technology that can be implemented to ensure less environmental degradation as well as tools to change the farming system as we know it. Collected data indicate the need for more support surrounding agtech companies in Norway, for them to be successful in adding value in the green shift and towards sustainable agriculture.

Agtech seeks to improve agriculture in all dimensions of sustainability, with rising growth and support. Better choices in farming can become available using new technology, which can withstand any changes agriculture encounters. The future is digital, however, whether it be large-scale conventional farming or smaller farming methods remains to be seen. Ultimately, I have no doubt that the future of farming is digital, and agtech has the potential to contribute towards sustainable agriculture.

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Thanks to my mom, stepdad, and sister- my mind has been halted from turning into a twister.

Support from my dad, brother, stepbrother and sister in-law, thanks, it seems I drew the lucky straw.

And not at least from my supervisor Ola Westengen with his words from the wise, without those there would be many more cries.

Thank you to my patient friends, who listened to me whine seemingly without ends.

Also, everyone who were able to participate, thank you, in this thesis you are the glue.

For the COVID-19 virus, timing could not have been more right, it gave me way more time to write. Unfortunately, a few less interviews I was able to possess, and that added a little stress.

But now I am much wiser than I was before, my interest has been deepened to the core.

Without much previous background of agriculture, I began this project, but now my knowledge is significantly broadened on this subject.

I am finally done, against all odds with my masters, thankfully without any major disasters.

Acronyms

CGIAR: Consultative Group of International Agricultural Research

EU: European Union

FAO: Food and Agriculture Organization of the United Nations

GDP: Gross Domestic Product

IPCC: Intergovernmental Panel on Climate Change

OECD: The Organization for Economic Co-operation and Development

PB: Planetary Boundaries

SDG: Sustainable Development Goals

UN: United Nations

UNEP: United Nations Environment Programme

WB: World Bank

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1. Introduction

The agriculture sector is the second largest emitter of greenhouse gases in the world, but it is not the most technologically developed (IPCC, 2014).

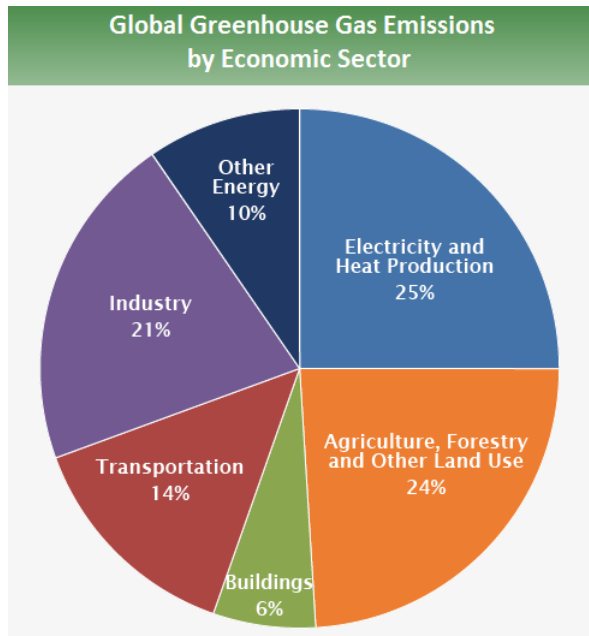


Figure 1: Global Greenhouse Gas Emissions (IPCC, 2014)

As a response to dealing with the emissions and impact from agriculture, *agtech* (agricultural technology) is emerging as a possible solution to tackle challenges related to climate change and a growing need for food. New technological advancements in agriculture, including big data, precision agriculture and smart farming are all directed at improving today's farming methods and systems. All towards a goal of increasing food production for a growing population, yet at the same time implementing sustainable practices that will benefit humans long-term. Norway has already taken a role in being on the

forefront of development and manufacturing of agtech solutions. In Norway, the startup environment within tech is noticeably growing. Specifically, agtech companies are on a path to potential significant contribution and progress, because of their efforts towards a low-emission society.

The agricultural sector must undergo massive changes, largely due to climate change. As the IPCC (2014) states: “*climate change, including increases in frequency and intensity of extremes, has adversely impacted food security and terrestrial ecosystems as well as contributed to desertification and land degradation in many regions*”. The Greenhouse Gas emissions (GHG's) beginning in the industrial era, until now, are why these changes are occurring (Shukla et al., 2019). The use of land due to the intensive growth in production for food has since 1961 increased 240% (Shukla et al., 2019). Changes to how land is used in agriculture at regional and global scales can help reduce the current path of climate change, in the frequency, intensity and duration of the events which in some cases have extreme effects (Shukla et al., 2019). The negative impacts of agriculture include climate change, irrigation problems, soil degradation, waste, deforestation, and land-use change. The IPCC working

group states that GHG's from the agricultural sector is responsible for about 24% (2014) of anthropogenic gases (Mastrandrea et al., 2015). It is the only sector which has seen a reduction in emissions during the previous decade (2000-2010), because of a decline in deforestation rates in some areas (Mastrandrea et al., 2015). As a mitigation effort, it is suggested by Mastrandrea et al. (2015) that on a global level, more efficient use of land and improved management efforts can cause a reduction in emissions from this sector.

Land-use change has also affected Norway. Something that was made noticeably clear first-hand during the 2018 summer. Over 100 weather stations recorded new records for average temperature rise. 80 stations recorded new maximum temperatures, many of which were over 30° C (Landbruk, 2018a). The extreme heatwave that swept across Europe in the summer of 2018, had serious implication for Norwegian agriculture. Lack of precipitation caused water scarcity, which in turn negatively affected the groundwater supply (Gangstø, 2019). Hence grass and cereal production crops suffered severely. The farmers had to send their animals to be slaughtered from a lack of feed. The yield returns led to major financial losses to the farmers, an estimated 5-6 billion NOK worth (Gangstø, 2019). The weather pattern at the time that drove the heatwave was due to a high-pressure system that blocked the rain from coming in, Gangstø (2019) states. The jetstream also took a different path that summer. In addition to these natural phenomena, the anthropogenic greenhouse gases contributes to the warming of the climate, creating extreme heat records and higher risk for events like this to occur more frequently in the future (Gangstø, 2019). The predicted changes in temperature does not have to be all negative, if one is prepared for what is to come. As the Norwegian Meteorological Institute claims, climate change can create opportunities in having longer growing seasons and thus be beneficial for food production (MI, 2017).

To mitigate the effects of climate change, sustainability can be a part of solving the puzzle. Therefore, a transformation of agriculture is recommended. Sustainability has been defined in many ways. It was first developed by the World Commission on Environment and Development in 1987, chaired by Gro Harlem Brundtland; "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Brundtland, Khalid, Agnelli, Al-Athel, & Chidzero, 1987). Thus, sustainability means having strategies to promote social and economic advancement whilst avoiding environmental degradation, over-exploitation, and pollution. Similar to the original definition, the Food and Agriculture Organization of the United Nations (FAO) defines sustainable agriculture as,

“agriculture must meet the needs of present and future generations for its products and services, while ensuring profitability, environmental health and social and economic equity”.

And for agriculture to be sustainable it *“must nurture healthy ecosystems and support the sustainable management of land, water and natural resources, while ensuring world food security”* (FAO, 2015).

Environmental health, social and economic equity are pillars of sustainability and these interlinking dimensions will be used to analyse the research content later.

The need for sustainable agriculture is due to the negative impacts of agriculture today. The use of resources and interferences in the environment has led to 1/3 of farmland becoming degraded (FAO, 2015). 75% of crop diversity is already lost. 22% of animal breeds are at risk, as well as 13 million hectares of forest being turned into other land uses every year (FAO, 2015). The need for agriculture will only increase as the global population grows. In order to achieve sustainable production, agriculture must undergo major changes in efficiency and the use of resources, both in environmental protection and in resilience of the food system (FAO, 2015).

A transition in agriculture is important if we are to feed everyone in a growing population, including moving towards plant based diets, having less food waste, and incorporating emerging technologies (Klerkx, 2020). The new technologies which include AI (artificial intelligence), robotics, IoT (Internet of Things), sensors, big data, and Precision Agriculture (PA) are alternatives to the current food systems in Norway. PA uses site specific technology to help observe and measure soil to improve production, and often uses AI to create forecasts and improve overall productivity (Walch, 2019). IoT provides monitoring systems to assist with humidity, temperature and soil moisture (Ravindra, 2020). Agricultural robots are most often used to improve yields through weed control, autonomous spraying and harvesting (Robotics, 2017). Whilst big data is the use of large datasets which collect and analyse data, previously done by farmers, there is now open source datasets available to assist in making decisions (Bronson & Knezevic, 2016). These technologies aided by multifunctional agriculture, which goes beyond production and includes management, conservation and socio-economic factors, can be alternatives to today’s systems through collaboration (Klerkx, 2020). The digitization of the farm entails using more robots and data that can give specialized advice and provide information flow via mobile devices and digital interfaces that can create new *hybrids* of agricultural systems (Klerkx, 2020). These also have to respond to disruptive

forces such as climate change, ecological change, changing farming systems, societal changes and shifting economic environments, as well as food systems policy (Klerkx, 2020).

For the purpose of this dissertation, the sustainability of agtech will be explored through a case study of agtech companies located in Norway. New technology is developed as a response to dealing with the challenges presented by climate change. To become sustainable, farming practices and how agricultural machines are used should undergo changes. The participants in my study use technology that aims to spray weeds (precision farming), reduce nitrogen use (recycling nitrogen at the farm), sensors to monitor crops, sensors to provide digital models of the landscape for decision making, and big data to track and monitor operations.

My objectives for this study are to look at how the agtech companies in Norway can contribute towards sustainability within agriculture in a Norwegian setting. Thus, my study aims to look at how the agtech companies define sustainability. How the agtech companies' products may improve the environmental conditions from agriculture, and how the agtech startups can be an asset in contributing towards the green shift. To investigate these objectives, I have created the following research questions to guide the focus of the study:

- What are the Norwegian agtech startups understanding of sustainability, and how can they contribute towards that in agriculture?
- What role does agtech startups play in the green shift in Norwegian agriculture?
- Can agtech startups provide more efficient agriculture, and how does that align with sustainability? What indication can it provide about the future of agriculture?

The framework that will be used to assess the sustainability in agriculture is mainly that of the degrowth and ecomodernist theories. These are frequently used in the current environmental debate and have varying views of technology used for sustainability. As pointed out in the research questions, sustainability is the core part of my study. It is also important to understand agriculture in Norway today and how it may be improved. The following section will introduce the history of agriculture in Norway today as well as the rise of agtech.

1.1 Background of Norwegian agriculture

The case study will be introduced in the following section and aims to give a general view of the current situation and brief history of the matter at hand. This information provides fundamental knowledge for the discussion and analysis later in the study.

1.1.1 Agriculture in Norway

In Norway only one in 14 inhabitants live on an agricultural property (Bye, 2019). The total area used for agriculture in Norway today is 3.5% of the available land, which is equivalent to 24.855 acres (SSB, 2019). In the last decade there has been a steady decline of land used for agriculture. There are 38.938 farms (2019), where the majority produce meat and dairy (Figure 2).

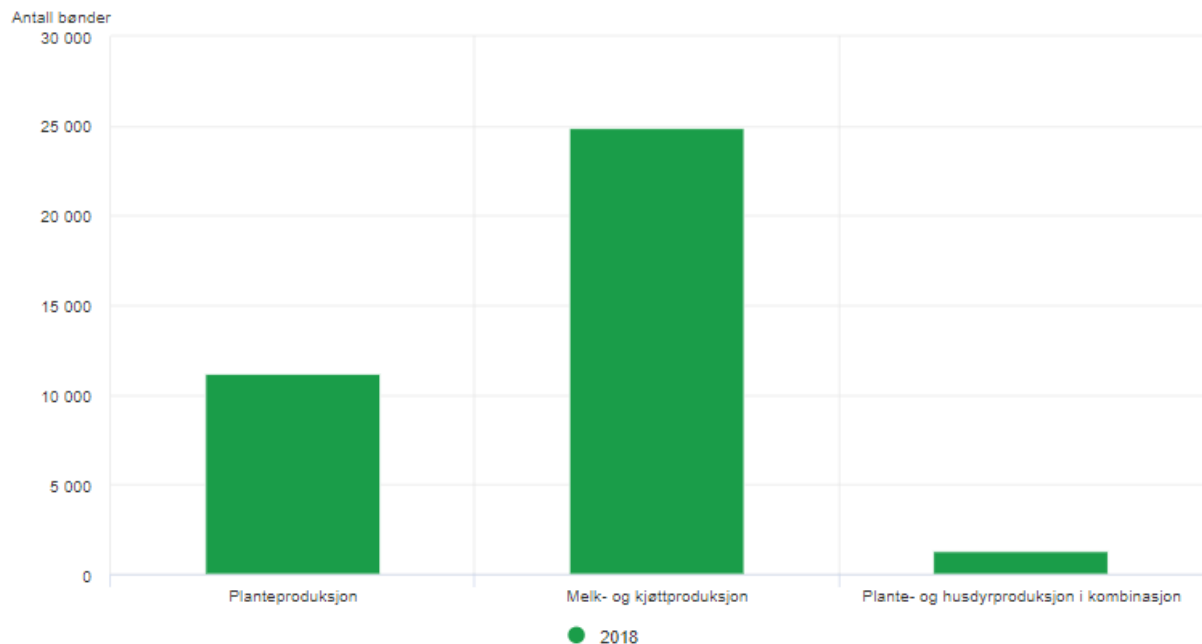


Figure 2: Production from farmers of Norway (Chaudhary, 2019)

Plant production comes second after livestock. Those farmers who operate on a combination of these are quite low in numbers (SSB, 2019). Only 13% are full-time farmer with an average income of 200.600 NOK (SSB, 2019). Data collected by the government show that emissions from the agricultural sector has been relatively stable since 1990, with a slow decline due to more efficiency (TBU, 2018). Agriculture is the main source of emissions of methane and nitrous oxide (see Figure 3). Agricultural machinery such as tractors emit up to 346.000 tonnes of CO₂ yearly (2016). All total emissions from the agricultural sector in Norway released 4,5 million tonnes of CO₂ (2016), thus 8,4% of total emissions (TBU, 2018).

A challenge facing Norwegian agriculture today is the new generation of people who do not wish to continue with the family farms, but prefer to use the property for recreational purposes (Bye, 2019). In the last decades the transition into recreational (and other) purposes has increased 500% fold (Bye, 2019). In the remote districts rapid depopulation leads to areas being overgrown and agriculture being phased out, as urbanisation grows. An effect of this is the increased pressure for urban agricultural areas being sold for construction purposes and

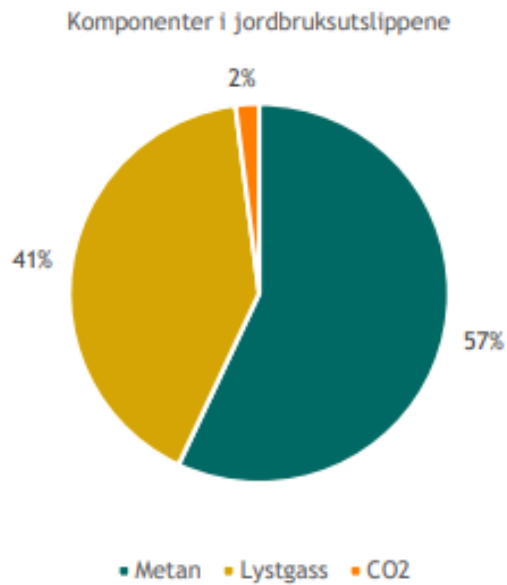


Figure 3: Components of emissions in agriculture (TBU, 2018)

nationally and globally (Regjeringen, 2019c). The background for the plan are the Sustainable Development Goals, which were formed by the UN in 2015. The Norwegian government wants to use the extensive knowledge of sustainable farming, within aquaculture and agriculture to change the current system, into a low-emissions society. The Norwegian government’s plan to improve the efforts of eradicating hunger is based on the Sustainable Development goal number two to, “end hunger, achieve food security and improved nutrition and promote sustainable agriculture” (Regjeringen, 2019a; UN, 2019). The Norwegian government states that they aim to increase sustainability, climate adapted food production and increased production from agriculture (Regjeringen, 2019a). The government wants to promote sustainable food systems through strengthened relations to institutions. This is part of the Norwegian governments five-year plan. Adapted technology with a focus on sustainable production and increased productivity is part of that plan, in cooperation with small-scale farmers and local actors. It wants to strengthen the knowledge of what sustainable food production is, locally, nationally and globally, and incorporate changes in the use of pesticides and the development and reduction of chemical inputs (Regjeringen, 2019c). Overall, the government wants to provide significant support that will make digital solutions more available, and that this adapted technology will support a sustainable food system. Part of where the Norwegian government wants to improve is through climate smart agriculture, which means reducing emissions from agriculture, maintain the biological diversity, reduce land and soil degradation and reduce deforestation (Regjeringen, 2019c).

expanding industry and infrastructure. Thus, putting additional pressure on agricultural soil. Unfortunately, many of the previous agricultural areas are now being used for development and occur on soil that is otherwise well suited for agriculture, which can lead to a shorter growing season (Bye, 2019).

Norway is one of the few countries in the world who has incorporated a plan for sustainable food systems in its

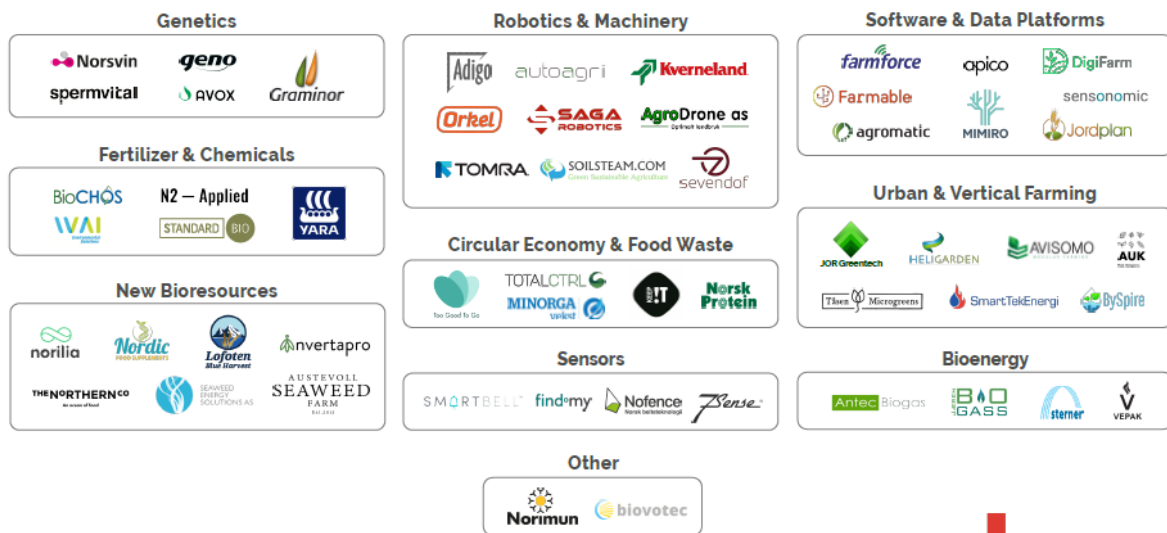
foreign and development politics, wanting to strengthen food security

1.1.2 Agtech in Norway

“*We are on the cusp of a third revolution in agriculture—the digitization of the farm.*”—

Mike Stern, President and COO, The Climate Corporation (Bell, 2016).

Agtech encompasses the use of software and hardware technology in agriculture, which delivers solutions to all phases of the production process (Kobayashi-Solomon, 2018). Large corporations initially started the agtech “*boom*” in 2013, when Monsanto bought the Climate Corporation data company, to provide modern solutions to “*bronze age problems*” (Kobayashi-Solomon, 2018). Now agtech has become a global industry. Agtech companies are on the rise in Norway. The growth in the Norwegian economy has led to an increase in entrepreneurship giving way for a thriving startup scene (Hub, 2019). The growth of the tech sectors in Norway can be attributed to a pro-active government. As an example, a governmental organization, *Innovation Norway* provides funding for new business ideas. The combination of having highly skilled labourers and plenty of tech education, early adoption of products is common. Private investors such as *Startup Norway* and *The Factory* also allow further expansion of this industry. Due to good infrastructure, it is easy to do business in Norway. In fact the World Bank (WB) states that Norway ranks 7th in the world for easiest place to do business, overall creating ideal conditions for startups (Hub, 2019). Another positive factor is that the key values for many Norwegian startups are transparency, innovation, and sustainability. The focus on sustainability within the startups is the highest of all the Nordic countries. Companies are founded basing themselves of sustainable products. This is made possible by all the government support and the focus Norway has on “*saving the earth*” (O'Dell, 2018). Since Norway is a heavyweight within agtech, a long-term solution to the food security issue potentially could be resolved. AgriTech Nordic is an initiative to facilitate innovation of agtech, and the founder states that the agtech scene can provide sustainable solutions (Jonson, 2019). The companies interviewed for my research are members of the startup agtech scene in Norway. The companies could be placed in different categories based of the Norwegian Agritech overview (see Figure 3). Two of which were in the software & data platform category, one within sensors, one company within fertilizers and chemicals and lastly one fall into the category of robotics and machinery. Below is a map of all the agtech players in Norway and the different arenas they operate within.



Overview by Innovation Norway.
Any inquiries regarding the overview should be sent to agritech@innovationnorge.no.



Figure 4: An overview of the agtech companies in Norway (Valseth, 2019).

Despite having small arable land nationally, the development of new technology in agriculture has become a driver for tech entrepreneurs (Torud, 2018). Torud (2018) suggests that the size of agricultural land does not mean the development of new technologies has to be slow. The shifting focus from oil and gas towards agriculture can perhaps improve sustainability in the country. As Torud (2018) says, “perhaps it will be the production of a different type of energy – the edible kind – that occupies the small mountain country from here on.” Sustainable food production is on the list of priorities for the agtech companies in Norway. They aim to be contributors towards reduction of greenhouse gases. Norway already has a very modern and high-tech food production system in place backed by digitization (Explorer, 2020). On the global agtech scene, Norway has a significant presence with several companies leading the way and driving innovation in the field. Several of the companies are often represented and mentioned at conferences worldwide (Virani, 2018). However, on a global scale Norway is still a relatively small player, as other countries are also pursuing agtech.

As agriculture develops and looks for new innovative solutions to improve practices and ensure global food security, agtech and data science has become a growing industry (McDade, 2018). Agriculture is expected to be the new big data industry. Farmers are becoming rigged with high performing machines that can interpret immense amounts of data and provides accurate performing tools (Pham & Stack, 2018). As shown in the figure below, big data is

entering the varying stages of the agriculture value chain. Changing the process, operations, and strategies, which may lead to a better process of information availability.

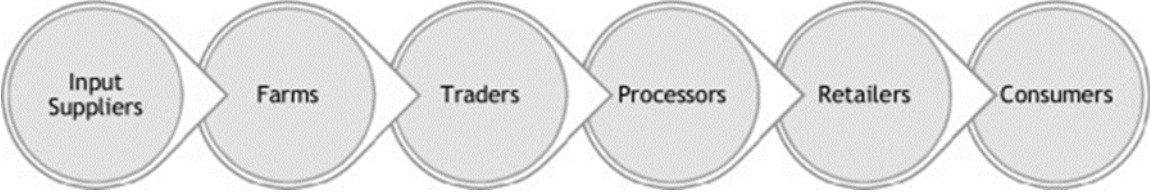


Figure 5: Big data in the value chain (Pham & Stack, 2018)

1.1.3 Green shift

A key part of my study is the *green shift*, which is defined as a restructuring of society and changes in specific fields. Meaning a shift in society towards an emphasis on renewable resources, effective use (and reuse) of materials, emission reduction, as well as transition to products and services that have less negative consequences for the climate and environment than they have today (Olerud, 2019). In order to transition into the green shift, lower emissions and more efficient use of resources is essential (Chaudhary, 2019). Both the private and public sector will be influenced by the new advancements in technology. Both developing and developed countries alike. New technology will be required to be effective in resource use. A transition to products and services that have less impact on the environment that surrounds us is important. Chaudhary (2019) goes on to say that the shift to improved technology that contributes to the green shift is important to reach both national and international climate targets, such as the Paris agreement signed in 2016. The last climate report from the UN states that emissions must be cut by 40-50% from 2010 to 2030 to halt the rise in global temperature, according to Chaudhary (2019). At the same time, global population growth continues and puts a strain on already limited resources, especially in relation to food. Norway was one of the first countries to commit to the Paris-agreement. The main priorities for the Norwegian government are reduction of emissions, clean production technology and a stronger role as supplier of renewable energy. Especially relevant here is the development of low-emission technology in industry, such as agtech. The ultimate goal for Norway is to have a low-emissions society by 2050, which is why the green shift is so important. The aim is to get there without compromising the competitiveness of today's market. The agricultural sector in Norway mainly produces animal feed, releasing around 4,4 million tons of CO₂ in 2017, which is why production and operation of today's farming methods are the keys to reducing these emissions (Chaudhary, 2019). In Norway, the locations of farmers are widespread, presenting many differences in what type of farming is

used. In many remote districts agricultural land is disappearing, yet in central areas the situation is different.

It is important to mention *greenwashing* when describing the green shift. On the path to become green, there might be blurred lines of what is qualified as a real contributor towards the green shift, and not just misleading marketing tools. Essentially, greenwashing is a misleading branding of a product as sustainable where environmental performance and benefits are false (Delmas & Burbano, 2011). The green shift, where products, services and capital markets are shifting into becoming more sustainable, has encountered significant growth in the latter decades. Companies are earning good money from a green marketing strategy. Yet, to market themselves this way, many companies are presenting falsified accounts of their environmental performance to consumers and investors alike, which in turn can lead to a distrust towards the green shift (Delmas & Burbano, 2011). Greenwashing by companies can also be in relation to cooperation amongst companies that are not considered to be environmentally beneficial in any way, such as NGO's receiving funding from the fossil fuel industry (Martinez-Alier, 2012). In efforts towards sustainability popular expressions have emerged such as *beyond GDP*, which aims to reduce emission shifting focus away from compulsory path of economic growth (Martinez-Alier, 2012). And *the greening of the economy* which aims to reassess the economy. Originating in Brussels these ideas have tried to go beyond the relevance of GDP and rather focus on social performance (Martinez-Alier, 2012).

Farming is important in Norway because it provides economic value, especially in rural areas where it maintains employment (Wiborg, 2011). It also contributes to food security, although the declining number of farmers leads to less productivity. Technology could be a way to get more people interested in farming again and maintaining production, in a sustainable way. In Norway, agriculture has the potential to be a leading sector when it comes to the green shift and sustainable practices. As agtech companies have very strong industrial and technological prerequisites for being significant contributors towards a shifting economy, according to the CEO of Norsk Landbrukssamvirke, Ola Hedstein (Landbruk, 2018b). Norwegian agriculture is in a unique position because we already have extensive use of renewable resources. In addition, some of the greatest challenges facing the agricultural production globally, includes diseases, the use of antibiotics and the antibiotic resistance. These are also addressed by having the most restrictions for use of antibiotics on farmed animals in Europe (Landbruk, 2018b). This means we can deliver sustainable food to consumers, says Hedstein. He goes on

to claim that through constant development of new technologies in agriculture in Norway, a modern and innovative agricultural sector continues to emerge. Yet, the respondents in this study are not necessarily inclined to see it the same way. There is still a long way to go, greenwashing is still occurring. Lobbyists may also want to resist changes. There are commonly opposing parties to change, and financial interests could be interfered if sustainability practices are implemented.

1.1.4 Sectors involved

Several sectors are involved in agriculture. There are those who are officially, and unofficially connected to improvements and transitioning within agriculture. The Norwegian government is the main driver of the green shift, and through governmental organizations such as Innovation Norway, provide funding and initiatives for agriculture.

For the Norwegian government, redistribution of agricultural land to be used for other purposes has been important for development of industry, housing, railroads and roads (Regjeringen, 2018). The majority of arable land lies near towns and cities where population growth is largest, which presents a struggle for the land to be used for agriculture rather than urban development. Since World War II, large areas of land had to be repurposed, but in the latter decades that trend was reversed and there was a national incentive to reduce the yearly repurposing of arable land by 50% by 2010. The new target now is that the yearly repurposing of arable land has to be under 4000 acres, a target to be reached slowly by 2020 (Regjeringen, 2018). Considering population growth, the need for arable land will increase in time and what arable land there is will be valuable.

In 2019, the Norwegian government, agricultural organizations, Norwegian Agrarian Association and Norwegian Farmers and Smallholders Union signed a deal to cooperate in reducing climate emissions, and increase carbon uptake from agriculture (Regjeringen, 2019a). Norwegian agriculture was one of the first industries in Norway to sign such a deal with the government, where a target of reducing emissions by five million tons of CO₂ equivalents in the period of 2021-2030 was set. The agricultural sector in Norway is leading in this area, and the deal affects 40.000 actors all over the country, and thus contributes greatly to Norway reaching its overall climate targets. The Norwegian government states that agriculture is a particularly important contributor to the green shift, through carbon uptake, and production of renewable and biobased energy and fuel. Further it says that climate change is a serious threat to food security, people, and nature. Thus, the industry working together is a large step in the right direction. In the deal signed by the aforementioned parties, they

specifically state that the goal is to reduce GHG's whilst increasing food production with the intention of more self-sufficiency, while sustainability remains a key factor (Regjeringen, 2019a). Innovative solutions such as precision farming that can contribute to climate and environmental beneficial production methods are favoured. Agriculture is the industry that is most directly affected by climate change, and thus needs more adaptation than other sectors. Change in climate can give new production opportunities, but also brings a lot of uncertainty. This is why adapted technology and science based approach is a underlying prerequisite to succeed under the challenging conditions that are predicted (Regjeringen, 2019a).

When the latest government was formed in Norway, a political platform was developed by the Conservative party, the Progress party, the Liberal party, and the Christian Democratic party on January 17th, 2019. The platform states that they wanted to invest in the future of agriculture, modernization, new technology and climate and environmentally friendly tactics that reduce emissions, whilst being sustainable (Regjeringen, 2019b).

1.2 Rationale for study

Norway is committed to reducing its emissions through the green shift, and agriculture plays a large part of that. The growth of agtech in Norway, combined with the government's effort to improve agriculture makes this subject a highly relevant and interesting topic of research. There is some research on the topic of agtech startups in relation to the green shift, and sustainability in Norwegian agriculture. However, as far as I am aware, there has yet to be a comprehensive study which evaluates agtech startups in relation to the green shift in Norway. Thus, this makes an interesting case-study. There are still many unanswered questions regarding this topic, but they go beyond the reach of this study.

1.3 Summary of introduction

Norway has 3.5% of active agricultural land, most of which is focused on livestock production. There is potential to increase production of food from the use of new technology. In recent time, the Norwegian government has begun to focus its efforts on reducing emission, meeting the Paris agreement goals, and transitioning towards a greener country. Part of this effort includes a shift in agriculture, towards more sustainable practices and methods. My study focuses on how the agtech companies define sustainability, and how they see themselves as contributing towards sustainability. How their products contribute towards reducing emissions and lessening the impact on the environment. And if they believe the future of farming can be driven by newly developed technology.

New technology in agriculture aims to be more efficient and modernize outdated solutions but must be sustainable for it to be beneficial in the agricultural landscape in the future. Further, the study will seek to give some insight into whether the current agtech startups are in line with the Norwegian governments plan to reduce emissions in agriculture by 2030.

2.Theory

This section contains theory based on ecomodernist and degrowth approaches that have been developed to interpret environmental issues. They have been chosen due to the varying definitions across the environmental debate, and for the differences amongst the companies involved in this study. The first section contains the varying definitions of sustainability and explanation of ecomodernism and the role that it plays in dealing with anthropogenic issues, especially related to technological advancements. Second, the degrowth movement section explains the opposing view of the approach to technology and responses to environmental issues related to agriculture. Lastly, the analytical framework will be introduced, which will be useful in interpreting the data in the discussion chapter later.

2.1 Conceptual framework

2.1.1 Sustainable agriculture

To understand the contribution and impact agtech can have in agriculture today, it is important to start by defining what sustainability is. The definitions from the FAO and UN were mentioned in the introduction and proves there are many definitions. It has also been described as,

“this agricultural sustainability revolution is not one thing – it is comprised of many elements that are adapted to localities and are, inevitably, different from place to place. (...). What is important, though, are the principles of collective action, locally adapted science and innovation, and making the best of what nature can offer through agroecological approaches to food production” (Pretty, 2013, p. 83).

And lastly the definition of sustainable agriculture from the SDG’s,

“by 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality” (UN, 2019).

With a wide array of definitions, measuring sustainable agriculture is a difficult task to say the least, there are many external indicators and it requires complex tools (Gennari & Navarro, 2019). Sustainability in agriculture is often site-specific too, yet the FAO has aimed at getting to a method of measuring sustainability that can apply to all contexts. Although there is variation in defining sustainable agriculture, there is a concept of three dimensions which is widely recognised in academic circles (Zhen et al., 2005). These are known as: ecological soundness, economic viability, and social acceptability. These three dimensions is what forms the basis of the analytical framework in my study.

For this study, the degrowth and ecomodernist theories have been used to develop the research. Both have different definitions of what sustainable agriculture is. The degrowth movement has a standard definition of sustainability as “*an equitable downscaling of production and consumption that increases human well-being and enhances ecological conditions*” (Caradonna et al., 2015, p. 2). On the other side is the ecomodernist movement who do not offer a single definition of sustainability, but state that “*modern technologies, by using natural ecosystem flows and services more efficiently, offer a real chance of reducing the totality of human impact on the biosphere*” (Asafu-Adjaye et al., 2015, p. 17).

2.2 Theoretical framework

The theoretical framework draws on the degrowth and ecomodernist theories. Degrowth and ecomodernist offer two differing views of the environmental debate. To give a simplified introduction, the degrowth movement want exactly that, degrowth. Where we move away from further growth of the economy and rather utilize what is already available instead of extracting more resources. The ecomodernist movement want to continue growth but using technology and to intensify rather than to use more land than is already being used. By separating people from nature, known as decoupling.

2.2.1 Ecomodernism

Ecomodernism stems from the words *eco*, referring to the ecological problems we face today, and *modernist*, originating from a classical modernist view, but with a focus on how to tackle environmental problems (Grunwald, 2018). It looks to classical modernity’s paradigm, and emphasises that reduction of resource usage is due to a technological development (Grunwald, 2018). The ecomodernist movement and term was popularized and published by 19 scientists in 2015 and named *An Ecomodernist Manifesto* (Asafu-Adjaye et al., 2015). They define ecomodernism as:

“...knowledge and technology, applied with wisdom, might allow for a good, or even great, Anthropocene. A good Anthropocene demands that humans use their growing social, economic, and technological powers to make life better for people, stabilize the climate, and protect the natural world” (Asafu-Adjaye et al., 2015, p. 7).

They believe that human impact must be reduced for nature to thrive, but also that human interaction with nature is to be avoided to refrain from economic and ecological disintegration (Asafu-Adjaye et al., 2015). The key part of the ecomodernist movement is the use of technology and climbing the *technology ladder*, meaning more intensification in agriculture and more compressed cities (Bliss, 2016). Wanting both better living conditions and less environmental impact, ecomodernists believe that we “*save nature by not using it*” (Bliss, 2016). The technology ladder requires more modern energy, such as more synthetic fertilizer in agriculture to intensify. The argument is that it will alleviate wild animals by land sparing (Blomqvist, Nordhaus, & Shellenberger, 2015). Efficiency is also a key factor, where machines play a significant role in yield outputs. The only thing halting that now are the vast amount of energy that is still required.

Ecomodernists believe that in order to achieve economic modernization, environmental protection and reduction of poverty on a global scale, technological advancements is a key factor (Asafu-Adjaye et al., 2015). Technological advancements and economic growth go hand in hand and are essential factors for growth in developing and industrialized nations, they are not mutually exclusive. In ecomodernist literature it strongly states that you cannot have economic growth without technology (Grunwald, 2018). Unlimited growth, however, poses questions of environmental impact and the need to reduce emissions. The ecomodernist approach is in line with the idea of *green growth*, to be further discussed below. Which is nurturing economic growth and continued development, whilst also continuing to use natural resources for providing us with environmental services for our own well-being (OECD, 2020), which can be sped up by technological progress (Grunwald, 2018). Ecomodernist ideas have been called “*techno-science for sustainable growth*”, and give a sense of utopian vision and is justified in that “*desperate times calls for desperate measures*” (Kerschner, Wächter, Nierling, & Ehlers, 2018, p. 1621). To be sustainable, ecomodernists believe in the reliance of technology to alleviate the current pressures on the planet, not halting current processes but rather transforming them.

The ecomodernist movement want an accelerated agricultural growth, a society in which humans are very much distanced from the natural world (Grunwald, 2018). They want to use

less land in doing so, to alleviate the impact on the environment. They want to achieve this through regulations and incentives within the system, ecomodernists want proper governance of technological processes, necessary to align the technical development with the needs of the environment (Grunwald, 2018). The ecomodernist view of technology is often seen as *tech-optimism*. Tech-optimism is defined as, “*belief in human technological abilities to solve problems of unsustainability while minimizing or denying the need for large-scale social, economic and political transformation*” (Gardezi & Arbuckle, 2020, p. 83). Technocracy is also worth mentioning here. From a sustainability policy position it is the concept that through technical fixes, they can be solutions to environmental problems, removing focus from politics, and may align with some ecomodernist thinking (Gómez-Baggethun & Naredo, 2015)

2.2.1.1 Green growth

The idea of *green growth*, a policy response to fight climate change and ecological collapse, endorsed by the EU, UN, OECD & WB, is also central to the ecomodernist view in that “*growth is not the problem, but the solution to the environmental crisis*” (Gómez-Baggethun, 2020, p. 4). Green growth is essentially the idea that using technology is sustainable. Further advancements in technology has the potential to substitute natural resources. This allows for a *dematerialized* and *decarbonized* economy, where growth is separate from resources and pollution, known as *decoupling* (Gómez-Baggethun, 2020). Though there are many varying definitions of green growth, the idea is that through incentives and regulations, governments will be able to incorporate technological change and replacements that will advance efficiency of the economy (Hickel & Kallis, 2019).

The ecomodernist manifesto deemed a new age for environmentalists, moving into *post-environmentalism*, which criticizes putting in place limits to economic activity (Kallis & Bliss, 2019). Post-environmentalist view is the same for those in favour of green growth and came after the 2004 essay *The death of environmentalists*, by Shellenberger & Nordhaus who criticised the environmental movement for not taking more action and wanting to put people before nature (Horowitz, 2007; Shellenberger & Nordhaus, 2009). Essentially being pro-growth, pro-technology and pro-environment all the same They wanted to step away from the current environmental model and rethink the ways in which policies are in favour of the environment, but not for industry and labour, and bring in technical solutions (Shellenberger & Nordhaus, 2009).

2.2.2 Degrowth

The degrowth movement in opposition to ecomodernism, call for system and behavioural change, and do not see continued economic growth and the finite resources of the earth as matching (Grunwald, 2018). The degrowth movement was also rooted in the publication by Meadows et.al in 1972, *Limits to Growth* , which is a report on consumption patterns and risks associated with pollution and resources (Gomiero, 2018). Degrowth is both an economic movement and a traditional intellectual one. Some of its first ideologies were developed in the 1970's as a follow up on *Limits of Growth*, by the philosopher Andre Gorz. It questions if capitalism can survive if the earths capacity limits are reached not allowing for further growth (Robbins, 2020). It was not until 2008 the term officially got introduced at the first International Degrowth Conference that it became popularized again in academic circles in English (Kerschner et al., 2018). However, it had been mentioned in French and Spanish publications in the years follow up to the conference. The degrowth movement opposes the constant growth of consumption, which drives the environmental problems we are facing today. They opposite capitalist views and want us to do less, make less and reduce consumption in order to be sustainable (Robbins, 2020).

Instead of the use of technology, the degrowth movement want *use value* instead of *exchange value*, (Robbins, 2020). Meaning a stronger focus on cooperatives, community currencies and wanting shared labour systems. With an apprehension for technology, the degrowth movement are more in favour of a re-use and fix mentality, rather than large scale use of different forms of technology. The idea of *autonomy* rules within degrowth (Gómez-Baggethun, 2020). That means self-governance and collective decision-making. Less is always more in degrowth. According to the degrowth movement, they wish to undergo a political and social transformation which will reduce material and energy usage, and also improve quality of life (Kerschner et al., 2018). The degrowth movement understands that economic growth does not promise human welfare to all, and looks beyond technology and includes looking at population, lifestyles, social justice, democracy and meaning of life (Kerschner et al., 2018). It is not to say that technology is not part of degrowth at all, but it is in a more symbolic or practical sense and often in a locally adapted setting.

In degrowth literature autonomy is important, which is by some seen as problematic in terms of technological terms. It was argued to be “*dependent only in itself*”, or as a “*god-like defining force of a new social order*” (Kerschner et al., 2018, p. 1622). By others it was seen as a liberator for society in that “*wage labour could be decoupled from income*” (Kerschner et

al., 2018, p. 1622). Andre Gorz wanted to change the industrial model and promoted open-source software and other IT tools that would allow for self-production and determining one's own future. There was a lot of back and forth between scholars about autonomy, because in the early days of the degrowth movement there was scepticism towards technology, but it later on developed enthusiasm among some in the movement (Kerschner et al., 2018). The scepticism was rooted in debates about whether use of technology contributes to sustainability. One thing that is agreed upon however within the degrowth debate is that technologies can be used but should beforehand undergo an evaluation and be carefully selected. Several scholars including Illich (1973), Leipzig (2014) and Latouche (2004) suggest the criteria to be; *conviviality*, *appropriateness*, *feasibility* and *viability* (Kerschner et al., 2018).

- *Conviviality* can be interpreted as “*the opposite of industrial productivity*” (Kerschner et al., 2018, p. 1628). That is how Illich viewed it. He was a critic of development and published a lot about technology and development, and he was a prominent figure in the degrowth movement. Furthermore, *convivial* tools were explained by Illich in three ways: (1) Do-It-Yourself tool allowing for peoples autonomy, (2) tools for limiting growth, that do not increase productivity, (3) Open-access tools are tools that are against consumption and that are not enforced on people, giving people freedom to choose (Gomiero, 2018).
- *Appropriateness* are technologies developed locally, that are adapted to local conditions and can be repaired, without external input (Kerschner et al., 2018). Sufficiency and creativity are also key words to include here. Appropriate technologies were first an idea by Schumacher (1973), who also argued they should be based on labour rather than capital (Gomiero, 2018). Like those used in industrialized countries and would be well suited for developing countries as their social situation would not be worse off.
- *Feasibility*, which is the compatibility between effort and constraints, and lastly *viability* which is the compatibility with internal constraints (Gomiero, 2018). These are all necessary to gain insights into sustainable agricultural practices

Georgescu-Roegen argued that a decoupling of economy and natural resources misleadingly gave the impression that technological development would always stay within the biophysical limits (Kerschner et al., 2018). Claiming technological development were mostly feasible and viable long-term. Considering this, degrowth advocates usually accept organic agriculture and

specific forms of genetic engineering when it meets the criteria for the movement. It is debated that it might not be achievable due to its risk, limits on populated areas and low yield (Kerschner et al., 2018). In degrowth literature, agriculture is rarely or briefly mentioned. However, the eight R's that were introduced by Latouche (2009; Re-evaluate, Reconceptualize, Restructure, Redistribute, Relocalize, Reduce, Re-use & Recycle), suggest the strategy of Re-territorialisation of production, Re-localisation of markets, Re-vegetation of diet and Re-seasonalisation of food consumption, is a good framework for degrowth (Gomiero, 2018). Self-sufficiency is a recurring theme in degrowth literature, including local production and short food chains. Yet this requires plenty of land which is often not available and resources that are not present. There is no doubt within the degrowth movement that deintensification is required, but there are many constraints in place such as biophysical limits and lack of land, which makes a transition towards organic or other forms difficult at best (Gomiero, 2018). Solution could be found in simpler technologies, which the degrowth movement is not against (Kerschner et al., 2018). They also want behavioural change and demand-side focus in addition to become sustainable. Further, they also argue that low-tech living could contribute to resilience towards climate change. This in turn could lead to better health by moving away from the stress of the current business models and would also benefit sustainability.

Many degrowth advocates believe that we face a paradox, in that the more developed society becomes, the less efficient it is with use of energy in agriculture (Gomiero, 2018). Overall, the degrowth movement seek out convivial lifestyles, a lower dependence and use of energy in society, reduced consumption and more interaction between people and the natural world. In agriculture, the degrowth movement looks to have self-sufficiency in the food department, turning focus away from large corporations and rather looking at local communities. Thereby having a shorter production chain and limiting the use of chemicals.

2.2.3 The degrowth vs. ecomodernist debate

Both ecomodernism and degrowth critique the prevailing environmentalist movements. They want to stop the current impact humans have on the planet and eradicate poverty while improving living conditions (Bliss, 2016). However, they have quite different approaches as to how they want that done. Robbins argues that because of technology, the farmer now has the ability to achieve the goals that everyone within agriculture dream of, namely: security, autonomy and freedom from drudgery (Robbins, 2020). The lives of the farmers change. The younger generation is more likely to take over the farm because of technological innovation.

The farmers can now continue or even increase their production, still being part of the circular economy in requiring input and outputs, but now they can do this without nearly as much physical labour. Robbins (2020) states the farmers would not require labour other than from their own family, as machines are doing most of the work. They can live a more fulfilling life and have become one of the *new peasants*, which are growing globally. Robbins (2020) goes on to say that although the degrowth movement has a reluctance to embrace technology, not believing in *techno-fixes*, many studies through time have shown that the use of new technologies does not always have a negative effect on culture, identity and low wages as has been assumed by many scholars previously. Rather, adoption of new technology has proven in many cases to improve their independence, whilst maintaining culture. The ecomodernists argue that technology can reduce the human footprint, and that every new technology revolution means first using many resources, later to be replaced by improved methods, leading to a state of using less to make more (Robbins, 2020). Yet, from an ethical viewpoint, fast acceleration of technology should not according to Grunwald (2018) be the only problem-solver. The ecomodernist all have a shared vision of energy and labour balance, and to reach this by 2050. And not necessarily by expanded capitalist growth, but by an economic change that is driven by new technological advancements, in opposition of carbon capitalism.

Furthermore, the vision of sustainability within the ecomodernist movement is in direct opposition to the continuous use of fossil-fuel driven economic growth (Barca, 2019). The separation of resources and pollution from the economy has been shown through scientific reviews that it does not alleviate environmental breakdown, and is also unlikely to happen according to the degrowth movement (Gómez-Baggethun, 2020). As we are facing environmental breakdown, green growth can be a fundamental problem in tackling those challenges, as it looks to further growth of the economy (Gómez-Baggethun, 2020). Linking to green growth and technological development, one model was developed where an optimistic scenario predicts up to a 70% drop in the use of materials, claiming decoupling is possible to achieve whilst reducing environmental problems (Hickel & Kallis, 2019). Models like these are often cited by green growth theorists and ecomodernists alike. What these models predict is that decoupling can work in wealthy countries only in the short term, (Hickel & Kallis, 2019). However not at a global scale, and it has been deemed by some scholars that green growth is not feasible because of this, Hickel and Kallis (2019) claim. The studies do not shy away from technology overall but need to be in combination with strong government policies, as well as a slow-down in economic activity. Another issue argued by

Barca, are the countries (including Norway) now transitioning into green growth, in that they have incentives and strategies for developing *green jobs*, (Barca, 2019). Yet this only contribute to continuation of capitalism by putting them into *green mode*, which does not include looking at ecological and social inequalities that are also a part of sustainability (Barca, 2019). When it comes to technology Barca states, “*only those technologies that could be controlled at the community scale, bring about greater individual or local autonomy, preserve the reproduction of life, and facilitate producers and consumers’ control should be developed*” (Barca, 2019, p. 231). In which case large industrial scale agricultural farms and their technology would require a system change towards sustainability.

On the other side of the debate, responding to the critique of degrowth, Baggethun argues that you cannot have unlimited growth as it will eventually be in conflict with ecological life and the socio-environmental costs of that growth will accelerate (Gómez-Baggethun, 2020). Therefore, you need limits to growth so the ecosystem is able to reclaim its resources which will in turn benefit the economy and be a “*sub-system of the biosphere*” (Gómez-Baggethun, 2020, p. 2). The earth’s resources are finite, and though new advancing technologies can contribute to replacing the use of fossil fuels, in doing so whilst also keeping up with continued economic growth, you would still have a need for finite materials to produce such products. According to Gomez-Baggethun (2020), the ecomodernist manifesto ignores any limits to growth. It claims the new technology being developed now has lesser impact than previous technology, and that urbanization, intensified agriculture and even nuclear power equals protection of the environment (Gómez-Baggethun, 2020). However, some of the technologies that have been adopted have had negative consequences both for agricultural labourers, in health, and are also very unsustainable for the environment. Therefore, scientists from the degrowth movement argue that tech-optimism itself is not an self-governing mechanism developed to fix all environmental problems (Gunderson, Stuart, Petersen, & Yun, 2018). Thus techno-optimism is a far-reaching ideology in responding to a crisis. Tech-optimism has three fundamental problems according to a study by Gunderson et al. (2018). Firstly, it ignores the social factors that are also a part of environmental problems. Secondly there are added environmental problems because of quick techno-fixes and lastly, techno-optimism ignores that increased efficiency leads to increased resources, known as *Jevons paradox* (Gunderson et al., 2018). He also says techno-optimism does not include social dimensions during innovation, use and adoption processes either. Another study, of tech-optimism in agriculture, has shown that farmers belief in technical capacity may ultimately

lead them to downplaying risks and relying on machines, rather than looking towards adaptation processes (Gardezi & Arbuckle, 2020).

When it comes to the post-environmentalist views, Kallis & Bliss (2019) argue that the post-environmental and ecomodernist have the same utopian vision as the current political-economic system (Gómez-Baggethun, 2020). An idea that growth can continue like it has forever because technology is the saviour that will gradually fix any problem between ecology and capital. Humanity seeks out a utopian idea whether it be from politics or from technology because we are now both further away from, and closer to sustainability than ever (Gómez-Baggethun, 2020). Degrowth's utopia on the other hand want fundamental change, but within reason. The post-environmentalist ideas can make sense in the current political climate with the continuous growth in production and consumption (Kallis & Bliss, 2019). Green growth then seems likely in the future especially in terms of technological developments. However, that does not mean that the ecosystem will be able to deliver the services that may be required. The degrowth advocates go on to argue, that the ideas within the ecomodernist manifesto may lead to increased environmental degradation and can therefore be deemed as destructive as capitalism. Further, these advocates claim that post-environmentalists have a utopian vision in a bad sense. Ecomodernists believe that technological fixes are the only solution, despite evidence that it would not work. Thus, this gave root to the degrowth movement as a response.

Increased production today is a large part thanks to new technology (Thornton, 2010). In the livestock sector particularly, this will continue to add to the carbon footprint. Based on life cycle assessments, Thornton (2010) claims that industrial farming has an exceptionally large ecological footprint, as opposed to Robbins (2020) who claims that high-tech industrial farms are more efficient most of all. Thus reduces environmental impact better than small-scale farms (Gómez-Baggethun, 2020). However, it is not as straight forwards as that, as efficiency is not necessarily a problem-solver for the environment. As mentioned in this article, technological responses are required to achieve environmental sustainability and food security by a combination of strategies (Rivera-Ferre et al., 2016). However, at the same time as large-scale industrial farms aim to use less resources and reduce their pollution, in order to achieve that they initially create more pollution and use more resources in the process, and backs up the degrowth movement claims (Gómez-Baggethun, 2020). Another study found that more efficient agriculture with higher intensity, in terms of production and use of technology, scored much lower than less technology intensive farms, (Rodríguez-Ortega, Bernués,

Olaizola, & Brown, 2017). Measured in energy output from non-renewable sources, manure, and fertilizer use. Initially indicating again that intensification and advanced industrialization, leads to more efficiency, but less sustainability. Based on Rodrigues article, more is not less, but more is more Gomez-Baggethun states (Gómez-Baggethun, 2020).

Schwartzman on the other side, claims the degrowth movement has its share of problems due do its lack of “*qualitative aspects of economic growth and its emphasis on the local economy without recognising the urgency to address global anthropogenic change from a transitional political perspective*” (Schwartzman, 2012, p. 119). He argues that the degrowth ideas are often based on local or national action and that there is a need for a transnational ecosocialist movement. A transition towards improved infrastructure and modern technology, especially in the energy sector will lead to economic growth in a sustainable manner. Not only providing employment, but also improving the quality of life. Especially in developing countries. It has been argued that moving into a degrowth society is near impossible because of humans need to “*engineer planet Earth*” with an amazing, but perhaps unrealistic confidence, backed by capitalism and the immense power corporations have today (Heikkurinen, 2018, p. 1655). However, there are small-scale examples of degrowth societies through which cooperation and sharing work well.

At one point or another, by design or default, society at large will learn to live with a lower rate of economic production and consumption (Kallis, 2019). According to Kallis (2019), using mostly solar power was the prediction of Georgescu-Roegen. Although the *solar socialism* may be only possible to some extent, this and other alternative systems will have lower economic output than the one we are experiencing today. The degrowth movement partly share this vision of its potential sustainability. The ecomodernists do not agree with this idea and want solar, nuclear, wind and so-called *negative emission technologies* to let us continue the indefinite growth in terms of energy usage. Kallis (2019) goes on to argue that even if there was a renewable source of energy that could sustain growth, it would have. But there is no source that can provide us with what we need to keep up with the modern global economy. He goes on to argue that substituting one resource for another, is like substituting one environmental problem with another. It will become unsustainable too. Therefore, both growth and GDP would have to degrow and an ecomodernist future cannot be sustainable. According to one study, moving over to renewable energies will lead to more intensified use of land (Capellán-Pérez, De Castro, & Arto, 2017). If to be implemented on a global scale, it would increase to existing vulnerabilities of land today and could threaten food sovereignty.

This means that a transition like that would require much more land than is sustainable to maintain today's world economy (Capellán-Pérez et al., 2017). This could work if the world economy operated at a lower and smaller level, supporting the degrowth movement.

In sustainable development discussions, technological advancements are often seen as an aid to assist in increasing quality of life (Binswanger, 2001). To raise living standards, whilst also using less resources and energy. The concept that increase in efficiency will reduce resource use in the same ratio is, according to Binswanger, common in the abovementioned scenarios. However, what is usually the case is that an increase in efficiency might reduce resources even less or even increase. This is known as the *rebound effect* (Binswanger, 2001). In simpler terms, the rebound effect depicts scenarios where increase in resources and energy efficiency do not necessarily cause a decrease in the energy of resource use. In this sense, technological improvements are not the reason for economic growth (Binswanger, 2001). Rather structural changes are, which is why it is argued that increase in the use of technology is unsustainable because growth still occurs. This backs up the degrowth movement as continued growth of economy is not in any way slowed by technological developments, it is ultimately not a sustainable option, according to Binswanger's study.

Today's intense throughput, the use of resources and use of materials which are turned into commodities, and later into waste is not within the regenerative capacities of the ecosystem (Heikkurinen, 2018). It is very unsustainable, and this shows the need for degrowth (Heikkurinen, 2018). The degrowth movement organizational methods should be incorporated into society at large and requires a change in cultural practices and structures for it to be sustainable (Heikkurinen, 2018). One way to incorporate technology in a degrowth society is argued to be the repurposing of current technologies, and the use of appropriate technologies (Likavčan & Scholz-Wäckerle, 2018). Thus, to be sustainable you have to be innovative and imaginative, perhaps even going beyond growth and modernist discourses (Likavčan & Scholz-Wäckerle, 2018).

The debate has taken place in media such as The Guardian. Here George Monbiot, an environmentalist and political activist, expresses criticism towards the ecomodernist movement (Monbiot, 2015). Stating they have solutions that are too simple to solve complex problems. Critiquing the need ecomodernists have for urbanisation and little regard for differences between rich and poor, Monbiot argues that the ecomodernists tend to generalize and ignore accounts of modernist history. Though the use of technology should be embraced, it is not as straight forward as the ecomodernist play it out to be. In their defence, three writers

of the ecomodernist manifesto responded to Monbiot's critique that the ecomodernists are wrong in endorsing the modernization of agriculture. (Nordhaus, Shellenberger, & Blomqvist, 2015). Because it is according to them a way to both feed the growing world population whilst freeing up land for rewilding. The post-environmentalists behind the ecomodernist manifesto clearly defend their agenda providing scientific statements, instead of using their technology driven viewpoints (Kallis & Bliss, 2019).

2.3 Analytical framework

Here I propose an analytical framework to better understand how sustainability connects to agriculture, how the companies may contribute towards the green shift, and the efficiency of their business in relation to sustainability. This framework was developed based on the empirical data collected and on the sustainability aspect of this research paper. It draws on multiple areas of sustainability and contexts I have collected from various other studies. In particular, the three pillars of sustainability are included to gain further insight into the different sections involving sustainability. The three pillars, or dimensions, of sustainability, specifically economic, environmental and social have been described in literature for decades and is commonly used in analysing sustainability issues (Purvis, Mao, & Robinson, 2019). The environmental, social and sustainability framework developed by UNEP (United Nations Environmental Programme) (UNEP, 2020) will serve as a guide through the pillars and be a major part of the analytical framework developed for this study, as well as that of the Planetary Boundary (PB) framework (Steffen et al., 2015)

2.3.1 Dimensions of sustainability

The UNEP and PB framework components will be used here to analyse the findings. Through analysis and research in this thesis it can determine whether the agtech companies are able to participate in changing the agricultural system to a more sustainable one. Economic, social, and environmental drivers have huge impact on sustainability in agriculture and the food system. Based on the assessment of the elements in the framework an evaluation of the contributions of sustainability of the agtech companies in Norway can be undertaken. The findings will be assessed by using the three dimensions of sustainability; economic, social, and environmental.

The framework includes several key concepts and their relationship is detailed in Figure 6. During the findings and discussion chapter these will be useful in linking the collected data to theory of degrowth and ecomodernism. The following section aims to go give a brief overview of these concepts that make up the analytical framework.

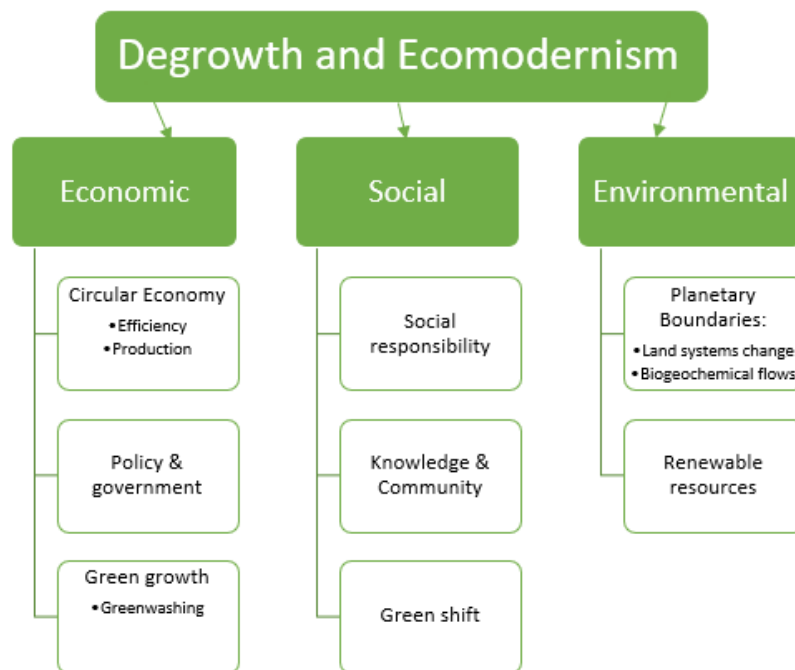


Figure 6: Analytical framework based on dimensions of agriculture

2.3.2 Economic sustainability

Economic sustainability plays an important role. So does circular economy. It ties in with the theoretical framework from the previous chapter also. Its major focus is on alleviating the environmental pressure by implementing circular economy (Pomponi & Moncaster, 2017). The benefits of circular economy in agriculture is the reusing of materials and substances, resource reduction and less waste, aiming to optimize the current system (Jurgilevich et al., 2016). Drawing on these components give valuable representation of the use of technology aiming to create efficiency, and thus benefit sustainable agriculture. Economic drivers have a major impact on the food system, and the businesses involved in my study have the power to change the current path of agriculture in Norway by producing sustainable solutions. Furthermore, the government has the power to implement planning and support ideas to change agriculture.

2.3.2.1 Circular economy

Circular economy as a theory is used in many sectors but is also relevant for sustainable agriculture. The definition of circular economy is,

“an industrial economy that is restorative by design and mirrors nature in actively enhancing and optimizing the systems. It applies several principles from nature: production out of waste,

resilience through diversity, the use of renewable energy sources, systems thinking, and cascading flows of materials and energy. Circular economy means reuse, repair, refurbishing, and recycling of the existing materials and products; what was earlier considered to be waste becomes a resource” (Jurgilevich et al., 2016, p. 2).

Circular economy addresses sustainable agriculture aimed at production, processing, and waste management. Linked to agriculture, circular economy theory looks to technological advancements as possible solutions to tackle problems (Jurgilevich et al., 2016). They are in turn linked to higher food security and availability. The technology development can have great scope of impact, “*technological niches form the micro-level where radical novelties emerge*”, by small actors with a niche network of dedicated companies they can be part of evolving sustainable agriculture (Jurgilevich et al., 2016, p. 4). The involved participants in my study had to some degree found a niche in agriculture and thus their attempt was to create a market for their products which would be contributing to sustainability. Several of the participants mentioned circular economy as a relevant theory for the current agricultural system and is something they aimed to implement in their businesses.

2.3.2.2 Policy and government

Policy and government are important to manage the future of agriculture. If long-term sustainability is to be achieved, then economic incentives and transitional programmes should also be implemented (Beddington et al., 2011). According to Beddington et al. (2011), multiple level government is needed to navigate the space of new technology, along with institutions and actors they must encourage participation and learning in the field. The organization CGIAR, claims that to achieve sustainability, nations should apply sustainable agriculture as part of their policies. They should make room in their budgets and support innovation and create platforms in which responses to these issues can be developed. Policy can play an active role in encouraging economic growth that leads down a sustainable path, in protection of natural resources and strategies to mitigate environmental problems, by investments and proper governance (Aldy, Hrubovcak, & Vasavada, 1998). Policy and government are needed to develop strategies to be used by nations and actors towards achieving sustainability. In Norway they have a visible support system for agtech companies. Several of the participants were pleased with the support they received from governmental institutions, both financially and as part of a larger community of support.

2.3.2.3 Green Growth

Green growth was mentioned in the theoretical framework also. It is a part of ecomodernism thinking and is related to the idea of a decoupling of society. It focuses on technological advancements and particularly in agriculture this may lead to improved agriculture. It is relevant to the theoretical theory and analytical framework alike due to the participants of the study being in favour of green growth.

2.3.3 Social sustainability

Drawing on the UNEP framework, protecting people and the environment from impacts of climate change and ensuring social sustainability is included (UNEP, 2020). To reduce future risks and vulnerabilities deriving from human-made impacts, particularly climate change and environmental degradation, key strategies relevant to this study is the integration and promotion of sustainable practices. This goes across all dimensions in addressing the environmental challenges. Social factors such as knowledge and responsibility can have massive impact on the current system. The agtech companies can play an important role in this setting. Social sectors of sustainability; particularly community, social responsibility and institutional services deriving from the UNEP framework will be beneficial and are relevant in the sustainability of the companies themselves and what social conditions they may improve.

2.3.3.1 Social responsibility

Social responsibility is in this context related to a business' positive and negative impact. It is about how businesses engage with their stakeholders and all the components of the value chain (Karbassi, 2020). The social responsibility of the companies involved here was great to some. They had not only a say in social sustainability beyond Norwegian borders, but they felt a moral obligation to contribute towards it. All the participants in this study mentioned social sustainability as part of their development process, this contributed towards their growth and allowed them to market themselves as sustainable. Finally, Karbassi (2020) states that there is not one definition of what social sustainability is, but it entails improvement of people's lives through goods and services, social investments, and local support policies as well as cooperation with businesses towards positive impact.

2.3.3.2 Knowledge and community

Knowledge is a vital part of development and innovation. Accumulated knowledge from a wide array of peoples and fields should be combined in order to develop sustainability, (UNEP, 2020). Thus, the importance of this knowledge should be recognised. To analyse

environmental impact, new, traditional, and indigenous knowledge are valuable resources and should be included also when developing technology that often require adaptation to local settings. Community engagement was in this study an important part of the agtech environment. It provided them with activities and connections that were valuable and gave incentives for further growth.

2.3.3.3 Green Shift

The green shift is as explained previously in this paper a restructuring of society, including agriculture. It focuses on a switch towards renewable energy and efficiency in production. Its already an important issue in Norway and is a central part of my study. Participants see themselves as part of the green shift happening in Norway in varying degrees.

2.3.4 Environmental sustainability

The definition of environmental sustainability is,

‘the ability of one or more entities, either individually or collectively, to exist and thrive (either unchanged or in evolved forms) for lengthy timeframes, in such a manner that the existence and flourishing of other collectivities of entities is permitted at related levels and in related systems’ (Standing, Jackson, Chen, Boudreau, & Watson, 2008, p. 187)

Included here are also concepts from the PB framework derived from Steffen et al. (2015). Its relevance in this study is its definition of a safe operating space for humanity and how agriculture can stay within the biophysical boundaries (Steffen et al., 2015). Specifically, those of land- systems change and biogeochemical flows. The degradation of the environment from excessive agriculture and impact on ecosystems is partly why the PB boundaries should not be breached. Further use of chemicals to the soil and modification of land are adding stress to an already vulnerable planet. By using these frameworks and incorporating them, it demonstrates how interwoven these complex issues are. As pointed out in the PB framework, *“the earth is a single, complex integrated system”* (Steffen et al., 2015, p. 8). Thus, achieving sustainability in one sector, namely agriculture, will have positive effect on all boundaries. Providing enough food to a growing planet, whilst using clean energy is a necessity to sustain ourselves, and an evolution of sustainable practices is needed now more than ever, Steffen at al. (2015) claims.

2.3.4.1 Planetary boundaries

Planetary boundaries is a framework developed to define the operating space in which the earth can operate in order to have a stable planet (Steffen et al., 2015). Emissions from

industry has had extensive impact on the environment. Through changes in the current system the land use and cover that has altered natural ecosystems can be improved. The PB framework is an attempt to guide human activity further away from resource destruction. There are nine boundaries set, but two of them will be used here as they are relevant for agriculture, although the boundaries are all connected. The nine boundaries are like tipping points, where each category is colour coded into how well within the boundary we are. Once the tipping points are breached it means less ability for the earth to sustain life. The biogeochemical flows in the PB framework includes phosphorous (P) and nitrogen (N) only, and applies greatly to the use of fertilizer from croplands for agricultural purposes (Steffen et al., 2015). It is suggested in the framework that the redistribution of nitrogen could be beneficial to production and could reduce the input of nitrogen. Overall, there needs to be a change in the use of fertilizer. Land-system change refers to the change in land surfaces which has been developed into croplands. Coming from deforestation and the impacts this has on the climate stemming from changes to the biogeochemical flow such as evapotranspiration. These two boundaries have direct links to agriculture, and to the participants in this study.

2.3.4.2 Renewable resources

Renewable resources are important to achieve ecological and environmental sustainability. Natural resources are crucial to long-term sustainability and thus the ecological footprint should be reduced (Standing et al., 2008). As for renewable energy sources, though it has been argued that the use of technology can put further pressure on environmental degradation by using more of high pollution production processes, it can also help lessen the pollution by replacing the current machinery with improved technology. Here, eco-efficiency, which aims to create sustainable development through using less resources and reducing pollution, can be implemented. To achieve sustainability, and especially in the energy sector, transformation is required as well as a shift in mindset. The use of technology, and those that run on renewable energy rather than fossil-based energy can mitigate environmental problems.

2.4 Summary of theory

“Humans are made from the Earth, and the Earth is remade by human hands” (Asafu-Adjaye et al., 2015, p. 6). The environmental debate in this context has two sides: the ecomodernist saying *more is less*, the degrowth movement saying *more is more*, but in the end as Robbins claims it should be about *“bringing enough to everyone”* (Gómez-Baggethun, 2020, p. 1; Robbins, 2020). The theoretical frameworks present these two sides and how they stand in relation to the use of technology in agriculture. Furthermore, the analytical

framework serves as a guide coming into the findings and discussion later in this paper. Three pillars of sustainability are linked to degrowth and ecomodernism and relevant subcategories are presented to give an overview.

3. Methodology

This section contains an overview of the methodological framework that has been used during my research as well as the methods used for data collection and the following analysis. In the final section limitations and ethical considerations will be discussed.

3.1 Methods

In deductive research theory, preliminary research questions are developed from theoretical perspectives (Bryman, 2016). Narrative research in contrast, is mainly formed by inductive theory, where the empirical data was collected without presumptions of results of theories (Bryman, 2016). Which was the case in my study. Inductive theory was favoured because the theories that deemed relevant for the study became clear after the initial data had been collected. Further, the research question was developed in accordance with the findings. Deductive theory was not relevant because a theory was not developed until further into my study. The interview phase was entered with an open mind. Though during the document analysis similar research was studied, there was no prejudice towards the interview subjects during the research process to the degree that was possible, which is important to acknowledge according to Bryman (2016).

The qualitative research process began with formulating research questions in a general matter, followed by selecting subjects and fields that were most relevant to this study (Bryman, 2016). The process of inductive theory approach begun with collection of data, then to interpretation of data (Bryman, 2016). Further, the conceptual and theoretical content is developed before the specification of research question. Further interpretation of the data also continues after the abovementioned steps have been taken (Bryman, 2016). However, collecting, and interpreting data are processes that are as Bryman (2016) says, constantly changing and connected. The themes and guides for the interviews were developed before the interviews took place. The focus of the study became clearer after the data had been collected, and the analysis and collection remained interconnected though the research process. Therefore, my study follows the inductive research approach.

3.1.1 Qualitative research

For the purpose of this study, qualitative research method was used because it is fitting for acquiring an in-depth understanding of a specific field and case study (Bryman, 2016). A non-probability sampling method, purposive sampling was used in because the participants were selected based on what they can bring to the study (Bryman, 2016). Purposive sampling means participants were “*chosen in a strategic way, so that those sampled are relevant to the research question*” (Bryman, 2016, p. 408). Before the process of interviewing began, I reached out to some of the agtech companies I could find that had relevance to the study, in terms of their sustainability focus. By simply googling “*agtech in Norway*” multiple companies appeared and led me to other companies. I found a map of agtech companies through an online article which was helpful. My focus has been on startup companies, but determining their size proved challenging. However, their specific size was not relevant as long as they would fall into the category of agtech startup. The geographical location was also a factor. Companies in and near greater Oslo area were favoured. That was because I initially intended to visit the companies at their offices. As interviews were moved online, remotely located companies could also have been useful. Due to time constraints and relevance, there had to be limitations on number of interviews. Thus, not all agtech companies in Norway would be involved.

Secondary data sources were used to provide substantial research on the topic. These included academic articles relating to agriculture, sustainability, technology, agtech, government policies and theory. The secondary data is important to acquire a wider understanding of the topic at hand (Bryman, 2016). The literature review is relevant for my study because it provides additional background information on the topic, and an overview of the available data. The literature review supplies information on what is already known about the topic, and allows for critical examination (Bryman, 2016).

3.1.2 Semi-structured interviews

The interviews were conducted as semi-structured interviews. Semi-structured interviews are a good way to get more meaning and understanding of the participants attitudes and perceptions (Bryman, 2016). Semi-structured interviews as defined by Burgess are “*conversation with a purpose*” (Burgess, 1984, p. 102). This type of interview is ideal because they are performed using a general guide. Which means the order of questions may vary, they can be more generalized and further questions that arise can also be implemented (Bryman, 2016).

Between March 9th and March 18th, 2020, six interviews were conducted. One pilot interview was conducted to test the quality of recordings and give an indication of the time required. two interviews were completed in person, and four were conducted over various on-line calling programmes due to the global pandemic. The interviews lasted between 27 minutes to 45 minutes. The participants were contacted directly via their websites in most cases, but some snowball sampling also occurred. All the subjects that were contacted agreed in advance to be interviewed and all received a letter of consent prior to completion. Initially I aimed at getting at least ten participants. Sample size may vary throughout the process, but as long as you are left with enough data the number is not necessarily relevant (Bryman, 2016). My focus was on small agtech companies and not larger established companies. My initial research question gave an indication of what group I needed to collect samples from, as Bryman (2016) states. One weakness is not having substantial number of participants, having more could have yielded different results. However, the ones that did partake in my study were truly relevant to what I aimed at researching.

Instead of repeatedly asking specific questions, the semi-structured interviews allow the conversation to develop naturally following certain themes. A few of the questions were;

- What do you think is the role of technology to achieve sustainable agriculture/ food system?
- Do you think your product can be part of a green shift in Norwegian agriculture? If so, how?
- Do you think that technology is the future? In the context of sustainability and agriculture

The open-ended questions gave plenty of flexibility for respondents and valuable information was added without being planned for.

Name	Affiliation	Date
Subject 1	Agtech startup	March 9 th
Subject 2	Agtech startup	March 10 th
Subject 3	Agtech startup	March 12 th
Subject 4	Agtech startup	March 13 th
Subject 5	Agtech startup	March 13 th
Subject 6	Governmental organization	March 18 th

Table 1: *Information of participants and interviews*

3.1.3 Study area and setting

The location of the interviews can be a deciding factor in how comfortable the interviewees feel, thus a familiar location is optimal (Bryman, 2016). The two interviews that were completed in-person took place at the offices of the respective participants because of familiarity to the subjects. The four-remaining interviewees had to be completed online due to the pandemic. As self-isolation was implemented, we were unable to meet in person. Being face to face with the interviewees has some benefits such as establishing a better rapport, (Bryman, 2016). With online interviews there can be technical glitches which leads to unintentional interruption. There were only minor technical glitches during my interviews, such as occasionally slow connections and at times unclear audio. I believe doing the interviews online did not affect my results to a large extent. Generally, the online interviews all ran smoothly. All the interviews were recorded on audio. Additional notes to how they responded such as body language were noted down during the interviews.

All interview were transcribed shortly after each interview, which is recommended to not have too much accumulated work and keep the interviews fresh in mind (Bryman, 2016). Transcription of an interview is a very time-consuming process. It typically takes five-six hours per one hour of speech. Therefore, it is advised that the analysis and coding work is not left until all the transcription is completed as it will add up to an extensive number of pages (Bryman, 2016). Though the interviews were semi-structured, the time for each interview was relatively short, even including the side-tracks along the way. The companies were happy to share the story of they were established even though it was not relevant to my study. The interviews were transcribed completely ad verbatim.

3.2 Data analysis

Coding was used as a method from the semi-structured interviews to best analyse the data. Qualitative data are categorized when coding through an analytical process which presents several themes related to the topic. In qualitative research coding, *“is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data”* (Saldaña, 2015, p. 3). Coding is key to understanding the content of information that has been collected in unstructured form first by being categorized (Bryman, 2016). Second by assigning numbers to these categories allowing the researcher to keep tabs. Some codes were created before the coding process, and many were developed underway. Often starting with short sentences and phrases but were later comprised into single words or concepts. Subthemes were also formed

based on these (Table 2). Participants names were anonymized during transcribing, so was their company affiliation. The coding process began with reading and re-reading the interview reports numerous times. The table below represents an outtake of some of the codes that were used in the process but does not include all of them.

Initial codes	Condensed categories
Technology is an abler	Tech-optimist
Technology is the way towards sustainability	
Localised production particularly important	Degrowth view
Less use of resources by use of their product	
More funding required to really thrive	Government action
Receive support from the government due to the green shift	
Optimizing resources cannot be done without technology	Ecomodernist view
Technology is better for the greater good, and for sustainability	

Table 2: *Example of coding process*

The results were analysed using the theoretical framework of the degrowth and ecomodernist theories, because they were best aligned with the ideas that emerged from the collected data. The results were broken into categories based on the analytical framework which was developed. Once the results had come in, the categories became clear (economic, social & environmental), and the theories of degrowth and ecomodernism were then used to analyse these results. Using the framework allowed for an in-depth look at the responses given and how it tied in with sustainability and relevant topics.

For data analysis of efficiency of the companies, I made a chart was made to clarify what contributions the companies each had (Figure 8). By going through the coded transcripts, I could identify the corresponding responses of why they believed they contributed to efficiency. Thus, categorizing them made sense to provide an overview. For the analysis, the findings and research in the study were highlighted through the three dimensions of sustainability, which in turn had several subcategories and related to theoretical theory. The aim of the analytical framework was to present the main topics and analyse main concepts relating to the research questions.

The context of the relationship between sustainability and the agtech companies, is explained through the theoretical and analytical framework. Sustainability is related to a variety of topics and ideas and the framework attempts to interlink these and see the connections. By using a framework like this it allows for an in-depth explanation of what the data collection provides, as well as an understanding of how agtech companies work to tackle sustainability issues.

3.3 Limitations, ethical considerations

It was challenging to find enough companies within agtech to interview. As these are relatively small companies. Some simply did not have the time or resources to participate. A few were hard to reach and did not respond to email. I also tried to contact them by phone, even that did not yield results in some cases. For interviews that were established, some had to cancel the planned interview due to the sudden situation with pandemic affecting their businesses during a trying time. Two companies however, got connected by an acquaintance who knew the company CEO's, which proved immensely helpful.

Prior to the interview, the participants signed a letter of consent, which explained that their name would be anonymized. They did agree to their company not being anonymized throughout the study, but during the process I deemed it as not relevant to include the specific company names. Although the content of the study is not tied to specific names, it may be difficult to prevent certain individuals or companies being identified based on the small size of the Norwegian agtech scene. The scope and reach of the study were communicated before the interviews began to the extent that I was aware. The implications of their participation were made clear from the consent form.

My personal motivation for doing a study on this topic is because of interest in the use and development of new technology. Particularly within AI, autonomous vehicles, and emission-free transportation and how they respond to climate change. My personal bias leans towards tech-optimism to some degree, and it may have unintentionally influenced the study. I was aware of my own bias during the study, but the aim was to be unbiased throughout to extent that is possible.

3.4 Summary of methodology

The method used in this study was an inductive qualitative approach because data collection, interpretation and frameworks were all intertwined. Semi-structured interviews were used for data collection. After a long coding process the data that deemed valuable were used for analysis and discussion. There were not many limitations to the study other than the small

number of participants and the few interviews that fell through. Yet it may have impacted the quality of the study to some extent. Everyone who took part in this study had consented their participation prior.

4. Findings and discussion

The purpose of this chapter is to give the reader an overview from the semi-structured interviews and provide discussion, analysis, and interpretation of the findings presented here. In this section I will be using the degrowth and ecomodernist theories to analyse the collected data. The definitions and relevant findings related to sustainable agriculture will be analysed before moving into the analytical framework. These frameworks will help with interpreting the results that will attempt to answer the research questions. The analytical framework presented in the theory chapter will serve as a guide and thus divide the content into relevant subheadings based on degrowth and ecomodernist theory, as well as that of the UNEP framework and PB framework. The first part of the chapter will focus on the economic dimension of sustainability broken down into subheadings. The second part will focus on the social dimension of sustainability, furthermore the environmental dimension will be discussed. Many of the concepts and theories discussed in this chapter are intricately linked, therefore there is likely to be some overlap in findings and discussion.

The views and responses from the participants in the study provide substantial material allowing for interpretation of the research questions presented in the introduction, in addition to facts and information. Excerpts from the interviews will provide perspectives of the interviewees. Five of the six interviews have been translated from Norwegian to English and is thus not always a word by word translation but are close to the original in meaning and attitude.

4.1 Sustainable agriculture

This section will provide an overview of how the participants in the study positioned themselves regarding definitions of sustainability in relation to agriculture. Sustainability is important to ensure the best outcome for nature, climate and for agriculture in general. Sustainability is a widely used term with different interpretations and contexts. Sustainability is a key part of all the agtech companies involved in this study's vision, but it has varying meanings and thus varying contributions. Their interpretation aligns with many of the environmental issues in agriculture that has been pointed out through the literature review and from theory.

The theoretical framework which categorizes the two sides of the environmental debate, and how these relate to the issues surrounding the use of technology is relevant for the analysis. The definitions introduced earlier correspond with the findings from the data collection. The respondent’s replies may align with the definitions of either degrowth or ecomodernism to some degree. In the varying responses to the question about the business owners and employee’s personal definition of sustainable agriculture, the wide range of definitions became clear. Several of the interviewees had mentioned sustainability and presented themselves as environmentally sustainable on their website. Their interpretation of the definition of sustainability proved that they each brought their own experience in defining it.



Figure 7: *Word cloud of participants view of sustainability*

Sustainability means different things to the involved companies, as the word cloud depicts. The frequency of words they used in responding to sustainability is highlighted, and some words were more recurring than others. It should be mentioned however that the question of sustainability was general and thus some of the participants may have been distracted or uncertain about a standard definition within agriculture. The lack of a clear definition of what sustainability is amongst the participants suggests there are no clear boundaries or guidelines for what is sustainable for them, thus it would be up to each company to define and interpret. Though sustainability was a driving force for the business’s strategy, first and foremost, for agtech to be successful they must thrive as businesses. Being sustainable is an additional added value to the company, but not the main goal. Agtech however, is growing in demand and popularity, thus these results demonstrate that the future consists of more growth in agtech, and it is predicted by some that future appears to be based on these new technologies

and increased development in this sector (Kallis & Bliss, 2019). This is in line with the view of the respondents in this study.

In coming face to face with climate change, agriculture will notice negative effects significantly and meeting those challenges with technology requires modernization of the industry (Regjeringen, 2019a). The involved companies want to expand their businesses and believe their growth can have global positive impact in some cases. From the research it becomes clear for me that improved technology in agriculture is the right path forward, with required regulations in place. Though throughout the study, and based on the findings, more questions regarding agtech and its actual contribution have risen. There are many unclear guidelines and definitions regarding sustainability that present themselves, and thus at this stage more research is needed on this topic beyond the scope of this paper.

4.2 Degrowth and ecomodernism

This section will attempt to provide an interpretation of the findings in relation to the theories of degrowth and ecomodernism. These theories can in some sense divide the respondents into two sides of the environmental debate to the degree that is possible.

Working with agtech, two of the involved companies had clear opinions about what their technology should add to agriculture and how it could be positive for sustainability in a degrowth perspective. These respondents' goals and strategies aligned with that of the degrowth perspective in several ways. Believing technology is an enabler for further growth and sustainable agriculture, yet not believing the hype that everything can be fixed by technology. As one participant stated, *“you can make it work in a closed setting where you have perfect conditions, but agriculture is so far from perfect conditions”*¹. These findings are in accordance with what the Norwegian government wish to accomplish in using adapted technology, to be able to foresee and respond with the required needs in the unpredictable times of climate change (Regjeringen, 2019c). That is why technology has to be adapted to local conditions, as the degrowth movement promotes human well-being, being able to produce in adapted settings is important, and the technology should be developed for certain areas to have best possible value (Kerschner et al., 2018). This is an important finding because it supports the degrowth movements view of technology. The businesses want to develop technology, but in a manner that will not add to increased growth in production to the extent that it will harm the environment further.

¹ Interview with agtech startup, March 9th, 2020

Technology has improved a lot over the years and become easier to handle, agriculture needs the large areas that we have available today to operate effectively. And organic farming or small-scale farming is not viewed as the solution by all the of participants in the study, except one. That is because the small-scale of organic farming and the resources and land required is not deemed feasible to feed a growing population, according to the participants. Some of the participants made claims that may align with ecomodernist thinking. As was pointed out, it is better to transform the process that already exists. It was stated by one interviewee that it is better to make conventional agriculture more sustainable, rather than moving into organic agriculture which can make people a little fanatic. That is because organic farming uses less technology and fertilizer than conventional agriculture, even though it is bad for the environment the cost is too high, according to a participant. The topic of organic and small-scale farming is debated in ecomodernist and degrowth circles. Where the ecomodernist claims that to get higher yield and to feed more people, organic and small-scale farming is not productive enough (Nordhaus et al., 2015). In ecomodernism they believe that an intensification of agriculture in a compacted area is more beneficial than using large land surfaces (Bliss, 2016), as a few of the respondents pointed out, the optimization of resources by the use of technology is important. The counterargument is that intensification and organic farming using less chemical fertilizer is better for the environment. These finding supports the idea that some believe intensification is what will feed the world. By not expanding and using more resources in larger landmass, the optimization using technology is favoured. However, that will ultimately lead to further devastation, and is not an optimal solution.

It is interesting to note that many of the participants products give the farmers more yield and an increase in production. The increase in yield from an efficient production method, in turn leads to improved food security. From this finding in relation to theory, ecomodernists emphasise that in feeding the world, technology has since the 1960's played a vital role (Asafu-Adjaye et al., 2015). Of course, there are many deciding factors, especially the differences between developed nations and poorer regions. The only reason high yields can be achieved in poorer regions according to ecomodernist advocates, is that they have more labour input. However, that may not always be the case and is a generalizing statement. In developed nations the high labour input can be replaced by modern technology and machinery, and thus higher yield over larger areas may be the result. Intensification and agricultural modernisation is the best way according to ecomodernist, to "*leave more of the Earth to nature*" (Nordhaus et al., 2015). The results in this context do not present a

conclusion regarding food security, and the outcome of yield varies amongst the participants technologies. As was pointed out in the findings, it may be more beneficial to transform the current system into a sustainable one, rather than to change the method of agriculture overall. Thus, my interpretation is that the use of technology may lessen the environmental impact of agriculture. It may also lead to increased food security, but to what extent the impact is lessened, versus how much more food is produced, is unclear.

4.3 Economic sustainability

The degrowth movement and ecomodernists present varying viewpoints on how agriculture should develop in the economic sector. This chapter aims to clarify where the two movements stand in the context of economics based on the findings from the data collection.

Although some of the participants explained their operation was not 100% sustainable yet, their long-term business goal is a work in progress, and the aim is to be an asset in improving agricultural sustainability overall. Economic sustainability was a core part of this and was incorporated into several of the research subject's definitions, when asked what sustainability meant to them. Economic sustainability should include lower cost to the consumers too, without compromising the environment. Several of the products by participants in this study has the potential to save the farmers money in the future, adding to economic sustainability.

The results demonstrate that both the businesses and the consumers must be able to have good finances to contribute towards greater overall sustainability in agriculture. Economic sustainability is also high on the agenda for the involved agtech companies and they see that as a natural part of their business model. They all experience growth,

“we have an aggressive expansion plan, also because agriculture is so big, the market is so big, and if we are to be truly sustainable, we have to create good conditions socially around the globe”².

Several participants believe the growth of their company along with their view of economic sustainability can be beneficial for many users of their products. For the farmers in Norway, the technology developed by the involved companies may improve their lives, but it first and foremost must be financially viable. It gives the company value to brand themselves as sustainable, but there is also value in tackling economic sustainability issues. As one interviewee responded, *“sustainability is tied to long-term profitability, but it also has to be*

² Interview with agtech startup, March 12th, 2020

*sustainable to think short-term. Economy and sustainability are well-tied together. It is just a matter of time perspective*³. A similar conclusion was reached by the founder of AgriTech Nordic in an online article from 2019. If Norway is to be a contributor to food security, long-term solutions is an important part of that (Jonson, 2019). These findings signify the importance of sustainability as long-term solutions expanding beyond the environmental problems but are well connected to economics. Agtech is expected to become the new big data industry, thus the growth in agtech is predicted to tackle food security challenges through technology development (McDade, 2018). Degrowth theorists however, believe this could negatively impact the environment and are not in support of massive growth in this industry (Rodríguez-Ortega et al., 2017). The growth of the agtech industry suggests that there is a focus for technological development to be tackling food security and being sustainable with a long-term focus. By also incorporating economic sustainability, the companies can add value to the market and position themselves as an asset in the agricultural landscape.

4.3.1 Circular economy

The companies involved in this study produce technology that allows resources to be reclaimed. This may in turn be an asset for the economy in the long run because those resources will still be available. Circular economy was mentioned in several of the interviews as a part of their business model, wanting to reduce waste, using resources already available and combining multiple aspects in order to “*save and feed the world*”⁴ through holistic thinking. One company says they spend a lot of their time working with “*the worst in the class, which increases the environmental awareness and thus has a positive effect on those who are also best in the class*”⁵. Stating that their focus on improving the worst parts of agriculture, in terms of emissions and deforestation particularly, can contribute to sustainability in the industry. Tackling the large emitters in agriculture can contribute to a circular economy if resources are kept at bay. Because we are a heavyweight in agtech in Norway according to some, problems of food security can be solved with innovation in technology providing a circular economy in terms of food availability at home (Jonson, 2019). There is no doubt between the agtech companies that technology plays a vital role, but the problems that require solutions to become sustainable cannot be solved in practice quite yet without further development. The Norwegian government’s plan of developing new technology is a new arena for entrepreneurs. And the digitization of agriculture is recognized

³ Interview with agtech startup, March 13th, 2020

⁴ Interview with agtech startup, March 13th, 2020

⁵ Interview with agtech startup, March 13th, 2020

as the direction for sustainable food production, but is still in early stages of development (Chaudhary, 2019). Technology is being developed continuously, and this innovation is what can lead us to being able to incorporate sustainability into agriculture in the future, it is argued (Landbruk, 2018b). It is unlikely that the development and use of technology will halt, but how they are developed and what purpose they serve can be defining force of the impact it will have.

Long-term solutions part of a circular economy can be beneficial to food security, particularly in Norway if agtech becomes a larger player in providing technology to facilitate this (Jonson, 2019). Having less input and reusing materials are essential parts of the business strategy and technology development of the products of the participants of this study. Becoming more sustainable is vital for agriculture in the future, which can happen when you have less input than output. As one respondent points out “*in agriculture that is almost impossible*”⁶. These findings are consistent with research showing that production in agriculture is benefitted from less input, it is rare however, to get high outputs with this strategy unless you have modern techniques or technology that will bring higher yields (Uphoff, 2003). For development in agriculture the technology will play an important role, but it is not quite there yet. As was pointed out by an interviewee, technology is not the final solution to everything. By the participants in the study, use of technology was not seen as a limitation. However, total use and will of how the technology is used, could potentially have some limitations. My data strongly suggests that limits to growth is an integral part of the outcome of using their product. Where less resources are needed, and thus allowing for continuation of the economy because of it. This was also the suggestion by Robbins (2020). Ecomodernist theorists however, oppose limits to growth and believe intensification means protection of the environment (Gómez-Baggethun, 2020). Ignoring limits to growth and expanding further and continuing use of resources is not in line with what the respondents of my data collection incorporate in their businesses. For them it is not about becoming rich but creating local ecosystems which in turn will make it circular “*to have local production and us receiving licensing in money in return is a much better way*”⁷. Based on this, the findings represent a desire to be a part of a circular economy. Yet I think more development is required for agtech

⁶ Interview with agtech startup, March 13th, 2020

⁷ Interview with agtech startup, March 12th, 2020

companies to have a significant impact in sustainability in Norwegian agriculture from an economic viewpoint.

4.3.1.1 Efficiency

Making the process of agriculture digital means more efficiency, more money for the farmers, and improved quality of life. One interviewee said “it appeals to the wallet, the mind, the heart and stomachs all at once”⁸. Informants said that their products also contribute towards more efficient agriculture. Often being able to replace hard manual labour, giving more control to the farmers and simplifying critical processes. This allows for fast action and predicting natural phenomena. The informants identified how their technology contributed towards efficiency and improved agriculture (Figure 8).

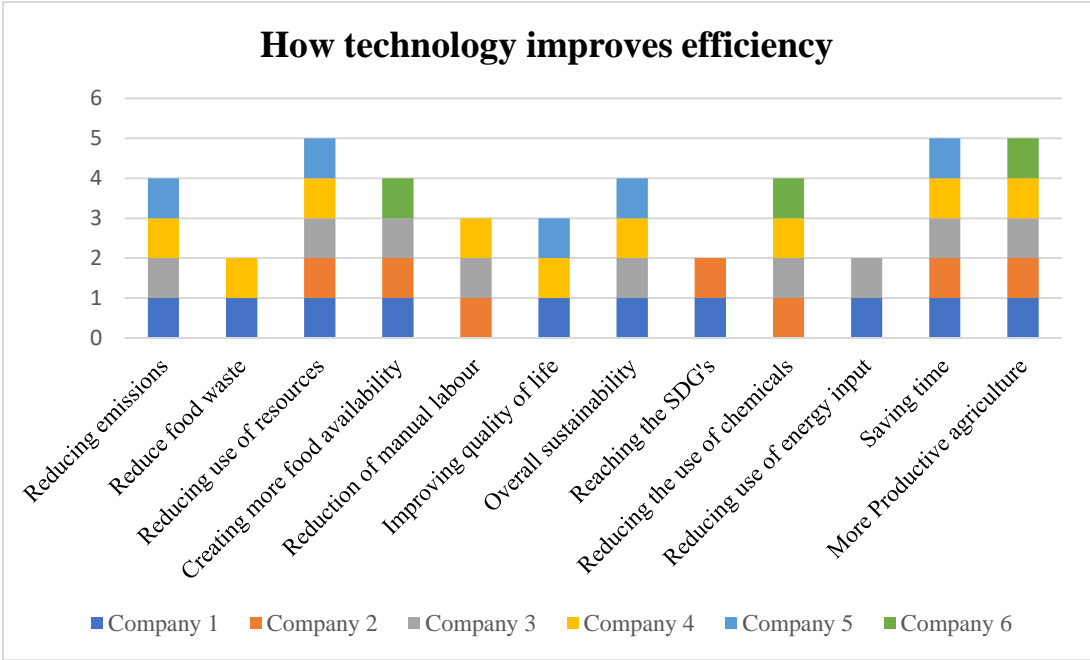


Figure 8: Companies contribution to efficient agriculture

This gives a rough overview of why they believe the technology they develop can contribute towards more efficiency in agriculture, and what other factors are considered. The 12 categories represent the most common responses across the interviewees on efficiency in relation to sustainability in agriculture. As made clear is that saving time, adding to more productive agriculture, and reducing the use of resources are the main effects from the technology from most respondents. Reducing emissions and chemicals from agriculture, adding to food availability, and contributing to overall sustainability were also a commonality

⁸ Interview with agtech startup, March 9th, 2020

between the companies. Whilst reducing the amount of energy required in agriculture, reducing food waste, and focusing on reaching the SDG's were least common. The technology removes the current and heavy labour system and creates a shared labour system with an easy tool. According to a study by Robbins (2020), technological innovation allows for higher production, but also less physical labour. In addition to not having to hire extra workers but in theory only need a few family members, leads to a more fulfilling life. The results suggest that agtech can lead to increased yield, which will have economic benefits to the companies and farmers involved and may serve as an alluring part of incorporating more technology at the farm. To achieve sustainable agriculture, being able to economically sustain the farm operations by using renewables and on-farm resources can lead to improving the farmers life as a whole (Aldy et al., 1998). Degrowth theory suggest that political and social transformation and using less resources can also improve quality of life (Kerschner et al., 2018). Even saving the farmers time and money. It is argued by Kerschner et al. (2018) that the human experience of the technology lessens the probability of making mistakes. These findings are in accordance with results reported by the ecomodernist movement. Within ecomodernism efficiency is a major keyword. Climbing the technology ladder will provide not only more productive agriculture but a more efficient one, presenting higher yields which will in turn lead to more food produced (Blomqvist et al., 2015). Ecomodernists also classify as tech-optimists in wanting increased efficiency in agriculture by technology, through intensification of land. However, this may lead to increased use of resources known as *Jevons Paradox* (Gunderson et al., 2018). Findings suggest that technology can add to efficiency in agriculture in many ways. In contrast to these findings the extensive use of technology in agriculture may, according to some previous studies, create an overdependence on technology instead of looking more closely at adaptation processes of environmental benefits (Gardezi & Arbuckle, 2020). Some of the findings concur with the ecomodernist movement in believing that the correct use of technology will also advance the efficiency of the economy. Through more efficient agriculture done sustainably, green growth can occur (Hickel & Kallis, 2019). Contrary to the ecomodernists, the degrowth movement say that the technology is not necessarily the only answer for efficiency in agriculture, but structural changes to the agricultural system is (Binswanger, 2001). Growth will still occur even though the technology is unsustainable. Thus the rebound effect, where technology may lead to increase in resources and energy, is not a sustainable option (Binswanger, 2001). Being efficient is not a solution to the environmental problems we are facing. The degrowth's debate, the intensification that comes with increased efficiency leads to less sustainability (Gómez-Baggethun, 2020). From

this standpoint, efficiency does not do much for sustainable agriculture other than adding to the environmental pressure. On the opposing side the efficiency may lead to less emissions and pressure on the earth eventually, if done correctly. It remains unclear to which degree the use of technology can in fact add to the greening of the economy, whilst being sustainable simultaneously. From the study it is clear to me that the participants believe they are contributing towards efficiency, thus also towards sustainability and growth in the economy to some degree.

4.3.1.2 Production

During the interviews it was pointed out that branding themselves as sustainable was good for business. The added value of being sustainable was an important factor throughout their supply chain. Processes are also getting more powerful. One interviewee pointed out that in agriculture, food production is one of the areas that will get more in return from technology. Sensors and big data are important for technological development and a lot that already exists. Therefore, technological development should continue, as well as the understanding of how integrated elements of that are. A point was made by one participant that although technology is a huge driver for modern agriculture in ensuring food security and progress, it may not always be sustainable. The production of food is of course essential for food security and the process of it is key to deliver on sustainability targets. Some were able to market themselves as sustainable. Being in visible support of the SDG's also give additional value. The SDG's are an integral part of businesses who work for sustainable agriculture, specifically working towards the SDG goal 2 which aims to "*end hunger, achieve food security and improved nutrition and promote sustainable agriculture*" (UN, 2019). Part of the governmental plan in promoting sustainable food system is also linked to the SDG's (Regjeringen, 2019a). Thus, the companies who embodies this in their strategy are already part of the path to making changes in the agricultural system to some extent. One of the companies said sustainability was a core part of their company from an early stage, before it was a requirement from any actors in receiving financial support. This company recently received an environmental certification *Miljøfyrtårn* for sustainable businesses. The criteria for receiving this certification is that a business must aim to improve the work-environment, recycle their waste, use less energy, and improve transportation and food waste. Furthermore these must be efficient and financially viable solutions that contribute towards several of the SDG's (Miljøfyrtårn, 2020). A large player in the Norwegian agtech environment is Innovation Norway, they provide guidance and recommendations to the Norwegian government, where they present the challenges and opportunities within agtech. And majority of agtech receive

financial funding from them. The criteria for receiving such financial support includes contributing to increased economic and social value and has to contribute to reduce emissions of greenhouse gases (IN, 2020). To some of the companies however, it was more important that the use of their products create sustainable agriculture, than the sustainability of the production process. A change in production methods is highlighted by the Norwegian government as an important solution where adapted technologies can mitigate climate change and lead to food security (Regjeringen, 2019c). From use of technology the farmers are better equipped to interpret large amounts of data, and this data is entering into every stage of the value chain. From the supplier to the consumer (Pham & Stack, 2018). This again leads to better information becoming available and for production to run more smoothly. A similar idea was obtained by Kallis & Bliss (2019). Whereas if growth in production is to continue as it has, it will lead to further environmental degradation, and technology can help in the production process. Moreover, this idea comes to fruition in the degrowth movement where downscaling of production aims to reduce consumption. And a natural effect of that is less pressure on the earth's resources (Robbins, 2020). Based on this finding I found that the companies incorporate sustainability as part of their product development, because it provides them with better business value and can be a factor in the company's growth. Sustainability is promoted also because it is required of them to receive financial support. It becomes then a key part of their business strategy. Their products aim to use less resources and promotes sustainability. Thus, a natural consequence is a better process and outcome for production within agriculture, leading to less pressure on the environment.

4.3.2 Policy and government

For agtech companies to thrive and truly be a part of the green shift, there was consensus that significantly more funding was needed. That is something startups in general may require. Especially if you add the sustainability aspect. One participant, whose product is within precision farming and weed spraying suggests having incentives for spraying in the field. These incentives could provide financial support for areas not sprayed with fertilizer. As one interviewee expresses:

“investment support for new things in environmental technology in the agricultural plan of the government would be nice. If there were government demands for use of environmentally friendly technology that could create a market”⁹.

When it comes to sustainability in agriculture, it cannot be expected that the farmers spend a lot of money out of their own pocket just because they have to make it sustainable. *“The government has to come in and take control of what the consumers do”¹⁰*. It can be tricky to get the product out to the consumers. The sustainability contribution can be significant. Some think that the government should make sure their machines reach the farms, and a lot of people, including the stakeholders, want to go in that direction. The hype and interest around many of these companies does not make up for the lack of political action. If the government really wants to go forward with the green shift in agriculture, many of the respondents agree there should be funding specifically directed at agtech. Subsidies and incentives, however, are by some not seen as good solutions because they can lead to unwanted side-effects. There is political will to some extent. *“If you combine business force and sustainability the government is willing to support”¹¹*. To keep the agtechs from being bought up by larger corporations finding a niche is key. *“You have to position yourself as a value without being an opponent”¹²*. It is argued by Jurgilevich et. al (2016) that having a niche is where the radical changes can be made, and sustainable agriculture can grow and evolve. Yet being a niche can be tricky, it is important for them to continue to be indispensable and there should be *“lots of regulations from the government, and that they have societies best interest in mind for agriculture. Not just in private sector, but in regulating how the giants behave”¹³*. And as was pointed out in the data collection, keeping the agtech within Norway will be more beneficial for Norwegian sustainability in agriculture than if they were bought and moved overseas. One respondent says, *“the politicians are starting to look more closely at it too. These tools will make us better equipped to produce food in Norway. We get better access to political environments when they see that this is a priority for the future”¹⁴*. There are dedicated people in every regional office of Innovation Norway working closely with agriculture and sustainability. It is a high priority one respondent says. Other issues raised by one interviewee were the need for better infrastructure and logistics in Norway. That also comes down to

⁹ Interview with agtech startup, March 10th, 2020

¹⁰ Interview with agtech startup, March 12th, 2020

¹¹ Interview with agtech startup, March 13th, 2020

¹² Interview with agtech startup, March 13th, 2020

¹³ Interview with agtech startup, March 13th, 2020

¹⁴ Interview with governmental organization, March 18th, 2020

political initiatives. In line with ecomodernist thinking, regulations and incentives within the system is key to have good governance of the technological processes (Grunwald, 2018). The green shift and the green growth have aligning ideas. In line with previous studies, the aim is to have incentives and regulations that will improve the economy through technological change (Hickel & Kallis, 2019). More support from the government is wanted from the agtech startups involved. Although the government express a desire to contribute, the companies feel the support still has a way to go. Even if their products are receiving attention, it is still in early days of growth for the businesses and there remains initiative to support the niche markets.

4.3.3 Green growth

In this study, technology is seen as the overarching solution to solve agricultural challenges by the participants. Technological development has already come quite far, and the price keeps going down. In the Norwegian government's plan for sustainable agriculture, climate adapted food production. Sustainable production and locally adapted production is mentioned throughout their plans to move to the green shift on numerous occasions (Regjeringen, 2019c). Using technology is a major part of that plan. The use of chemical fertilizers, pesticide and exploitation of land must be done in a controlled manner. This is to not reduce land or soil quality, which leads to deforestation or interfere with biological diversity. Part of the green shift, the production stage is where many of the changes and transformations must come, participants argue. Technology is driving this change (Landbruk, 2018b). The continuous growth in consumption, which naturally leads to higher production by technology through green growth, provides a viable solution for the ecomodernist (Kallis & Bliss, 2019). Thus, technology, viewed as the saviour to the agricultural system by the ecomodernists receives support by participants in this study. In support of ecomodernist theory, technology will be the change agriculture needs to be sustainable for the future. The Norwegian government's strong support of a shifting agriculture is because of its ability to contribute to carbon uptake. Taking the shifting step is needed to meet the threats of food security from climate change (Regjeringen, 2018). Again, ecomodernist ideas support the idea of green growth where the growth in production is made possible by technology and that this will alleviate the pressure from agriculture (Grunwald, 2018). Grunwald goes on to say that for green growth to be successful, government support and initiatives should be implemented (2018). In contrast, green growth (like green shift ideas) models only work in wealthy nations and not long-term. Stating also that technology and government policies is not all that is

required for this to be successful. Any further growth will be a problem for the environment, the degrowth movement claims (Gómez-Baggethun, 2020; Hickel & Kallis, 2019). The Norwegian government favour green growth ideology, and so do participants in this study. However, further growth could have substantial impact in an already degrading environment. There is no easy answer to whether green growth is the only viable solution. By wanting to reduce emissions and focusing on sustainability, it could be a step in the right direction.

4.3.3.1 Greenwashing

Most of the participants in the study were clear on the fact that they do not participate in greenwashing in any way. As one company CEO pointed out, “*we do not do greenwashing, on that we are very open and clear*”¹⁵. However, like every business they also must make money. All the participants were asked about greenwashing, which can be a sensitive topic as they work and promote themselves as sustainable businesses. Some were more reluctant to answer than others. One company said,

*“for our products to work it has to have value for the consumers and customers. To give it value we increase its efficiency and improve the current state. By doing that it also leads to an improved environmental footprint, it all hangs well together”*¹⁶.

To receive funding businesses also must provide documentation of their sustainability and therefore greenwashing becomes less common. However, greenwashing does exist, it can be a misleading marketing tool, with falsified accounts of sustainable performance (Delmas & Burbano, 2011). Green shift is growing in capital markets and there is lots of money circulating. Greenwashing may lead to a mistrust in the green shift. If you have a company and you add sustainability in the end as an afterthought, it may be greenwashing in some sense. One respondent says, “*the results can still be good even if you are forced to become sustainable*”¹⁷. Continuing by saying there is plenty of greenwashing in the industry, but one must look at the big picture. You should not just look to isolated factors, “*you might solve one problem, but another one will arise*”¹⁸. As an example, large tractors are effective and use less diesel, but at the same time you push the soil harder and harder and lose the natural soil qualities. Thus, there is not always an easy answer. Everybody wants to be sustainable, and in agriculture it starts with the farmer. Having to start at the root with them, “*providing great solutions that your average farmer doesn't have access to, doesn't actually solve the*

¹⁵ Interview with agtech startup, March 9th, 2020

¹⁶ Interview with agtech startup, March 9th, 2020

¹⁷ Interview with agtech startup, March 9th, 2020

¹⁸ Interview with agtech startup, March 12th, 2020

*problem*¹⁹. From this standpoint, greenwashing is present in the industry. There is misleading information out there which aims to benefit from the green shift without providing the necessary environmental improvements (Delmas & Burbano, 2011). The companies involved in this study were noticeably clear on not greenwashing in any way. They have transparency in their businesses mostly fuelled by economic benefits. Also, from an ethical viewpoint they were sincere in their efforts towards the green shift, at least from an outside perspective. This is consistent with previous studies where going beyond GDP and greening the economy is important for companies and having a strong focus on social performance (Martinez-Alier, 2012). Contrary to these findings, the ecomodernist movement has received criticism for greenwashing. In ignoring accounts of deforestation due to agricultural expansion (Caradonna et al., 2015), and thus in questions regarding greenwashing, the degrowth movement ideas are favoured by participants in the study. Overall, I believe the majority of agtech in Norway take sustainability very seriously. They do have an aspect of sustainability incorporated in their business which relates to climate and environment. Some have more direct links than others, but if they have any negative affect it can be more challenging to receive funding.

4.4 Social sustainability

The social sector of the three pillars of sustainability involves community and knowledge. In this section I will use the collected data to analyse the social factors incorporated into the degrowth and ecomodernist movement.

4.4.1 Social responsibility

As far as product development goes, some participants concerns were more directed at the value of what their product delivered, “*quality over quantity*”²⁰, rather than producing as much as possible. Overall, the agtech companies in Norway were characterized to have a “*good moral compass*”²¹. Where the companies interviewed not only have technological knowledge and competence, but also a sense of responsibility within the community and for sustainability, appreciating the value it brings. A similar conclusion was reached by O’Dell (2018), noting that the values within the Norwegian startup community are positive and particularly transparent and sustainability focused. Within the degrowth movement the idea of value is supported, particularly use value where there is a focus on community and shared knowledge systems (Robbins, 2020). In line with the ideas of Heikkurinen (2018), these ideas

¹⁹ Interview with agtech startup, March 13th, 2020

²⁰ Interview with agtech startup, March 13th, 2020

²¹ Interview with governmental organization, March 18th, 2020

from the degrowth movement regarding a change in values to be sustainable, are supported by these findings. The transparency of businesses in Norway is resolute. With the added value for sustainable growth this is a positive driving force for Norwegian agtech.

4.4.2 Knowledge and community

A sense of community within agtech in Norway was something most of the participants were part of. Sharing of knowledge was an important asset for growth and development.

Knowledge can be a facilitator, and the technology can build on that even further. However, throughout the study a few were not in any way tech-optimists, with one saying,

“technology can make sure there is less probability of making mistakes. In the end, humans are needed for final decisions. We can quickly get insight to things that are only possible through human experience”²².

They argued that technology can be an asset in sustainable agriculture if you have the required funds, and you are able to use it sensibly, combined with human knowledge and experience.

A key point made by many of the interviewees is the amount of knowledge possessed that allows to make for sustainable solutions and that add value to agriculture in Norway.

Specifically, within agtech and technology there seems to be many opportunities for the future. Several of the interviewees stated that there is plenty of competence and talent, partly due to the oil industry which is why agtech is doing well in Norway. Stating, *“agriculture is slow, but it is innovative”²³*. In Norway we are early adopters of new technology and may bring the masses on board if they can prove successful. It is slowly and steadily moving in the right direction. With newer and improved technology constantly being developed the companies are rolling out new products often. AI and automation play a role in that success. As one interviewee points out, if you look at the rate of digitization across global industries *“agriculture is the dinosaur”²⁴*. That is because of the lack of access to technology, in addition to barriers such as language and culture. The resources are not always available to assemble the industry. With innovation one company says they now have an opportunity to *“transfer the knowledge that is typically in the heads of farmers”²⁵*, which then can be turned into a dataset and give more knowledge to learn from. Allowing for improved analysis and decision making. Another company says they are now able to close the gap, by making simple, easy,

²² Interview with agtech startup, March 13th, 2020

²³ Interview with agtech startup, March 9th, 2020

²⁴ Interview with agtech startup, March 13th, 2020

²⁵ Interview with agtech startup, March 13th, 2020

and automatic core data points, giving the farmer simple tools for being in the field. That in turns leads to better analysis and thus “*operational efficiency, and a natural consequence of that is a more sustainable farm*”²⁶. This suggests that knowledge and technology lead to an increase in productivity in agriculture and the technology contributes to less risk. From the short review above, key findings emerge. Especially harvesting knowledge that has been accumulated throughout and using it in an innovative way is greatly beneficial in a sector that has largely lagged in technological development. Overall, these findings are in accordance with findings reported by Grunwald (2019), that ignoring accumulated knowledge can demonstrate side-effect of the use of technology that are not favourable. It is argued that sustainability is best achieved when knowledge from several fields are combined (UNEP, 2020). And in development of new technology knowledge input from all peoples involved should be incorporated. Therefore, it can be essential that when developing technology, the established knowledge is not ignored and is part of the process. This way agriculture will have the best possible outcome.

It is noteworthy however that even though the Norwegian government has a focus on the green shift, to make this happen, support from government institutions and initiatives are vital. As well as a community of support. Overall, the companies do not receive funding in large sums of money, they rather get support from activities and initiatives, from municipal, local, and regional level. Many were also part of a cluster program run by Innovation Norway, an arena to meet and exchange ideas. Cooperation was highlighted as an important factor by many of the respondents. One company is working closely with international scientists and institutions where they are providing solutions to the UN and EU. Thus, receiving a lot of support in more than one way. There are also many arenas, such as conferences, where the agtech communities meet, where “*there is understanding and support of the technology and the impact it can have*”²⁷. It was pointed out that majority of those working in agtech are entrepreneurs and often look to what other countries are doing, being systematic and seeing connections across countries and disciplines. A key point made by many of the interviewees was that there is also a lot of transparency and trust within the Norwegian agtech community. Meaning sharing and discussing good ideas and supporting each other is prominent. One respondent claims the climate for agtech in Norway is particularly good, and for environmental problems “*cross-industrial competence is the name of the game*”²⁸. Stating

²⁶ Interview with agtech startup, March 13th, 2020

²⁷ Interview with agtech startup, March 12th, 2020

²⁸ Interview with agtech startup, March 12th, 2020

there is shared knowledge of algorithms and an environment for sharing data. For initiators such as Innovation Norway, facilitating knowledge exchanges and networks gives Norwegian agtech a strength and becomes a united value chain and an advantage to the development of Norwegian agtech environment and businesses alike. The use of the accumulated knowledge from a highly educated people is how the government plans to develop agriculture sustainably. There is plenty of cross-cultural competence that will add great value in the chosen sectors (Regjeringen, 2019a). The government wants to have strengthened relations with institutions. They cooperate with small-scale and local actors harvesting the knowledge of what sustainable food production is at all levels. From an agtech point of view they also want to support technology and make digital solutions more available. My results confirm that where the government plan is headed is also where the agtech community see themselves. They have a shared vision of knowledge sharing. The cooperation between agtech and the government is crucial to find workable solutions for sustainable food production. These findings are in accordance with the vision of the ecomodernists, who want to combine knowledge with technology to meet the challenges of the future (Asafu-Adjaye et al., 2015). However, there is not a general agreement that the ecomodernists use that knowledge. It has been argued that ecomodernists ignore previous knowledge on technology especially in regards to unwanted side-effects (Grunwald, 2018). Thus, the results tie well with what the government wants, using incorporated knowledge to expand and develop the agricultural sector and use agtech for all it is worth in the campaign for sustainability.

4.4.3 Green shift

Many of the respondents said they feel a moral responsibility to contribute to reducing emissions and being part of changing the current agricultural system and contributing to feeding the world. They all regarded their products to contributing towards the green shift in Norway. There is extensive interest in many of the products from stakeholders and other actors, but there was consensus in the research that without proper initiatives and funding from the government it would be difficult to implement products large-scale. A commonality for several of the interviewees was that their goals were aligned with the green shift initiated by the Norwegian government. However, grants and investments in agtech are lacking. They say it will benefit them greatly in growing the business to be able to be part of the agricultural shift needed. The applicability of these results align with the green shift, which is a restructuring of society and aims to use less resources, more effective land use, cut in emissions and a switch to products and technology with less environmental impact (Olerud,

2019). This corresponds well with what agtech in Norway is trying to achieve. The results have demonstrated that lowering emissions will have positive influence in the agricultural sector, thanks to the new technologies they are developing. The green shift is particularly important in working towards the goals set in the Paris agreements and in using the newly developed technologies without trying to influence the competitiveness in today's market (Chaudhary, 2019). In Norway in particular, it is interesting to note that we have a remarkably strong prerequisite in knowledge and innovation in technology allowing us to be leader in this field (Landbruk, 2018b). The results, however, indicate a lack of financial support from the government to truly be a part of the green shift that is widely promoted as the path to sustainability. Companies working with agtech do not receive funding equivalent to the need being expressed.

Sustainability being an important parameter for the companies, they address sustainability challenges with their products. They all want to be successful within Norwegian agtech and to be a part of the green shift. There were multiple barriers and contributors to their positioning in the green shift in Norwegian agriculture (Table 3).

Barriers	Contributors
Green shift is a buzzword: it is unclearly defined in the industry	Their product adds value, and includes not only sustainable agriculture but sustainable society
Not receiving enough support from the government, incentives etc.	Agtech is innovative, being early adopters in Norway means moving in the right direction
Farmers are not directly part of the green shift, for them it is solely business	New product launches happening regularly, the expansion of companies is positive for green shift
Organic agriculture can be difficult to implement large scale towards the green shift	Using more renewable energy in all aspects of production and use
Lack of funding from private and public sector	Understanding technology and fuelling new trends
More hands-on action required from the government	Cooperation with international organizations

Not having a clear picture or a good starting point	Running farms more efficiently
Policy, infrastructure, and logistics can be halting	Electrification in machines has a high priority

Table 3: A breakdown of barriers and contributions toward the green shift

New product launches with constantly improved technology, and the expansion of companies, are positive for the green shift. So is the use of renewables. Moving all lines of production into renewables, as one company states *“in relation to the green shift and the climate agreement our contribution can be significant”*²⁹, but even more support needed to get there. A point is made by one respondent was that:

*“where I think we need to be very clear is what it means to be green, and that we are not just greenwashing things, the green shift has to align with real problems. Like any sustainable practice you implement on farm it is got to align with cost savings and improvements”*³⁰.

From these results there are some indicators that action towards the green shift is already there by agtech in Norway. If this continues it will contribute to a reduction in the use of energy and emissions, moving to renewable resources (Olerud, 2019). Already Norway is ahead of the curve when it comes to using renewable energy sources. According to research we are in a unique position in delivering sustainable food (Landbruk, 2018b). Contrary to the findings, it is argued that renewable resources are not able to provide the energy needed to sustain the future of food production, as it will not be able to keep up with growing demand. From a degrowth perspective, degrowth then becomes the only option. A green shift is simply not sustainable if economies will continue to grow (Kallis, 2019). A similar conclusion was reached by others claiming a more intensified agriculture would add additional pressure to already vulnerable land if everything moved over to renewable energy sources (Capellán-Pérez et al., 2017). The extent to which the use of renewable resources in all sectors of agriculture is unknown, at least from a global viewpoint. In Norway this is already the case for many areas, but there are still emissions from transportation and there is still effort required when headed towards the green shift. Thus, there are still some barriers as to why the green shift is not easily achieved from a business point of view.

²⁹ Interview with agtech startup, March 12th, 2020

³⁰ Interview with agtech startup, March 13th, 2020

Breaking agriculture into segments can be useful in ensuring simplicity and accessibility, which can then become sustainable. That is because to achieve sustainable agriculture, “*technology plays a central role. It is an absolute prerequisite to succeed. We need sensors, we need accumulated data about the soil and other information*”³¹. Technology can make plants more robust, in relation to climate change. The technology is a necessity to achieve for this type of development. Technology becomes a necessity for the greater good and to create a more sustainable agriculture some respondents claim. When comparing the results with previous studies, I have pointed out that through regulations of the current system, transformation by using technology can be done (Grunwald, 2018). This was included to verify that the ecomodernists claim of climbing the technology ladder will in turn save nature (Bliss, 2016). However, the extent to which it is possible to save nature simply by using technology in agriculture is uncertain. The somewhat utopian idea presented by ecomodernists is reflected by some of the participants in the study. It can be true for some of the technologies they develop, yet it is still in early stages of development and not widely implemented. Thus, it is difficult to reach a final conclusion on this. In addition, the sustainability their products bring can by some be measured specifically. Others are only estimating and goal setting. Overall, the agtech companies in this study all have a vision, and a contribution to some extent towards the transformation of agriculture towards sustainability. However, whether it is the technology itself or combined with other outside factors is unclear.

4.5 Environmental dimension

The environmental dimension entails categories relating to the physical properties of the earth. This section aims to analyse the findings from the collected data by using the PB framework and the use of resources.

4.5.1 Planetary boundaries

The companies in my study have a strong focus on reducing emission by use of their products and have long-term goals and ambitions to see this through. Particularly one company's goal is to reduce the use of nitrogen in agriculture today. Its technology has a focus on reusing resources already available at the farm. Thereby responding to the challenge of staying within the boundary of biogeochemical flow, from the PB framework. Technology like that has the potential of having huge impact if implemented large scale. So far, it is only small-scale, but with proper funding this product could really deliver on reducing emissions. In line with degrowth thinking, with the idea of reusing something that is already available, this has

³¹ Interview with governmental organization, March 18th, 2020

potential to change the labour system and parts of the value chain (Robbins, 2020). To be able to stay within the earth's boundaries of resources, the re-use of nitrogen and the amount of fertilizer that will decrease using their product. This presents opportunities to really change the agriculture system. It be good for soil health, and could also boost crop production from less chemical fertilizer and more use more organic fertilizer (Steffen et al., 2015). Other companies' products are meant to make agriculture more efficient in one way or another. Thus, seek in some way to intensify agriculture by using more resources than what is already available. This is in line with ecomodernist thinking in that intensification of agriculture could lead to sustainability (Bliss, 2016). By not using more land, saving nature in some ways, the findings from the companies in my research demonstrate that use of their technology would add to improved yield and productivity. Expanding agricultural land can as the PB framework states, influence climate regions, and act as a feedback loop for climate change, having negative impact on evapotranspiration (Steffen et al., 2015). Thus, whether intensification and efficiency on already available land, or expansion of agricultural land is better, is unclear. The use of technology developed by the involved companies are still in early stages but can have impact on the planetary boundaries in the long-term.

4.5.2 Renewable resources

Clean energy sources are required to become truly sustainable. Using technology to become sustainable is essential according to the participants. The technology sector within agriculture is going through a paradigm shift: going from coal to electricity, *“being able to jump from fossil fuels and to produce food using renewables is everyone's wet dream, right?”*³². If you are to feed the world you need to transition from fossil fuels into renewable energy, which is more efficient and would reduce the carbon footprint. With other technology, including sensors and precision farming, the industry can help in the transition in the form of solar panels and windmills. As for now there are price concerns, but higher rates production will lower the price. As the ecomodernist manifesto states, technological innovation and transfer of energy is essential in agriculture (Asafu-Adjaye et al., 2015). In this finding I found that the ecomodernists want renewable energy sources to continue growth. In contrast I found in this paper by Kallis (2019), that to continue with indefinite growth, replacing one source for another may only cause more problems, and can lead to more use of land. It is not generally agreed that switching to renewable sources may be positive for continued growth. Renewable resources are already a major source of energy in Norway, (Chaudhary, 2019). Norway is

³² Interview with agtech startup, March 12th, 2020

headed towards a low-emission society, which is especially relevant in the development of agtech. Therefore, the problems caused by switching to renewable source may not be relevant in a Norwegian setting. The participants that have exports products overseas may encounter these issues as renewable energy sources are not as widely used on a global basis.

Some of the participants believe their technology can contribute towards a change and that they can be a part of a restructuring towards sustainability. Thus, agreeing with the ideas of the degrowth movement, leaning towards the interpretation of sustainability where reduction was a key factor. This falls within the context four of the eight R's developed by Latouche, reconceptualizing agriculture , restructuring and reducing how agriculture operates (Gomiero, 2018). For most of the companies a reduction in resource use and reduction of chemicals were most important and correspond with what they are trying to achieve with their products. This is in line with Barca's (2019) theory, stating technologies that can be implemented at smaller scale, will lead to a smaller carbon footprint, and is achieved by deintensification. Thus, downscaling of the current agricultural system into more a efficient one, aligns with Barcas idea that large scale industrial farms require a system change. Findings from my study reveal that agtech companies, though they conduct business operations aiming for growth, believe that what they have to offer can work towards a system change that will benefit agriculture long-term. Another reason why a system change is important is that unless large industrial farms change, it will continue to affect ecological life and impact socio-environmental costs (Gómez-Baggethun, 2020). It is argued however, that transition and improvement in infrastructure towards modern technology in the energy sector will improve quality of life (Schwartzman, 2012). It was predicted by one scholar (Kallis, 2019), that we will live with a lower rate of economic production and consumption by using solar power as energy source. The degrowth movement support this idea, but it may not be relevant in a Norwegian context to a large extent as we use hydro as renewable source. My research shows that the participants believe in the increased human well-being and ecological conditions that the degrowth movement aim to improve. The idea behind the products they have developed is to have less direct impact on the environment. That is one of the main motivations most of the respondents have for wanting to be in agtech.

4.6 Summary of findings and discussion

Through the analytical framework key concepts were analysed in relation to my results and discussed. Several interesting findings became clear through categorizing. Such as the varying drivers the companies had for environmental, social, and economic sustainability as they all

faced the same challenges in solving problems related to this. Together all the businesses had a strong focus on sustainability, working towards the SDG's, the three pillars of sustainability, resilience, yield increases and productivity.

Early in the findings and discussion chapter, it becomes noticeably clear that sustainability is hard to define. There is no one definition that entails what sustainability is for the involved companies and they bring their own meaning and interpretation of it. However, they all believe they add to sustainability especially in reduction in emissions and being valuable players in improvement of agriculture. They take the role of sustainability very seriously even though they are mostly small companies, operating at relatively small-scale farms. Four of the companies work with large-scale conventional agriculture or has products that are meant to serve large scale agriculture in the future. Whilst only one company was based in the organic farming field with goals to transform conventional agriculture in terms of minimizing resource use.

To the extent it was possible, I attempted to divide the respondents into the two theories of degrowth and ecomodernist. I did this to get an understanding of their viewpoint of the use of technology, and to what type of agriculture the companies were aimed at. Based on this, it became clear to me that four out of five companies are aligned with ecomodernist thinking. They want to intensify the use of land using technology and contribute towards land sparing. I interpreted the findings such that these companies wanted to increase production, leading to optimization of resources through increased use of technology. One company's ideals were aligned with the degrowth theory. In favouring organic, small-scale farming, wanting to use less chemical input combined with resource management and sustainability practises.

Economic sustainability was a core part of all the respondent's visions. They were all in favour of long-term growth. Wanting to create improved conditions financially for the farmers, and for themselves to become valuable assets in agriculture. Circular economy is an important aspect of all the participants. They were all truly clear in wanting to reduce their environmental impact, which they believed could in turn improve economic conditions for all involved parties. Increased efficiency can lead to improved yield and food security and was another integral part of their strategies. Enhanced production, but in a sustainable manner can lead to less pressure on the earth systems and thus the technology can be an aid in that goal. However, although there is some support from government and stakeholders, more financial support is required to establish agtech in the agriculture market. Green growth is a step in the

right direction in embracing the green shift, yet despite the transparency of Norwegian agtechs, some greenwashing is present in the industry.

All involved companies have a good moral compass. The social responsibility of what they can deliver in agriculture, from a sustainability viewpoint, was integral to all the involved companies' strategies. They have a responsibility to incorporate their knowledge with technology to make it sustainable. The strong agtech community is valuable in sharing and exchanging information to constantly improve their sector. The technologies they develop have convinced that they add value towards the green shift in Norway. Though there are some barriers, their contributions are great.

The reduction of emissions from the use of their products is essential for most of the companies. They have real potential to reduce emissions from transportation, use of chemical fertilizers and utilizing resources available at the farms. Most of them are in an early stage of production and use, and I think they have promising impact on the planetary boundaries thus far. Agtechs are motivated to have less impact on the environment, and through using renewable and local resources, they can be truly sustainable.

5. Conclusion

Through empirical research, I have evaluated agtech companies' contribution towards sustainability in agriculture. Most of whom were start-up companies. The purpose was to assess whether new technology could in fact contribute towards sustainability in agriculture and be a part of the green shift underway in Norway today. Research was conducted via semi-structured interviews. From the data collected and the analysis of the data, it appears to me that the agtech companies involved in the study, have products that are aimed at sustainability in agriculture. The degrowth and ecomodernist theories as well as the analytical framework allowed for an in-depth analysis of the collected data. The analysis stimulated suggestions for how technology can be implemented in agriculture, and how that may lead to a sustainable agricultural system.

The theories of degrowth and ecomodernism were useful in interpreting the results and the ideology of the companies. The companies leaning towards ecomodernism were characterized by their application in large-scale conventional agriculture and wanting to intensify the use of land. Whilst reducing emissions and using renewable energy sources, as well as using land already available. The one company leaning towards degrowth aimed its ideology at organic

farming, wanting to transform conventional into organic by using less chemical fertilizer and combining management practices to have less environmental impact.

There were varying definitions presented throughout this study, and many interpretations of participants what sustainability is to them, creating uncertainty of what constitutes sustainable practices. However, I have no doubt that what they do as businesses, from all stages of the production process, is centred around sustainability issues. They were focused on long-term growth and implementing circular economy ideas. Using their technology, the involved companies can focus on reducing emissions, using less chemical fertilizer, implementing tools for easier data handling, and give room for more efficiency. Thus, as a result, the companies contribute to sustainability in varying degrees. Norway does have an accomplished startup scene which allows for entrepreneurs to develop ideas that work to tackle sustainability issues. The agtech companies have a community to thrive and grow in, sharing ideas and data. The initiatives by governmental organizations through activities such as conferences has proven immensely valuable. This has given Norwegian agtech a good reputation as a leader in the field. I found that the participants in the study want to contribute to economic, social, and environmental sustainability, and to grow their business simultaneously. The companies have a goal to become sustainable in all dimensions, though are perhaps not fully there yet. Further development of products, business, strategies, and governmental support could see the growth of these products being implemented even more. Overall, I see that the agtech companies have potential of becoming an asset in reducing emissions in the agricultural sector in Norway and is on the path to sustainable agriculture.

The companies in my study believe they are adding to the green shift by having developed technologies aiming to use less resources and increasing productivity and efficiency in many aspects. To what extent that is true is difficult to evaluate as there is no way to measure their actual contribution towards the green shift. The green shift and implantation of new technology in the agricultural sector is high on the agenda of the Norwegian government, that has signed agreements committing to reducing emissions. As climate change and other factors, such as population growth, lead to an increased demand for food, the transitioning of agriculture is vital for future generations to be fed. Based on my findings I would suggest a transitioning which should include improved technology in the agricultural sector. That would in turn contribute towards the green shift also. Until recently, the agricultural sector has been slow to implement new technology. The slow implementation of technology is acknowledged by agtech companies and farmers, as well as governmental organizations. It became evident to

me that the companies were seeking more support from the government in terms of funding. Especially in a startup phase, more focus on agtech would help lift the industry and bring more attention to the needs and solutions required to deal with sustainability. I found that financial support was important, it could allow them to become more visible thus attracting investors. This could lead to growth in their company, and a wider implementation of their sustainable products. It could potentially be a win-win situation. This suggests that more support is still needed for agtech to truly be a contributor to a larger extent in agriculture both towards sustainability and the green shift. Though we are ahead of the curve in Norway according to my findings, development is happening at a relatively fast rate, we are still only in the early stages of graduating towards changes in the use of technology. The technologies may be available only to some. Therefore, it would require more wide-scale adoption of the products to contribute to the green shift adequately. Of course, as pointed out in the limitation chapter, if more companies had been involved in the study, these results may have been different. As the number of agtech companies in Norway is relatively low, and some products are further along in their development and implementation stages than others, no concise conclusion can be drawn to whether or not they are in fact contributing towards the green shift.

From my findings it became evident to me that more efficient use of land and improved management can assist in reducing emissions in agriculture. New technology can change the current food system, and the Norwegian government has already incorporated sustainable food systems in the policies. Moving towards a low-emission society, I believe the Norwegian agtech community has the potential to be a great contributor. The government wants to support digital solutions, and specifically adapted technology that leads to a sustainable food system. The companies involved in my study are truly certain however, that the future of farming is digital. Further, the agtech companies may make the entire line of food production more efficient. Efficiency may lead to sustainability, however, probably not in the early implementation stages. More use of technology may lead to less risk, if the knowledge already possessed of agriculture is combined with new technological developments.

Agtech is on the path to improve agriculture already in all dimensions of sustainability and the will and support of using agtech is rising. From further development of technology in agriculture, farmers, businesses, and industry can make better choices in creating sustainable agricultural system, able to withstand irregularities that can affect food supply. There is uncertainty in what the future might bring, if it is to be large-scale conventional farming with

efficient enhancing technology or reverting to smaller farming methods. However, I have no doubt that agtech is here to stay and has a great potential to contribute to the transitioning into sustainable agriculture.

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