The promised land for bioenergy

Exploring farmers' motivations to increase agricultural feedstock production for energy purposes

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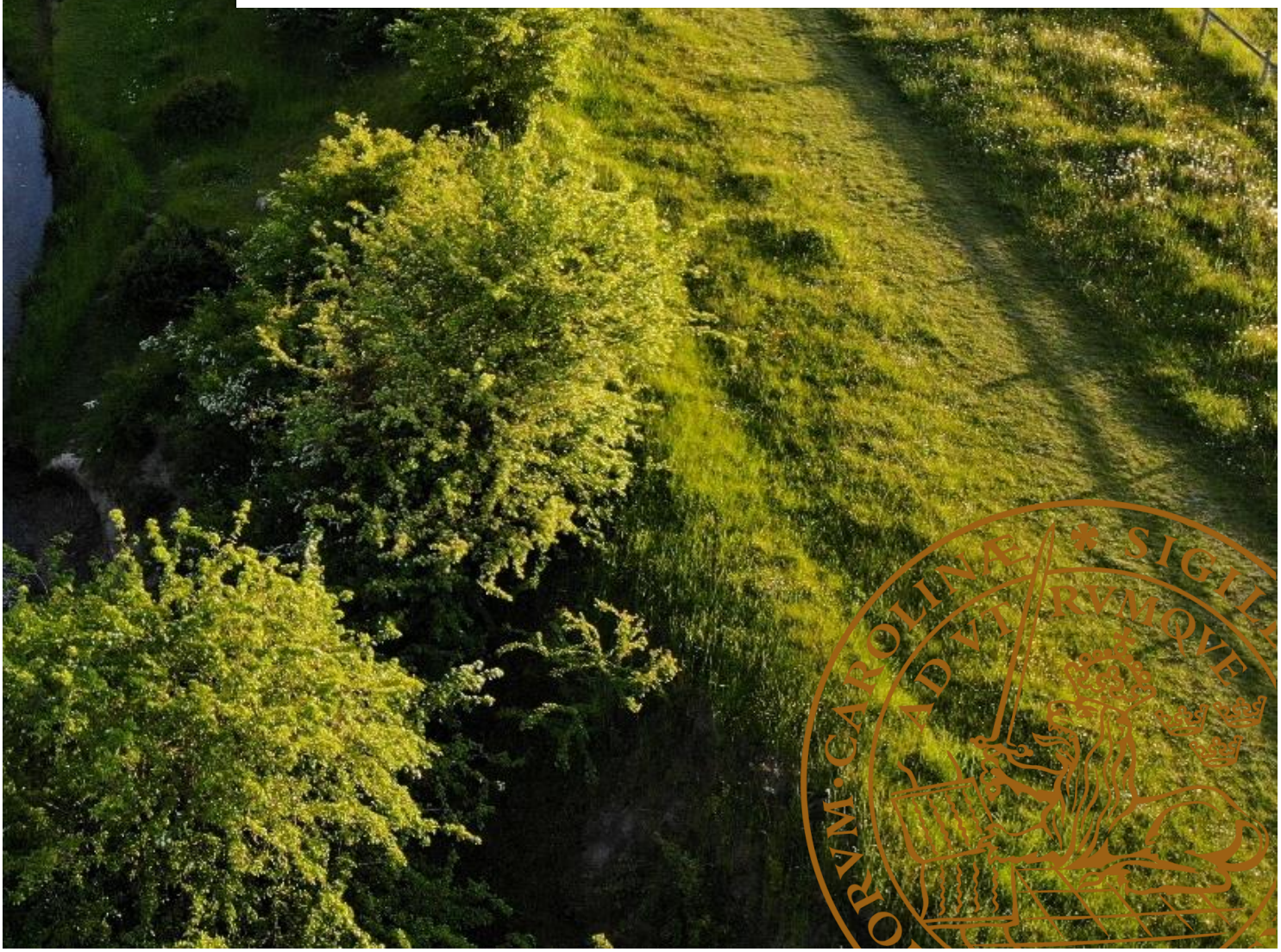

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Cover picture: Farmland in Scania, Sweden.
Photo by: Hedda Thomson Ek

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Abstract

Bioenergy derived from agricultural biomass has potential to phase out fossil energy sources while strengthening the bioeconomy. To estimate the agricultural sector's potential to meet the rising demand for renewable energy sources, it is crucial to understand what motivate farmers to sustainably increasing agricultural feedstock production. Through eight semi-structured interviews, and online surveys with 174 farmers in southern Sweden, this study explores which opportunities and barriers farmers see in starting or increasing feedstock production for energy purposes. Furthermore, the study investigates which production methods with low risk for indirect land use change (iLUC) that farmers see the most potential in utilising. Motivational factors found in this study include higher market prices for plant residuals and energy crops, combined with more long-term and reliable subsidises that supports investments in new facilities and production systems. Low profitability, high risk investments and potential negative ecological consequences were seen amongst the most prominent barriers. Using residuals and growing intermediate crops were seen as particularly interesting production methods amongst many farmers, conditioned that there is a strong demand, and a flexible infrastructure for utilisation of the feedstock. The insights in which factors affect farmers' willingness to produce feedstock for bioenergy using low iLUC-risk production methods are important to consider when estimating the potential of agricultural derived bioenergy, as well as for forming policies that encourage sustainable bioenergy production.

Keywords: Agriculture, agricultural residuals, bioeconomy, bioenergy, energy security, farmers, intermediate crops, iLUC, willingness, land use change, motivation and action, Sweden, Scania, production methods, underutilized lands.

Populärvetenskaplig sammanfattning

Med kriser och konflikter i Europa ökar intresset för självförsörjning av mat och energi, och viljan att fasa ut fossila bränslen. Skåne, med sina bördiga marker, är bland de regioner i Sverige som har bäst förutsättningar att bidra med både mat och energi från jordbruket. Men medan behovet av råvaror från jordbruket ökar, så förblir tillgången på åkermark begränsad.

Konkurrensen om råvaror från jordbruket kan få effekter på hur både jordbruksmark och andra typer av marker används. En ökad efterfrågan av energigrödor kan leda till att jordbruksmark prioriteras för energiproduktion istället för matproduktion, vilket i sin tu kan leda till att skogsmark, och andra typer av mark, omvandlas till jordbruksmark för att kunna möta behovet av råvaror från jordbruket. Konkurrensen om marken ser många lantbrukare i Skåne som ett av de största problemen med att odla för bioenergi på åkermark. Men genom att använda växtrester, odla energigrödor på underutnyttjade marker, och odla mer intensivt, kan jordbruket bidra till bioenergi utan att konkurrera med matproduktion. För att förstå vilken potential jordbrukssektorn har för att bidra till en hållbar bioenergiproduktion behövs mer kunskap om vad som skulle motivera lantbrukare att odla mer för energiändamål utan att konkurrera med matproduktion, och vad det finns för hinder.

Genom intervjuer och enkäter med lantbrukare i Skåne har den här studien identifierat både morötter och käppar i hjulen som lantbrukare i Skåne upplever med att starta eller expandera odling för bioenergiändamål. Studien visar att även om många lantbrukare är positiva till att bidra med bioenergi till den egna gården och till samhället, så saknas idag tillräckligt med ekonomiska incitament att starta denna typ av odling. Många av bönderna upplevde att det krävs för stora investeringar till hög risk och låg lönsamhet att producera växtmaterial genom att använda restprodukter, odla på underutnyttjade marker, eller odla mer intensivt.

En ökad efterfrågan på energiråvaror, bättre infrastruktur för bioenergiproduktion, och ett mer flexibelt stödsystem, skulle kunna öka lantbrukares intresse att producera mer växtmaterial för bioenergi, framför allt genom att odla mellangrödor, och att använda växtrester.

Att förstå vilka faktorer som motiverar lantbrukare att producera råvaror för bioenergi, och vilka hinder som lantbrukare upplever, är centralt för att kunna utforma policys som är förankrade hos lantbrukare, och för att förstå jordbrukssektorns potential att bidra till den svenska gröna energimixen.

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Definitions

Bioenergy: A form of renewable energy derived from non-fossil organic matter.

Biomass: Organic matter derived from i.e., plants or animals.

Biofuels: Liquid or gaseous fuels, such as biodiesel and bioethanol, produced derived from biomass.

Common Agricultural Policy (CAP): A common policy formed by European Union with the objectives of providing affordable food for EU citizens and a fair standard of living for farmers.

Direct land use change (**dLUC):** A process when human activities transform land as a direct effect of changed land utilisation.

Energy crop: A crop grown for the purpose to be used for energy production.

Ecological focus areas (EFA): Agricultural land where the main objective is to provide environmental benefits and to improve biodiversity.

Indirect land use change (iLUC): A process when human activities transform land as an indirect effect of changed land utilisation.

Intermediate crops: A crop grown between two main crops.

Fallow land: Arable land which is left without sowing for one or more vegetative cycles to allow the land to recover and store organic matter.

Feedstock: Agricultural raw material supplied to a machine or processing plant.

Underutilised land: Land which has potential to be used for agricultural purposes, which is left out of production for whole or parts of the year.

1. Introduction

The harmful environmental impact of fossil fuels, paired with rising energy and fuel prices, has increased the demand for renewable energy sources (Mandley et al., 2022). Bioenergy plays a significant role in phasing out fossil fuels within a limited time frame, as biofuels and other forms of bioenergy can be used with the current infrastructure (Khan et al., 2021).

In Sweden bioenergy is the largest renewable energy source, mainly used for heating, energy production, industrial processes, and transportation (Energimyndigheten, 2021 a). The demand for bioenergy sources has increased steadily over the past decades, yet Sweden heavily relies on imported biofuels to meet the ever-growing demand (ibid). In the future, bioenergy is expected to play a critical role in meeting environmental targets to phase out fossil fuels, which calls for increased domestic energy production (Energimyndigheten, 2021 b).

Most biomass produced for bioenergy in Sweden derives from the forestry sector (Börjesson et al., 2017). However, there are ecological and economic limitations to how much biomass forestry can provide for energy purposes. Therefore, we cannot rely on forestry alone to meet the increasing demands for biomass (Bryngemark, 2020). The agricultural sector can play a significant role in meeting the increased demand for domestic energy production (Börjesson, 2021). Agricultural biomass derived from plants comes from natural biomass, energy crops, or agricultural residues (Roberts et al., 2015), as illustrated in figure 1.

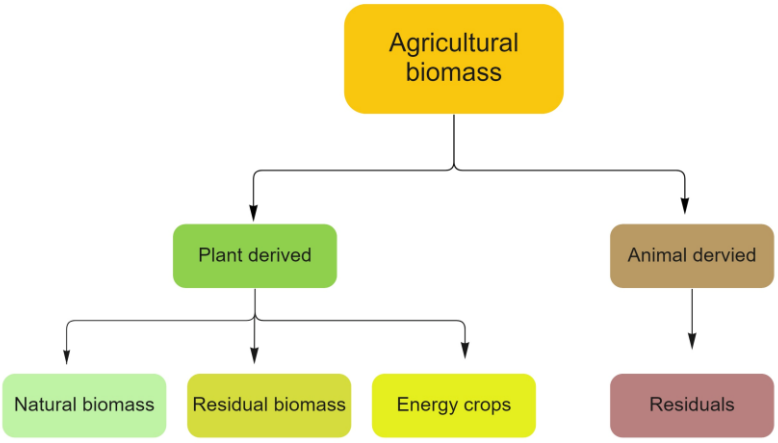

Figure 1. Agricultural biomass
Classification of agricultural biomass according to its origin.

The first-generation biofuels, which derives from crops rich in starch and oil, often compete with food production (Khan, 2021). The increased demand for energy crops, and in extension agricultural land, may cause changes in how land is used a process called direct land use change (dLUC), for example afforestation (Fritsche et al., 2010). Furthermore, it may compete with food crop production on existing agricultural land, which may cause indirect land use change (iLUC), where land is turned into agricultural land to meet the demands of the outcompeted food crops (ibid). The process of changing land use has environmental impacts both on biodiversity (Donnison et al., 2021) and on the climate, as this process may cause a release of CO_2 if areas high in carbon stock, such as forests, wetlands, and peatlands, are transformed (Don et al., 2012). Therefore, the European Union aims to reduce the usage of high iLUC-risk energy crops produced in the EU in line with the Commission delegated regulation (EU) 2019/807 (European Commission, 2019). To be sustainably compatible with food production, agricultural biomass used for energy purposes, used as feedstock, must therefore be produced with production methods which do compete with food or feed production.

An alternative to using food crops is using other cellulosic biomass, such as perennial grasses, wood, and plant residuals, to produce the second-generation of biofuels (Khan, 2021). Several studies have found that agricultural feedstock can play a significant role in meeting bioenergy demands by 2030 by producing these types of feedstock using low iLUC-risk production methods (Ahlgren et al., 2017; Prade et al., 2017; Börjesson 2021). One iLUC-risk production method is utilising agricultural residuals, e.g., straw, ensilage, and excess grass, that are not used for other purposes such as animal bedding and animal feed (Ahlgren et al., 2017). Another production method is growing additional crops, such as intermediate crops, on arable land which when it is not cultivated, or harvesting biomass from agricultural lands which are primarily used to provide ecological values, so-called Ecological focus areas (EFA) (ibid).

A third way to produce agricultural feedstock without causing iLUC is by extensively producing feedstock, such as grass, on underutilised lands. Due to their marginal profitability, these lands are often referred to as 'marginal land' (ibid).

Finally, the authors suggest that biomass can be produced through intensifying production, mainly for extensive grass production, and thus not competing for additional land.

Based on previous literature, this study identifies four categories of low iLUC-risk production methods (P1-P4):

Agricultural residuals (P1)
Additional feedstock from arable land (P2)
Feedstock from underutilized land (P3)
Intensified production (P4)

Ahlgren et al. (2017), Prade et al. (2017) and Börjesson (2021) have estimated how these production methods can contribute to meeting the future of agricultural bioenergy. There is, however, little understanding of what would motivate farmers to adopt these practices. Previous research on farmers' attitudes toward bioenergy production has commonly focused on specific types of energy crops, such as energy wood (Hannerz & Bohlin, 2012; Paulrud et al., 2010; Fütner et al., 2022) or farmers' attitudes towards adopting new farming practices (Ranacher et al., 2021). These studies have identified amongst other things profitability, unreliable policies, and relation to the land as factors affecting farmers' willingness to grow specific energy crops. However, there is a need to investigate how these factors apply to the willingness to produce feedstock for bioenergy in a more general sense.

This study aims to fill the gaps left by previous literature by bringing in the farmers view on low iLUC-risk production methods through semi-structured interviews and online surveys with Scanian farmers. The study investigates farmers willingness to grow feedstock for bioenergy purposes by identifying motivational factors for producing feedstock for bioenergy, and what production method farmers see greater potential in. Learning more about what opportunities and barriers farmers see in producing low iLUC-risk feedstock is crucial to understanding how the agricultural sector can contribute to sustainable bioenergy production. The knowledge brought forward in this thesis can assist in planning for a sustainable expansion of domestic bioenergy production from agricultural land in Sweden.

Purpose and scope of study

This study aims to explore farmers' willingness to sustainably produce feedstock for energy purposes. Farmers' willingness to produce feedstock for energy purposes is explored by identifying motivational factors for farmers to adopt low iLUC-risk production methods.
In this study, sustainable feedstock production is identified as production methods that are considered not to compete with food production or drive land use change. The study focuses on farmers who have active crop cultivation in Scania, the most arable part of Sweden, where farmland makes up almost half of the region (SCB, 2019). Scania is one of the regions with most farmers in Sweden (Jordbruksverket, 2020) which makes it particularly interesting when exploring the potential of agricultural bioenergy.

Understanding which production methods farmers see potential in adopting, and what barriers they experience in producing feedstock for energy purposes, can give a clearer picture of the agricultural sectors' potential to contribute with renewable energy. Furthermore, the knowledge provided in this study may help develop agricultural policies and support measures for farmers.

Research questions

The three research questions which will be researched in this thesis are:

1. What motivates farmers in Scania to start or increase feedstock production for bioenergy?
2. What barriers do farmers in Scania see in starting or increasing feedstock production for bioenergy?
3. Which low iLUC-risk production methods do farmers in Scania see the most potential in utilizing?

2. Theory

This study aims to identify factors that influence farmers' willingness to produce feedstock using low iLUC-risk production methods. These factors will be analysed using a motivation and action model (Heckhausen & Heckhausen, 2018), which assumes that people's motivation to pursue a goal depends on situational factors and personal preferences seen in table 1. Factors related to the farmers' values and habits are considered as personal factors, whereas policy frameworks, support systems, market situations and legal regulations are considered as situational factors.

Table 1 Personal and situational factors
An overview of personal and situational factors affecting a person's motivation to pursue a goal, according to the Motivation and Action model (Heckhausen and Heckhausen, 2018).

Factors	
Personal factors	Behavioural tendencies, needs, personalities, habits, self-images, objectives, emotional preferences, attitudes, values.
Situational factors	Opportunities, stimuli related to positive or negative outcomes of certain situations, institutional framework and legal setting, infrastructure, market situation

3. Method

3.1 Study design

This study has adopted a qualitative and a quantitative methodology to explore farmers' willingness to produce feedstock for bioenergy. Firstly, the research questions were approached qualitatively through semi-structured interviews conducted with eight farmers in Scania. Semi-structured interviews are commonly used to understand the world from the interviewee's point of view, where themes can be researched with the possibility of following up answers with further questions (Kvale & Brinkman, 2014). Eight interviews were considered a suitable number for the scope of this study to gain a variation in the previously mentioned factors (Francis et al., 2010). The farmers were selected strategically to vary in cultivation type, farm size, and geographical spread, and were found mainly through websites of Scanian farming businesses and farming organisations.

The eight interviews ranged from 30 to 60 minutes and were carried out over phone and videocall. All interviews followed an interview guide, attached in Appendix A, which was developed based on literature in the field and tested on two researchers within agricultural bioenergy production. The questions in the guide explored the farmers willingness to produce feedstock using low-iLUC risk feed production (P1-P4), and what opportunities and barriers they experience in starting or increasing feedstock production.

The interviews were recorded and transcribed with help of Microsoft Words online transcribing software. The transcriptions analysed with the software NVIVO R2018 (QRS International, Netherlands) which allows a structured analysis of qualitative data by sorting the transcriptions according to research topics. All transcriptions were analysed individually, where common topics were identified, and categorised according to whether they were motivational factors or barriers. These factors where then categorised according to weather they were personal or situational factors. Quotes presented in the results are referred to as Sayings (S), which are included in their original language (Swedish) in Appendix.

Next, a quantitative approach was undertaken to indicate how the themes from the interviews could be generalised, complementing the qualitative interviews as it can reach a larger group with the limited time frame (Trost & Hultåker, 2016) Based on the interview-guide and additional knowledge gained through the interviews, a survey was developed using the survey software Survey&Report (Artisan Global

Media, Sweden). The survey, presented in Appendix B, was made up with closed ended questions, which in this study are referred to as Questions (Q), often the possibility to comment, which are referred to as Comments (C). The survey was tested on three researchers working with agriculture and bioenergy, and then sent via e-mail to 1672 farmers in Scania through e-mail addresses gathered from a database of farmers who have applied for financial support (gårdsstöd) 2021 provided by Jordbruksverket. The farmers were selected to have a geographical spread, which was done by arranging all farmers contact information according to their postal number and drawing every third e-mail address. Five days after the first e-mail, a reminder was sent out to the farmers. The survey was open for one week, in which 174 persons responded, giving a 10,4 response-rate. These responses were analysed in Microsoft Excel R2013 (Office 365, USA), where the answer rates for each question was calculated.

3.2 Methodological considerations

When conducting an interview there is a risk that the interviewee is affected by the presence of the interviewer, i.e., through adjusting his or hers answers according to what is perceived as a good answer (Kvale & Brinkman, 2014). As the purpose of this study is to identify motivational factors and barriers rather than weighing these factors against one another, this is considered to have a limited impact on the study.

For the quantitative data, considerations are taken to how the survey-answers can be generalised amongst Scanian farmers. The contact information used to reach farmers included people leasing out their farmland and farmers whose main direction is other than crop cultivation, and it can therefore not be excluded that people who are not considered to be active farmers, answered the survey, despite being informed that the survey was directed to farmers who had active crop production. Further, with a response rate of ten percent, there is a built-in bias where some opinions amongst farmers are more prone to answer an online survey, e.g., for technical or topical interests, will be overrepresented. This could be improved by further contacting farmers who did not fill out the survey in a drop-out analysis (Torts & Hultåker b, 2019). This was not done due to the time frame of this study. The survey is therefore analysed to bring additional knowledge to the interviews, rather than attempting to generalise the opinions of all farmers in Scania.

3.3 Ethical considerations

Ethical considerations were made in several steps of this study. Firstly, all interviewees and survey respondents have been informed about the purpose of the study, and have given their consent for the data to be used in the scope of this study in which their participation is kept anonymous. The contact information, recordings and transcriptions has been handled according to GDPR-regulations at Lund University.

Secondly, when analysing qualitative data, there is a risk of bias representing the farmers through the ways the data is selected and presented (Kvale & Brinkman, 2014). To minimise the risk of applying personal values to the analysis, all interviews were transcribed and analysed individually and thematically. The themes brought up in the results are selected as they either are prominent, or in other ways reflect important aspects of the farmers views.

Finally, the impact of the study is considered as it brings forward knowledge which could contribute to insights for policymaking and decision-making. The opinions of farmers brought forward in this study are not necessarily what would be most economically, ecologically, or socially motivated in policymaking, however, the knowledge can contribute to forming more inclusive policies.

4. Results

4.1 Qualitative results

4.1.1 Sociodemographic

All interviewed farmers were men between 30-70 years old, with varying crop cultivation systems and sizes of farms in Scania. None of the farmers were selling feedstock for bioenergy purposes, however, two of them used feedstock to generate heat and electricity on their farm, and one was planning on starting bioenergy production.

Table 2 Characteristics of farmer
Description of interviewed farmers (N=8) and characteristics of their farms.

Farmer number	Gender	Age	Farmland for crop cultivation (ha)	Cultivation form
1	Man	60-70	30	Conventional
2	Man	50-60	45	Conventional
3	Man	60-70	78	Organic
4	Man	40-50	190	Conventional
5	Man	30-40	300	Conventional
6	Man	40-50	440	Conservation agriculture
7	Man	30-40	550	Conventional
8	Man	50-60	11000	Conventional

4.1.2 Motivational factors and barriers

Both personal and situational factors related to farmers willingness to grow feedstock for bioenergy were identified amongst the eight interviewed farmers. The most prominent topics amongst the interviewed farmers related to energy security, competition with food and feed, availability of tools and know-how, profitability and policies. Table 3 summarised the motivational factors divided into opportunities or barriers. The factors are categorised as personal factors such as values, habits and needs, or situational factors such as market situations, institutional frameworks and legal settings, and infrastructures. Each factor is followed by a reference number, which refers to the descriptions of the factors found in 4.1.2 and 4.1.3.

Table 3 Motivational factors and barriers
An overview of motivational factors affecting farmers' willingness to produce low iLUC-risk feedstock used for bioenergy categorised as personal and situational factors, and divided into opportunities and barriers. Each factor is followed by a reference number referring to an explanation found in 4.1.2-4.1.3.

	Factors	***Opportunities***	***Barriers***
Personal factors	Values	- Utilising or contributing with renewable energy (3) - Positive ecological consequences (22)	- Insignificant energy contribution (2) - Competition with food and feed (4) - Negative ecological consequences (21)
	Habits	-Low maintenance (12)	- Lack of knowledge and experience (6) - Limitations in cultivation systems (19)
	Needs	- Utilising by-products (14) - Better use of underutilized land (16)	- Costly investments of time and resources (9) - Lack of machinery and facilities (23)
Situational factors	Market situation	- Profitable opportunity (8)	- Lack of interest and demand (10) - Too low profitability (11)
	Institutional framework and legal setting	- Financial support for certain purposes (15)	- Bureaucracy (7) - Unreliable framework and financial support (13) - Regulations (20)
	Infrastructure	- Decentralised infrastructure (18)	- Lack of technical utilisation (5) - Lack of infrastructure (17)
	Environment	- Contribution to domestic energy system (1)	- Negative physical impact (24)

Energy security in a fossil free society

On a larger scale, several farmers were motivated to produce feedstock for bioenergy to contribute to a domestic energy mix for a more self-sustaining country(1). When asked what the major motivations to start producing biomass for bioenergy Farmer 6 was motivated by contributing to energy security in Sweden:

"The biggest advantage is that we actually increase preparedness in Sweden if you look at it from a larger perspective. Here we have […] an energy buffer in the field, which can be used when needed. If there is no need, we will improve the soil quality, so [there] are only benefits." (S1)

Several farmers also saw geopolitical conflicts as a motivation to contribute to domestic energy production. Farmer 4 commented on political conflicts in Europe at the time of the study, as a driver to improve the domestic production of both food and energy:

"I see it as we have the potential to produce both food and energy in Swedish agriculture. It would be a shame not to use that potential. A lot has happened in the world in the last month, and we see that there is a demand, and it also strengthens our country if we can produce the food and energy ourselves. So I think it's right in time." (S2)

However, there were conflicting views of the agricultural sectors' potential to produce feedstock for energy purposes. Whereas some of the farmers saw great potential in using low iLUC-risk production ways to produce more feedstock, other farmers saw the agricultural sector's potential as insignificant compared to other energy sources e.g., of the forestry sector(2). This opinion was especially prominent amongst farmers who had forest on their land.

Food and feed first

Although most farmers considered bioenergy as a necessity to lessen their own, and the country's, dependency on fossil fuels(3), increasing the bioenergy production was less prioritised than food-and feed production(4). When given the alternative to use land and biomass for food, feed or bioenergy production, under the conditions that the profit would be the same, all farmers asked agreed that they would prioritise food and feed over selling feedstock for bioenergy. Farmer 8 motivates that producing food and feed could be seen as more 'correct' than producing feedstock for bioenergy.

"If you were to be paid as much for food as bioenergy, there might be a slight tendency to fall on the food side because one might think that it is the more correct to produce food right now. We can produce energy from other areas, but we only have agriculture to produce food." (S3)

Know-how and tools

Although most farmers were more open to producing crops they already had the tools and knowhow for, several farmers were interested in trying new crops and production techniques, as long as it was profitable and/or did not have any adverse environmental impacts. Several farmers were well-read in to new production methods for bioenergy, some of which had already been involved or considered starting feedstock production. They commented that Sweden had yet to learn from technical advances in e.g., Germany and Denmark. Barriers seen in implementing new energy crops, such as intermediate crops, were the availability of tools, technical advances to utilise the feedstock (5), and experience in cultivating the crop(6). When asked where they would look for information and guidance to start cultivating a new crop or land, most farmers would turn to existing advising organisations for information about new crops and production systems. Still, some farmers saw the need for governmental agencies to act more advising rather than monitoring(7).

Profitability is key

The most prominent opinion amongst the farmers was that profitability was the most important part of the equation, both as a motivational factor and a barrier. Utilising feedstock for bioenergy purposes could be a good investment if it e.g., could be utilised on-site, or sold without increasing production costs(8). Farmer 5 had recently invested in a facility for heating and electricity production to lower their cost for energy, and as an investment for the future:

"There are two things you can make money of today, and it will last for a long time to come. That is to produce electricity and get carbon rights, which you get from a boiler for charcoal. All companies want to get climate-zero in footprint, and then it's just a question of how you as a farmer can profit from these things. So, in the end, it all comes down to that you, in a company, have to make money on what you do."(S4)

However, several farmers brought up the large investments needed to utilise energy on their farms, such as facilities and machinery, as a barrier to cultivating new energy crops(9). Furthermore, many farmers saw it as a high risk due to a lack of interest in buying energy crops and residuals(10), and too low selling prices(11). Most farmers agreed that more profitability would be the most considerable motivation to start production or increase feedstock production for bioenergy. Subsidies were generally welcome to support these investments, such as a boiler, or for supporting farming of new types of crops and farming systems(12). However, it was often brought up in a negative context, and most farmers wanted to be less dependent on subsidies. A higher demand from the market was seen as a better alternative to subsidies, which were seen as bureaucratic(7) and unreliable(13). Farmer 4 framed it as:

"I am personally against all this support really. Pay us for what we produce instead, so we can stop with this charity. It will be more sustainable companies if we get the right profit for our thing." (S5)

4.1.3 Low iLUC-risk production methods

The factors above applied to P1-P4 in general, however, there were factors which were more prominent for some production methods than others.

4.1.3.4 Agricultural residuals (P1)

Although the farmers, in general, were positive towards utilising residuals, the access to plant residuals varied depending on farm size and type of production. Two farmers used plant residuals for their own energy production, motivated to decrease their dependency on fossil fuels(3) and use underutilised residuals(14). However, no one sold their residuals for energy production. Instead, in several cases, the residuals were used on the farm or sold as animal feed(4). One farmer commented that he might not have any use for the straw, when the neighbouring farmer, who now bought it as feed, would retire. This could potentially open up the usage of the residuals for energy.

Barriers brought up for selling residuals were lack of demand(10) and low selling prices(11), whereas barriers for energy production on-site primarily related to the large investments needed for facilities(9).

4.1.3.5 Additional feedstock from arable land (P2)

Several farmers were open to harvesting biomass in EFAs, which could be used as feedstock, given that they were exempted from current regulations, which generally prohibit harvests on these lands. Not all areas, however, could be used for bioenergy production. Some farmers saw barriers in harvesting vegetation, which they rather keep for ecological benefits. Several farmers pointed out that they would rather integrate feedstock production for energy purposes into the current crop rotation(16). With soil-improving crops, the farmers meant that this type of cultivation could increase feedstock yield in the future and would therefore not compete with food production.

One of the crops seen with the most potential on productive land was cultivating intermediate crops. The major benefits brought up were that they could make a profit(8) from using low-maintenance energy crops(15) while making use of underutilised land(16), to grow and utilise biomass which would otherwise be left on the field(14). Although some commented that the organic material was needed to improve the soil, several farmers saw the fertiliser that they got back from biogas facilities as equally beneficial, or even better as it could be portioned out according to needs(14). Farmer 3, who has an organic farm, saw this as the largest motivational factor for producing feedstock for bioenergy, as he needed fertilisers approved for organic farming.

A barrier that several farmers mentioned was that the interest from biogas facilities to take in intermediate crops was limited if the was a long distance between the farms and biogas facilities(17). Many of the farmers wanted a more decentralised and flexible biogas facility structure ie., as cooperation between farmers, to shorten

the distance to the facilities(18). There were also practical issues with growing and harvesting intermediate crops, such as hindering ploughing the land during the fall for improved sowing conditions and adverse effects on the soil quality when harvesting the biomass during certain weather conditions(19). Farmer 5, who currently left his intermediate crops in the field, found flexibility to be critical if intermediate crops were to be used for bioenergy(16):

"When you sow intermediate crops, you can basically use it in three different ways; either you can have animals graze it down if there is a lack of feed, or you harvest it for animals. The alternative is biogas if it is suitable, but if it is a wet autumn and you don't want to drive in the fields, you can let it be, and rot in the field to improve the soil and build up mulch in the field […] With the right choice, there is no down side really to any alternative. But it is important to find a recipient who is just as flexible."(S6)

Feedstock production on underutilized land (P3)

Although many of the farmers had included their most unproductive land in their fallow land, they were open to using parts of the fallow land for growing energy crops, such as energy wood or extensive grass production, if they were exempted from current regulations prohibiting harvest on these lands(20). The farmers, however, saw little potential in using marginal lands such as field edges and small and irregular lands, as these were costly to harvest(9) and often served a purpose for ecological benefits(21). Farmer 5, however, pointed out that shrubs grown for bioenergy purposes could favour game, benefiting both environmental values and hunting(22). One of the major barriers to cultivating energy crops on underutilized land was that the land was often unproductive and suited for other crops than the farmers currently cultivated, which thus calls for other machinery(23). Another barrier was that these perennials could harm the soil structure(24) and that there was a long rotation time compared with annual crops(19).

Intensifying production (P4)

When asked if the farmer would consider intensifying their current production, most farmers experienced that they produced the maximum capacity within their economic and ecological limits. The farmers brought up that an intensified production would either negatively impact the soil or crop(24), be too costly as they had to use more fertilizer(9) or have adverse effects on the environment and ecosystems(21).

4.2 Quantitative results

4.2.1 Sociodemographic

The 174 respondents who filled out the online survey varied from under 25 to over 80 years old with various sizes of farmland in all Scanian municipalities except Bromölla, Landskrona and Malmö. As seen in table 4 describing the characteristics of the farms, most respondents were men (87%), and conventional farming was the most common type of farm. Out of the 174 farmers, 17 were currently producing feedstock for bioenergy purposes, the majority using straw residuals and energy wood, which two-thirds sold for energy production, and almost half used for onsite for heating and/or electricity, some doing both (figure 1 in Appendix D).

Table 4 Farmer characteristics
Description of respondents in the online survey (N=174) and farm characteristics. (Q1-Q2 & Q31-Q33)

Age		Gender		Size of farm		Type of farm	
<25	1%	Men	87%	<5	16%	Conventional	77%
25-30	11%	Women	11%	5-10	17%	Organic	6%
30-40	16 %	Unknown	2%	10-20	20%	Conventional and organic	11%
40-50	28%			20-50	23%	Other	9%
50-60	28%			50-100	38%		
60-70	32%			100-300	17%		
70-80	9%			300–500	5%		
>80	1%			500–1000	3%		
Unknown	2%			>1000	1%		

4.2.2 Motivational factors and barriers

When the farmers (N=174) were asked to choose up to three out of ten beneficial factors they saw as with producing feedstock for bioenergy, the most chosen factors were; 1) that it contributes with energy to society, making out 21 percent of the answers, 2) that they could produce heat and electricity on their farm (14%), and 3) that the feedstock could be sold for a good price (14%) (table 1 in Appendix D). These opinions aligned with the 17 farmers who were currently producing feedstock for bioenergy (table 2 in Appendix D).

Self-sufficiency and profitability were also the most prominent barriers when the farmers were asked to choose up to three factors which they saw as the major barriers for starting or increasing biomass production for bioenergy (table 3 in Appendix D). Almost half of the 174 farmers agreed that energy crop production would compete with other types of crop production, making out 21 percent of the answers. In the free comment section one farmer had written:

"Food production must be a priority, as hungry people in a small country without self-sufficiency become dangerous in the long run. Energy becomes secondary."(C1).

Almost as common were the opinions that profitability is too low (19%) and that harvesting biomass for bioenergy would remove nutrition from the soil (13%). One of the farmer commenting on the soil fertility wrote:

'On agricultural land we need to produce food, long term it most sustainable with animal products, the fertility on the land must be developed and provide added value"(C2).

Market prices were seen to be more reliable than subsidises. When the farmers were asked what would motivate them to produce more feedstock for bioenergy (table 4 in Appendix C), increasing the market prices was chosen by most farmers making out 31% of the answers, followed by more long-term financial support and a higher demand for bioenergy, both making out 13%.

Potential of increasing energy production

When the farmers (N=174) were asked if they would consider starting or increasing their feedstock production in ways that did not compete with current production, a majority of the farmers (53%) answered that they would consider it, while 21% percent would not consider it. Almost half of the farmers (44%), would, however, only be willing to increase their production under other circumstances (figure 2).

Out of these 76 farmers 87 percent would consider doing it if the market prices for feedstock was higher, while 38 percent would consider it with more long-term financial support and subsidises (figure 3).

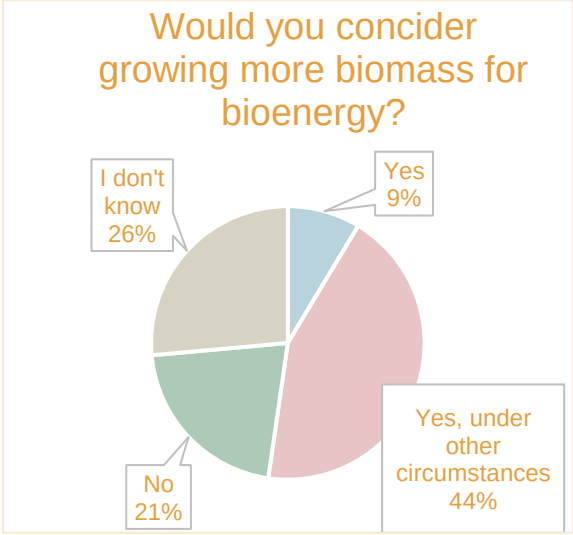

Figure 2 Increasing production
Percentage of farmers (N=174) willing to increase production of energy crops or residuals for bioenergy purposes, given that it does not compete with current production. (Q10)

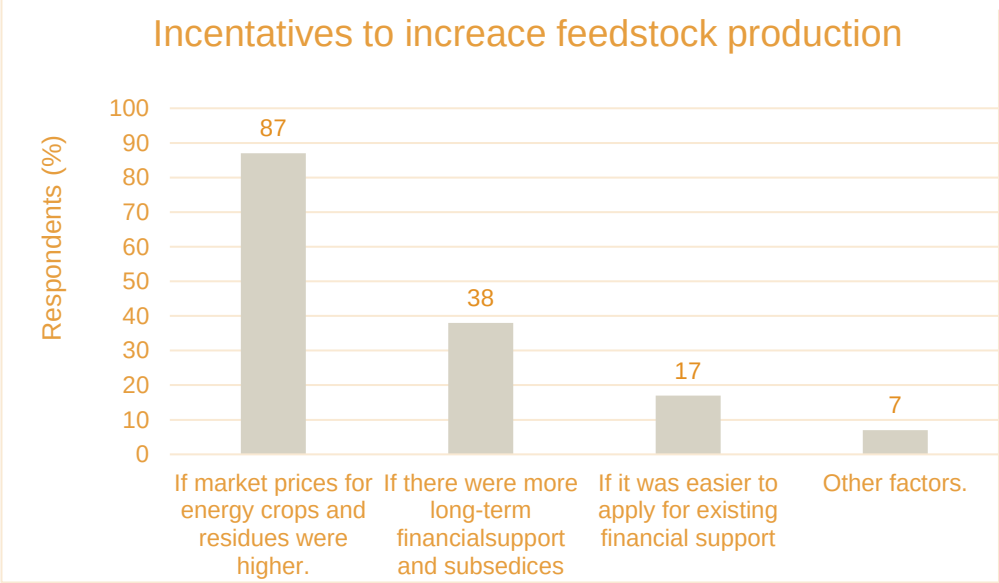

Figure 3 Conditions for increased production
Conditions under which farmers (N=76) would increase their biomass production for bioenergy, arranged according to most agreed-on factor, to least agreed on. (Q11)

The farmers who would not consider increasing their feedstock production for bioenergy purposes motivated this in comments which are categorised into four themes; competition with feed and food (1); low profitability (2); limited space for additional production (3); and negative environmental consequences, mainly for soil quality (4) as seen in table 6.

Table 6 Barriers for bioenergy production
A selection of comments from farmers who would not consider producing feedstock for bioenergy, when asked why they would not consider this. (Q12)

Barriers	**Comments (C3-C10)**
Competition with feed and food (1)	*"I need all my farm for cultivating animal feed and grazing for my meat animals" (C3)* *"We must provide Sweden with food" (C4)*
Low profitability (2)	*"It is almost impossible to get it harvested today. No one can or thinks it is profitable anymore. Very sad!" (C5)* *"The energy forest I have has been a very bad business" (C6)*
Limited space for additional production (3)	*"The small area is needed for producing only fruit to achieve profitability." (C7)* *"Have too small area, cultivate food for the pigs" (C8)*
Environmental consequences (4)	*"The added value is too low for the energy you get, animal products provide more for food and for sustainability such as biodiversity and coal storage". (C9)* *"It is madness to take energy away from land, when energy can be extracted more efficiently with nuclear power plants."(C10)*

4.2.2 Low iLUC-risk production ways

The 137 farmers who had answered that they would consider growing more biomass for bioenergy, or that they did not know, were asked further about their potential in producing biomass in low iLUC-risk production ways (P1-P4) as presented in 4.2.2.

Agriculture residuals (P1)

The most common plant-derived residuals amongst the farmers (N=137) was straw residuals (55%), followed by haulm (19%). Although more than half of the farmers got straw, only 36 percent would consider using it for bioenergy production (table 5 in Appendix D). The major barriers brought up, presented in table 7, were that 1) the farmer could not afford to produce bioenergy on their farm, making out 23 percent of the options, 2) that it was not profitable enough (22%), and 3) a lack of interest to buy residuals (15%).

Table 7 Barriers for using residuals

Barriers for producing residuals arrange according to factors which most farmers (N=137) agreed with when asked to choose up to three barriers for using residuals for bioenergy production. (Q24)

Barriers for using residuals for bioenergy	**Number of persons answering yes**	**Percentage yes out of available options** (%)
I cannot finance a facility to produce bioenergy on my farm	56	23
It is not profitable enough	53	22
There is not big enough of an interest to buy residuals	36	15
I don't have enough storage space to store residuals	34	14
I am already using the residuals for other purposes (e.g., feed)	30	12
Other	18	7
I don't see any barriers	16	7

Additional feedstock from arable land (P2)

Intermediate crops

The majority of the 137 farmers were positive to harvesting intermediate crops for bioenergy, however, most farmers (58%) would only do so under other circumstances (figure 4).

When these 80 farmers were asked to choose up to three factors which would motivate them to grow intermediate crops (table 6 in Appendix C), the factors mostly chosen were that they 1) wanted to get better paid for intermediate crops, making out 33 percent of the options, 2) an increased interest in purchasing the crops (18%), 3) and more financial support (11%).

Other circumstances mentioned in the optional comments were if the yield could be increased by using fertilizer.

One respondent commented on the investments needed and timing as barriers to growing intermediate crops:

"Two major problems with the intermediate crops are the cost of seed, time and diesel, but also for buying machines to establish in a fast and smooth way. It is usually a bussy times with harvest when the middle crop is to be established and then we are more than fully occupied "(C11)

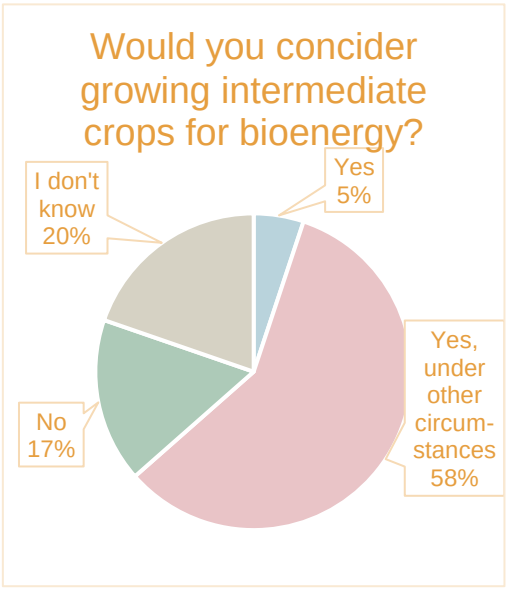

Figure 4 Intermediate crops
Farmers (N=137) willingness to grow intermediate crops for bioenergy purposes. (Q18)

Ecological focus areal

Out of the 137 farmers, 78 had ecological focus areas. When asked what they would harvest on these lands if they were allowed, about half of them would use it for growing and harvesting intermediate crops, and 40 percent would harvest grass that could be sown into the main crop (figure 5).

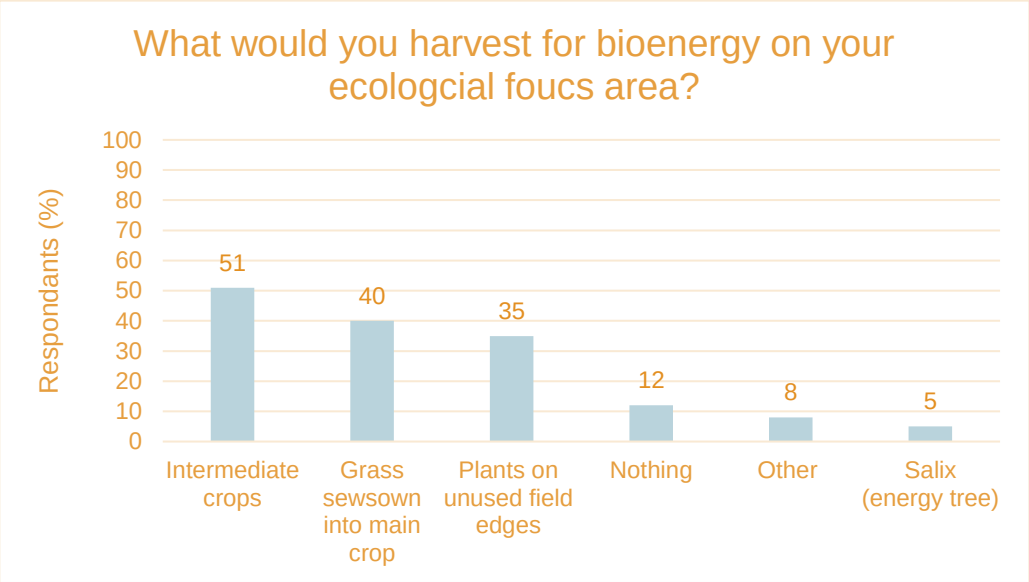

Figure 5. Ecological focus areas
Different types of biomasses that farmers (N=78) would be willing to grow for bioenergy purposes on their ecological focus area. (Q15)

A barrier brought up in the free text comments was that harvesting the biomass on these lands could risk a good soil quality. One farmer for example wrote:

"I want to keep what grows in the field, or get back other biomaterial. Fertility is crucial and soil content is an important factor. That's why I don't really want to grow for energy in that way. Or we have to find crops that build massive amounts of roots, and then we harvest above-ground and the roots remain and increase fertility."(C12)

Feedstock production on underutilized land (P3)

Twenty-two of the 137 farmers had additional types of underutilized land, of which 17 would consider using the land for bioenergy purposes. Nearly all of them would consider using uncultivated unproductive land, and almost as common was using uncultivated productive land and follow land (figure 6).

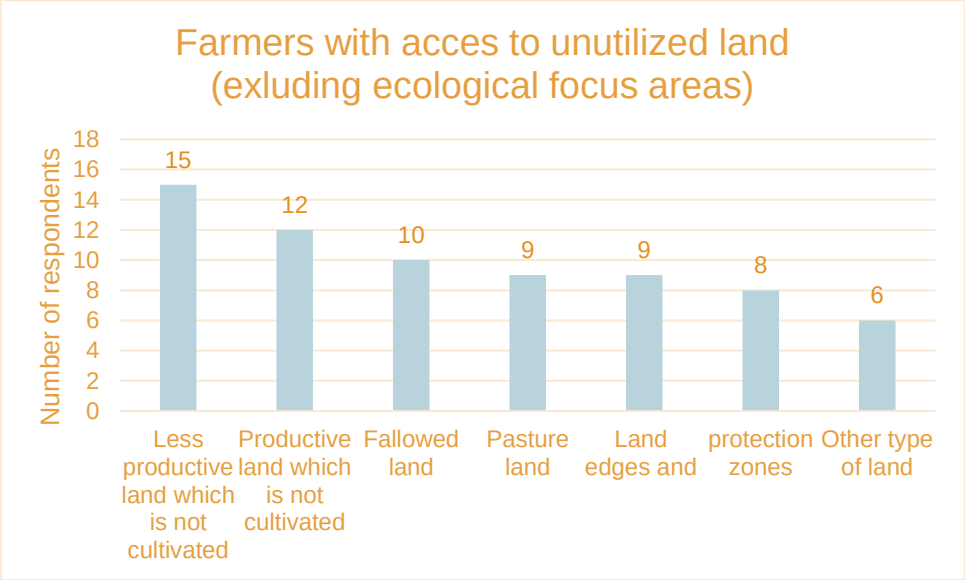

Figure 6. Underutilized lands

Types of underutilised lands (excluding ecological focus areas) which farmers (N=17) would consider using for bioenergy production. Arranged from most common land type to least common land type. (Q21)

When asked which crops, they would consider growing on the unutilized land the most common crop was using grass, cereals, or energy grass (figure 2 in appendix C). Other options mentioned as comments were grass on grassland or main crops used for food productions. While some motivated that the crop should be "profitable", other farmers laid more weight in providing flowers to benefit biodiversity. One of the major barriers brough up was that cultivating these lands would be too costly. One farmer wrote that these lands would be:

"Too small and often poor area to spend time sowing and harvesting something there, the fallowed lands are often in fallow for that very reason. The field edges are too cumbersome and expensive to sow and cultivate."(C13)

Intensified production (P4)

When asked if the farmers (N=137) would consider growing more biomass for bioenergy purposes 43% would consider growing more intensely (figure 7). Out of these 59 farmers, most would consider intensifying their production of cereals (70%) and grass (51%) (table 3 in Appendix C).

The 23 percent who would not consider growing more motivated this in the comments mainly related to three barriers; increased costs due to fertilizers and fuels (1); ecological consequences (2); limitations in soil conditions (3) (table 8).

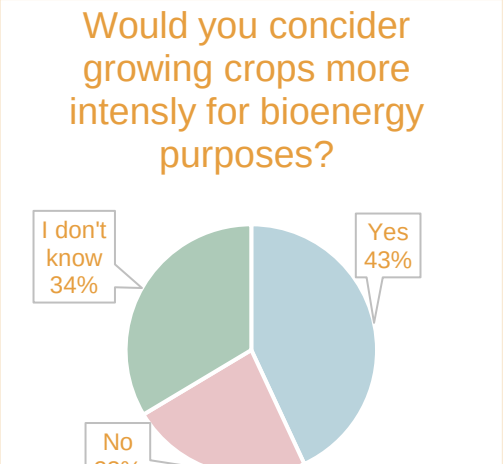

Figure 7 Intensified production
Farmers (N=137) willingness to grow intermediate crops for bioenergy purposes. (Q18)

Table 8 Intensified production
Comments written by farmers (N=23) when asked why they would not consider intensifying their production. (Q27)

Barriers	Comments (C21-C26)
Increased costs (1)	*"The input costs today are too high, i.e., fertilizer and diesel" (C14)* *"It is difficult to grow more intensively than is already being done. Especially with the prevailing external situation and shortage/costly inputs"(C15)*
Environmental consequences (2)	*"Catastrophe for the environment and poorer quality of straw hay sustainability"(C16)* *"Intensive cultivation rhymes poorly with organic farming, and can lead to increased energy consumption / ha, which takes advantage of more"(C17)*
Limitations in soil conditions (3)	*"The fields are too small and in poor condition"(C18)* *"I grow as intensively as I can (at the moment) already. Of course I try to improve my cultivation continuously, but it is mostly increased fertility that can give a higher harvest now"(C19)*

One farmer summarizes the themes with:
"More intensive would require machine investments and possibly effect the environment more. The areas I have are well suited for extensive grazing and forage"(C20).

5. Discussion

Understanding what motivates farmers to produce feedstock for bioenergy in low iLUC-risk production ways, is essential to assess how the agricultural sector can contribute to renewable energy production without harming the environment or competing with food security, as well as to develop policies supporting bioeconomy. This study has identified both personal factors such as values, habits, and needs, and situational factors, namely market situations, institutional frameworks, infrastructures, and environmental effects to influence farmers' motivation to produce feedstock for bioenergy with low iLUC-risk production methods.

The knowledge in this study drawn from interviews and surveys with farmers confirms that many of the motivational factors identified in previous studies looking at energy tree production (Hannerz & Bohlin, 2012; Ranacher et al., 2021), applies to farmers' motivation for producing energy crop bioenergy in a more general context.

In line with the study by Hannerz & Bohlin (2012) this study finds that many farmers are motivated to contribute to a more self-sustaining energy production, both on their farms and in Sweden. This study adds to the existing literature by illuminating how the ongoing political conflicts in Europe, affecting the food and energy supply (Benton et al., 2022), increase farmers' willingness to contribute to energy security. Crisis, such as the corona pandemic and the Russian invasion of Ukraine, has exposed the need for a quicker transition to renewable energy systems (Hosseini, S. E., 2022), and it is likely that an increased demand for bioenergy may increase the interest amongst farmers to produce feedstock for bioenergy through using low iLUC-risk production methods. At the same time the European Commission supports Member States "to reduce the blending proportion of biofuels which could lead to a reduction of EU agricultural land used for production of biofuel feedstocks, thus easing pressure on the markets for food and feed commodities", which exposes how food security is prioritised over energy security derived from agricultural land (European Commission, 2022).

That food-and feed production is prioritised over energy production has also been prominent in this study. Similar to findings by Ranacher et al., (2021) many farmers brought up the competition with food as a barrier for agricultural bioenergy production. While this could have been a misreading of the production ways in focus, which were considered to have a low risk of competing with food production, it may also signal that many farmers do not see energy crop production as compatible with food production. This is considered to be one of the major barriers identified amongst personal factors, in line with previous studies finding that farmland gives the most value when used for food (Convery et al., 2012). The

conflicting perceptions amongst farmers of the agricultural sector's role in the future energy system, calls for better understanding to which production system farmers see most potential in.

The low iLUC-risk production ways identified by Ahlgren et al., (2017), Prade et al., (2017) and Börjesson (2021), had varying support amongst the farmers in this study. Out of the four production ways in focus (P1-P4), the greatest potential was seen in utilising agricultural residuals (P1) and using additional feedstock on productive lands (P2), as these ways were considered to compete the least with food production, while better utilising arable and accessible lands with machinery and knowledge the farmers already have.

A common barrier for these production ways was that bioenergy production would remove nutrition from the soil. Bioenergy forms which brings back organic fertilisers, such as biogas, can in this context be seen to have great potential. Several interviewed farmers wanted a decentralised infrastructure with more biogas facilities closer to make shorter transportation and lower costs.

However, feedstock which is most efficient to produce does not necessarily align with the type of biofuel which society has highest demand for (Energimyndigheten, 2021 b), which makes it important to reflect weather subsidies should be prioritised to change the production methods, or the demand from the market. Furthermore, the availability of residuals such as straw and haulm depends on the demand for feed for animals in animal farms in Sweden, both of which have been heavily reduced during the last two decades (Jordbruksverket, 2020), and thus may cause a larger interest amongst farmers to utilise for bioenergy. These findings stresses the importance of the role of both organisations and governmental agencies to be active informants and communicators, to help farmers to adopt production methods which are suitable to their crop rotation and cultivation system.

On productive lands intermediate crops were found to be particularly interesting if it would be more profitable than today. Likewise, many farmers would consider harvesting biomass on EFAs for bioenergy purposes (P2). A prominent barrier to grow additional crops on productive land was that the potential negative effects on biodiversity and other ecosystem services when harvesting the biomass. Several interviewed farmers saw a possibility to integrate energy crop cultivation into their crop rotation, allowing harvest of soil-improving crops which would not compete with food or feed production as it would increase the yield in the coming vegetation periods. However, harvesting biomass from EFAs areas would call for changing policies which currently prohibit harvests on these lands. Due to the increased demand of agricultural products as an effect of the war in Ukraine, the European Commission has for 2022 exempted EFAs from regulations prohibiting harvests on these areas (European Commission, 2022). With the effects of climate change pressing agriculture (ibid) this may be a measure adopted more frequently. Further research can bring valuable knowledge on how this exemption affects biodiversity, and farmers willingness to use these areas for biomass production, and how policies could be formed to balance these factors.

Less potential was seen in utilising other forms of underutilised lands, such as field edges and small patches, for feedstock production for bioenergy (P3). While the survey showed an interest of utilising both productive and unproductive lands better, many farmers both in the interviews and surveys commented on this being unprofitable due to high costs and lacking demand of the feedstock. As Scania provides the most fertile farmlands in Sweden, it can be assumed that it is used efficiently, whereas other parts of Sweden may offer more abandoned farmland.

An increased grass production has in previous literature shown amongst the greatest potential of low iLUC-risk production ways (Ahlgren et al., 2017). Although the survey showed an interest to intensify grass production (P4), an occurring barrier amongst farmers in both interviews and survey responses was that they were already producing at maximum capacity withing their economic or ecological conditions.

In the end, profitability was what decided how the farmers lands were utilised. Economic factors, in most cases, outweighed the personal factors. Profitability both motivated and hindered farmers to start new types of productions, depending on their perceptions of risk and reward. The importance of economic aspects is also seen in previous studies on farmers' willingness to cultivate certain energy crops (Ranacher et al., 2021) and adopt new agricultural systems (Morris et al., 2017).

Interestingly, subsidies were often mentioned in the interviews in a negative context, where it was looked upon as a flawed system rather than a support. Most farmers would rather see an economic system where they could sell their products for better pay and be less dependent on financial support. Subsidises were, however, seen as valuable for financial investments in facilities and new production ways.

How these policies and subsidies are developed to meet farmers' interests is largely influenced by the Common Agricultural Policy (CAP), which is the guiding agricultural policy in the EU (European Commission, n.d). The new CAP23, which will be taken into effect in January 2023, will significantly impact how farmers will receive their subsidies and how bioenergy production from agricultural land is weighted against other values from the agricultural sector, such as food security (ibid). For a susceptible implementation of the CAP reform in Sweden, further research could investigate how policies related to the usage of low iLUC-risk production methods should be formed to be beneficial for both farmers, the society, and the environment. However, equally important is to look further into market solutions, as most farmers would rather rely more on the market. It is therefore essential to highlight the role that other actors play for farmers' willingness to produce feedstock for bioenergy. Governmental agencies, politicians, energy producers and food-and energy consumers all play a role in deciding how agricultural lands will be used in the future.

Conclusion

This study finds that farmers in Scania are generally interested in increasing their feedstock production for bioenergy using low iLUC-risk production methods, as long as it does not compete with food-and-feed production or have negative consequences on the environment. Motivational factors to increase feedstock production involve higher market prices, long-term subsidies, and more flexible infrastructure. The production methods with the most potential were utilising agricultural residuals and growing additional crops on productive lands, such as intermediate crops and harvesting biomass from EFAs. This calls for changed policies and further developed infrastructures. The knowledge of farmers' willingness to increase feedstock production for bioenergy can motivate farmers to increase their low iLUC-risk production of feedstock should be considered when estimating the potential of bioenergy deriving from agriculture and when developing new policies.

Thank you

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References

Ahlgren, S., Björnsson, L., Prade, T., & Lantz, M. (2017). Biodrivmedel och markanvändning i Sverige. *Miljö-och energisystem*, (Report No 105*)* Intuitionen för teknik och samhälle*, LTH,* Lund Universitet, Lund, Sweden.

Benton, T. G., Froggatt, A. and Wellesley, L. (2022). The Ukraine war and threats to food and energy security: Cascading risks from rising prices and supply disruptions, *Research Papers Chatham House*, London: Royal Institute of International Affairs, https://doi.org/10.55317/9781784135225

Bryngemark, E. (2020). Bioenergy versus forest conservation: a partial equilibrium analysis of the Swedish forest raw materials market. *Scandinavian Journal of Forest Research*, *35*(7), pp. 367-382. https://doi.org/10.1080/02827581.2020.1808696

Börjesson, P. (2021). Potential för ökad tillförsel av inhemsk biomassa i en växande svensk bioekonomi–en uppdatering. (Report No 121.) Avdelningen för miljö-och energisystem, Lund University, Lund, Sweden.

Börjesson, P., Hansson, J., & Berndes, G., (2017). Future demand for forest-based biomass for energy purposes in Sweden. *Forest Ecology and Management*, *383(2017)*, pp. 17-26. https://doi.org/10.1016/j.foreco.2016.09.018

Convery, I., Robson, D., Ottitsch, A., & Long, M. (2012). The willingness of farmers to engage with bioenergy and woody biomass production: A regional case study from Cumbria. *Energy Policy*, *40(2012)*, pp. 293-300. https://doi.org/10.1016/j.enpol.2011.10.009

Don, A., Osborne, B., Hastings, A., Skiba, U., Carter, M. S., Drewer, J., Flessa. H., Freibauer A., Hyvönen N., Jones M. B., Langian G. J., Mander Ü., Monti A., Njakou Djomo S., Valentine J., Walter K., Zegada-Lizarazu W., Zenone, T. (2012). Land-use change to bioenergy production in Europe: implications for the greenhouse gas balance and soil carbon. *Gcb Bioenergy*, *4*(4), pp. 372-391. https://doi.org/10.1111/j.1757-1707.2011.01116.x

Donnison, C., Holland, R. A., Harris, Z. M., Eigenbrod, F., & Taylor, G. (2021). Land-use change from food to energy: meta-analysis unravels effects of bioenergy on biodiversity and cultural ecosystem services. *Environmental Research Letters*, *16*(11), 113005. https://doi.org/10.1088/1748-9326/ac22be

Energimyndigheten. (2021) a. Styrmedel för nya biodrivmedel. (ER 2021:22) https://energimyndigheten.a-w2m.se (accessed 2022-05-15)

Energimyndigheten. (2021) b. Scenarier över Sveriges energisystem 2020 (ER 2021:6) https://energimyndigheten.a-w2m.se (accessed 2022-05-15)

European Commission (n.d.) The new common agriculture policy: 2023-27 https://ec.europa.eu (accessed 2022-05-20)

European Commission (2019). Commission Delegated Regulation (EU) 2019/807. *Official Journal of the European Union.*

European Commission. (2022). *Communication from the Commission to the European Council, the Council, the European Economic and Social Committee and the Committee and the Committee of the Regions.* COM(2022) 133 final. Safeguarding food security and reinforcing the resilience of food systems. Brussels, 23.3.2022

Francis, J. J., Johnston, M., Robertson, C., Glidewell, L., Entwistle, V., Eccles, M. P., & Grimshaw, J. M. (2010). What is an adequate sample size? Operationalising data saturation for theory-based interview studies. *Psychology and health*, *25*(10), pp. 1229-1245. doi: 10.1080/08870440903194015

Fritsche, U. R., Sims, R. E., & Monti, A. (2010). Direct and indirect land-use competition issues for energy crops and their sustainable production–an overview. *Biofuels, Bioproducts and Biorefining*, *4*(6), 692-704. https://doi.org/10.1002/bbb.258

Fürtner, D., Perdomo Echenique, E. A., Hörtenhuber, S. J., Schwarzbauer, P., & Hesser, F. (2022). Beyond Monetary Cost-Benefit Analyses: Combining Economic, Environmental and Social Analyses of Short Rotation Coppice Poplar Production in Slovakia. *Forests*, *13*(2), 349. https://doi.org/10.3390/f13020349

Hannerz, M., & Bohlin, F. (2012). Markägares attityder till plantering av poppel, hybridasp och Salix som energigrödor: en enkätundersökning. Institutionen för skogens produkter, Raport nr 20. Sveriges lantbruksuniversitet (SLU).

Heckhausen, J., Heckhausen, H. (2018). Motivation and Action: Introduction and Overview. In: Heckhausen, J., Heckhausen, H. (eds) Motivation and Action. Springer, Cham. https://doi.org/10.1007/978-3-319-65094-4_1

Hosseini, S. E. (2022). Transition away from fossil fuels toward renewables: lessons from Russia-Ukraine crisis. *Future Energy*, *1*(1), pp. 02-05. https://doi.org/10.55670/fpll.fuen.1.1.8

Jordbruksverket. (2020). Lantbrukets djur i Juni 2020 Slutlig statistik.

Jordbruksverket. (2022) Nyheter i jordbruksstödet. https://jordbruksverket.se (accessed 2022-05-15).

Khan, M. A. H., Bonifacio, S., Clowes, J., Foulds, A., Holland, R., Matthews, J. C., ... & Shallcross, D. E. (2021). Investigation of Biofuel as a Potential Renewable Energy Source. *Atmosphere*, *12*(10), 1289. https://doi.org/10.3390/atmos12101289

Kvale, S., & Brinkmann, S. (2014). Den kvalitativa forskningsintervjun (ed.3). Lund: Studentlitteratur.

Mandley, S., Wicke, B., Junginger, H., van Vuuren, D., & Daioglou, V. (2022). Integrated assessment of the role of bioenergy within the EU energy transition targets to 2050. *GCB Bioenergy*, *14*(2), pp. 157-172. https://doi.org/10.1111/gcbb.12908

Morris, W., Henley, A., & Dowell, D. (2017). Farm diversification, entrepreneurship and technology adoption: Analysis of upland farmers in Wales. *Journal of rural studies*, *53*, pp. 132-143. https://doi.org/10.1016/j.jrurstud.2017.05.014

Prade, T., Björnsson, L., Lantz, M., & Ahlgren, S. (2017). Can domestic production of iLUC-free feedstock from arable land supply Sweden's future demand for biofuels?. *Journal of land use science*, *12*(6), 407-441. https://doi.org/10.1080/1747423X.2017.1398280

Paulrud, S., Roennbaeck, M., Gunnarsson, C., & Olsson, J. (2010). Evaluation of salix farmers experiences and attitudes to growing; Utvärdering av salixodlares erfarenheter och attityder till odling. (SP-RAPP-2010-71)

Ranacher, L., Pollakova, B., Schwarzbauer, P., Liebal, S., Weber, N., & Hesser, F. (2021). Farmers' Willingness to Adopt Short Rotation Plantations on Marginal Lands: Qualitative Study About Incentives and Barriers in Slovakia. *BioEnergy Research*, *14*(2), 357-373. https://doi.org/10.1007/s12155-020-10240-6

Roberts, J. J., Cassula, A. M., Prado, P. O., Dias, R. A., & Balestieri, J. A. P. (2015). Assessment of dry residual biomass potential for use as alternative energy source in the party of General Pueyrredón, Argentina. *Renewable and Sustainable Energy Reviews*, *41*, 568-583. https://doi.org/10.1016/j.rser.2014.08.066

SCB (2019). Land use in Sweden. Seventh edition. Statistics Sweden, Regions and Environment Department. SCB-Tryck, Örebro, Sweden. https://www.scb.se (accessed 2022-05-20)

Trost, J. & Hultåker, O. (2016). Enkätboken. (ed.5) Studentlitteratur, Lund, Sweden.

Appendix A – Interview guide

Research topic	Research questions	Interview questions
How informed are farmers on bioenergy production?		
Farmer characteristics	What information about the farmer and the farm	What is your age? Where in Scania is your farmland? How many acres agricultural land do you cultivate? What type of crops do you cultivate? What is your main direction?
Experience with agricultural energy production	What experiences does the farmer have with agricultural bioenergy production?	How familiar are you with how agricultural feedstock can be used for bioenergy? Do you currently produce feedstock for energy purposes? If yes: What type of energy crops/ residuals do you produce for bioenergy use purposes? For how long have you produced crops/residuals used for bioenergy purposes? What motivated you to start growing energy crops?
What is the potential for producing biomass for bioenergy?		
Willingness to start or increase feedstock production for bioenergy purposes	Would the farmer consider starting new or increasing current low iLUC-risk production of feedstock?	Would you be willing to increase/start the production in ways that does not compete with food production? Yes, as it is today. Yes, under other circumstances No, not even with increased profitability
Willingness to increase production through low iLUC-risk production methods	Could the farmer increase feedstock production though using **residuals?**	Would you consider starting/increasing feedstock production using residuals? Yes, as it is today. Yes, under other circumstances No, not even with increased profitability

	Would the farmer increase feedstock production using **additional feedstock derived from arable land?**	Would you consider producing feedstock for bioenergy purposes using productive lands which are not used for food production? I.e., intermediate crops and ecological focus areas? Yes, as it is today. Yes, under other circumstances No, not even with increased profitability
	Would the farmer increase feedstock production using **feedstock from underutilized land?**	Would you consider using underutilized land which could potentially be used for energy crop production? I.e., Abandoned farmland, field edges, turning zones, small and irregular lands, fallow land) Yes, as it is today. Yes, under other circumstances No, not even with increased profitability
	Would the farmer increase feedstock production by **intensifying current production?**	Would you consider increasing current production through intensifying current production? I.e. Grass production Yes, as it is today. Yes, under other circumstances No, not even with increased profitability
Follow up questions for options: Yes, as it is today. Yes, under other circumstances No, not even with increased profitability	What would the farmer grow if increased/new production?	What crop would you produce?
	Under which circumstances would the farmer start/increase low iLUC-risk production methods?	Under which circumstances would you start increase feedstock production? Does it matter if profitability comes from the market prices or subsidies and financial support? What crop would you produce?
	How would farmers increase production indirectly?	Why would you not consider starting or increasing feedstock production?
What motivates/demotivates farmers for biomass production for bioenergy		
What motivates/demotivates an increased production?	What factors would motivate farmers to increase feedstock production for energy purposes?	What benefits do you see with producing biomass? What would motivate you to produce more feedstock for bioenergy (using low iLUC-risk production methods)?

	What obstacles do farmers experience in increasing/new energy crop production?	What obstacles do you see with starting/increasing production for energy purposes (in low iLUC-risk production methods)
Agricultural sector's role in energy production	What is the farmers overall attitude to growing bioenergy deriving from agricultural land?	What role do you think the agricultural sector should play in producing bioenergy?
Round up	Additional thoughts/ questions?	Do you have any additional thoughts/questions on the topic? Do you have any other questions about the study?

Appendix B – Survey questions

Q1 Hur många hektar åkermark har du som används för växtodling?

0-5
5-10
10-20
20-50
50-100
100-300
300-500
500-1000
1000+

Q2 Vilken typ av odling har du?

Ekologisk
Konventionell
Både ekologisk och konventionell
Annat

Q3 Vad odlar du på din mark? Välj alla som stämmer.
Spannmål (Ex. vete, råg, havre, korn och rågvete)
Oljeväxter (Ex. raps, rybs, vitsenap, oljelin)
Trindsäd (Ex. ärtor, bönor och linser)
Rotfrukter (Ex. potatis, sockerbetor, morötter)
Andra grödor för livsmedelsproduktion
Vall & grönfoderväxter
Fleråriga energigräs (Ex. rörflen)
Energiskog (Ex. salix, poppel, hybridasp)
Annat
Om annat, skriv gärna ut vad.

Q4 Vilka faktorer påverkar valet av dina grödor mest? Välj upp till tre faktorer.

Att jag kan sälja grödorna till bra pris
Att grödorna är lätt att odla
Att jag kan utnyttja befintlig maskinpark för att hantera grödorna
Att jag har bra beslutsunderlag för odlingsåtgärder
Att jag bidrar med ekosystemtjänster (ex biologisk mångfald, kvävefixering etc)
Att grödorna passar bra in i växtföljden
Att jag får stöd eller bidrag för att odla grödorna
Att grödorna används till ett visst ändamål (ex livsmedel eller djurfoder)

Annat
Om annat, skriv gärna ut vad.

Info: Så definierar vi bioenergi

Bioenergi definieras här som energi i form av värme, el eller biobränslen som produceras från organiskt material. Från jordbruket kan bioenergi bildas genom att bränna, röta eller förädla växtrester, stallgödsel eller energigrödor. Energigrödor är odlade växter som används för att utvinna energi inklusive energiskog.

Q5 Odlar du energigrödor eller får du restprodukter som används för bioenergiändamål?

Ja
Nej
Jag vet inte

Q6 Om ja: Vilka energigrödor eller restprodukter använder du för bioenergiändamål? Välj alla som stämmer.

Växtrester
Stallgödsel
Spannmål
Oljeväxter
Andra grödor för livsmedelsproduktion
Vall & grönfoderväxter
Energigräs
Energiskog
Annat
Om annat, skriv gärna vad.

Q7 Om ja: Vilken typ av produktion använder du energigrödorna eller restprodukterna för? Välj alla som stämmer.

Jag har egen bioenergiproduktion på gården (ex halmpanna eller värmekraftverk)
Jag säljer grödorna till bioenergiproduktion (ex biogas och biobränslen)
Annat
Om annat, skriv gärna ut vad.

Q8 Om ja: Vad motiverar dig att odla energigrödor eller använda restprodukter för bioenergiändamål? Välj upp till tre alternativ.

Jag kan nyttja det till värme eller el på min gård
Jag kan söka stöd/bidrag
Det kan säljas för bra marknadspris
Det kommer att kunna säljas för bra marknadspris i framtiden
Det bidrar med energi till samhället
Jag kan testa på nya typer av grödor
Jag kan nyttja mina marker mer effektivt
Det passar bra in i växtföljden
Annat
Om annat, skriv gärna ut vad.

Q9 Vilka av följande grödor eller växtrester känner du till att man kan göra bioenergi på?
Växtrester och stallgödsel
Spannmål och andra stärkelserika livsmedelsgrödor
Oljeväxter
Vall & grönfoderväxter
Fleråriga gräs ex. rörflen
Snabbväxande träd ex salix, poppel, hybridasp
Ingen av dem

Q10 Skulle du kunna tänka dig att producera mer* energigrödor eller använda mer restprodukter för bioenergiändamål? * Genom odling som inte konkurrerar med nuvarande produktion.

Ja, med dagens förutsättningar
Ja, men bara om det var mer lönsamt än idag
Nej, jag kan inte tänka mig att producera mer energigrödor, eller använda mer restprodukter för bioenergi
Jag vet inte

Om:
Ja men bara om det var mer lönsamt än idag:

Q11 Under vilka förutsättningar skulle du kunna tänka dig att odla mer energigrödor eller använda mer restprodukter för bioenergi? Välj alla som stämmer.

Om det skulle vara bättre marknadspris på energigrödor och restprodukter
Om det fanns mer långsiktiga stöd och bidrag
Om det var lättare att söka befintliga stöd
Annat

Om annat, skriv gärna ut vad:

Om:
Nej, jag kan inte tänka mig att producera mer energigrödor, eller använda mer restprodukter för bioenergi

Q12 Om nej, varför kan du inte tänka dig att odla/producera mer växtmaterial för bioenergi?

Om:
Ja, med dagens förutsättningar
Ja, men bara om det var mer lönsamt än idag

Q13 För vilka ändamål kan du tänka dig att producera energigrödor eller använda växtrester för? Välj alla som stämmer. Grödor och restprodukter som kan...

...säljas och förädlas till biobränsle (ex bioetanol, biodiesel eller biogas)
...säljas till värme eller elproduktion
...användas på gården till biobränsleproduktion (ex bioetanol, biodiesel eller biogas)
...användas på gården till värme eller elproduktion.

Q14 Har du ekologiska fokusarealer?

Ja
Nej
Jag vet inte

Q15 Om du fick skörda växtlighet från ekologiska fokusarealer, vilken typ av växtlighet skulle du odla och skörda?
Salix
Mellangrödor
Vallinsådd i huvudgröda
Växtlighet på obrukade fältkanter
Annat
Ingen
Om annat, skriv gärna vad.
Mellangrödor

Information:
En mellangröda är en gröda som du odlar mellan två huvudgrödor. Syftet är att den ska täcka marken, binda växtnäring och bidra till biologisk mångfald. Det kan exempelvis vara våroljeväxter, olika typer av klöver eller bovete och honungsört.

Q16 Odlar du mellangrödor idag?

Ja
Nej
Jag vet inte

Q17 Odlar du dina mellangrödor som en del av ekologiska fokusarealer?
Ja, helt eller delvis
Nej
Jag vet inte

Q18 Kan du tänka dig att odla och skörda mellangrödor för bioenergiändamål?
Ja, med mina nuvarande förutsättningar

Ja, under andra förutsättningar (ex mer lönsamt eller bättre rådgivning)
Nej
Jag vet inte

Q19 Under vilka förutsättningar skulle du kunna tänka dig att skörda mellangördor för bioenergi? Välj upp till tre faktorer.

Om det fanns större intresse att köpa in mellangrödor
Om jag fick bättre betalt för mellangrödorna
Om jag fick stöd eller bidrag för att så och skörda mellangrödorna
Om det var mindre kostsamt att så och skörda
Om anläggningarna som köper in mellangrödorna fanns närmare
Om anläggningarna som köper in mellangrödorna var mer flexibla i hur ofta och hur mycket de vill ha.
Om jag kan så eller skörda dem på ett sätt som påverkar jorden mindre.

Om jag kunde få bättre rådgivning i hur man odlar och skördar mellangrödor
Jag vet inte
Annat
Om annat, skriv gärna vad.

Q20 Har du obrukad mark som i dagsläget inte är inkluderad i ekologiska fokusarealer?

Ja
Nej
Jag vet inte

Q21 Om ja: Kan du tänka dig att odla för bioenergi på den obrukade mark du har?

	Jag har marken och kan tänka mig att odla för bioenergi på den.	Jag har marken men kan inte tänka mig att odla för bioenergi på den.	Jag har inte marken.	Jag vet inte
Produktiv åkermark ur produktion (ex små arealer)	JA/NEJ	JA/NEJ	JA/NEJ	JA/NEJ
Mindre produktiv åkermark ur produktion	JA/NEJ	JA/NEJ	JA/NEJ	JA/NEJ
Betesmark/äng ur Produktion	JA/NEJ	JA/NEJ	JA/NEJ	JA/NEJ
Kantzoner/Vändzoner	JA/NEJ	JA/NEJ	JA/NEJ	JA/NEJ
Skyddszoner	JA/NEJ	JA/NEJ	JA/NEJ	JA/NEJ
Mark i träda	JA/NEJ	JA/NEJ	JA/NEJ	JA/NEJ
Annan typ av mark	JA/NEJ	JA/NEJ	JA/NEJ	JA/NEJ
Om annan typ av mark, skriv vad.	JA/NEJ	JA/NEJ	JA/NEJ	JA/NEJ

Q22 Vilka typer av energigrödor kan du tänka dig att odla på den obrukade marken? Välj alla som stämmer.
Spannmål
Oljeväxter
Andra matgrödor
Vall
Fleråriga energigräs (ex. rörflen)
Energiskog (ex. salix och poppel)
Fånggrödor
Annat

Om annat: Vilken typ av gröda kan du tänka dig odla?

Q23 Får du restprodukter* som du kan tänka dig att använda för bioenergiändamål? *Som inte redan används för bioenergiändamål till bioenergi.

	Ja, jag får restprodukterna och kan tänka mig att använda dem till bioenergi	Ja, jag får restprodukter men kan inte tänka mig att använda dem till bioenergi	Nej, jag får inte restprodukterna	Vet inte.
Halm	JA/NEJ	JA/NEJ	JA/NEJ	JA/NEJ
Blast	JA/NEJ	JA/NEJ	JA/NEJ	JA/NEJ
Stallgödsel	JA/NEJ	JA/NEJ	JA/NEJ	JA/NEJ
Annat	JA/NEJ	JA/NEJ	JA/NEJ	JA/NEJ

Om annat, skriv gärna vad.

A24 Vilka ser du som de största hindren att nyttja restprodukterna till bioenergi i dagsläget? Välj upp till tre faktorer.
Jag använder redan restprodukterna till annat (ex foder)
Jag har inte lagringskapacitet att lagra restprodukter
Det är inte tillräckligt lönsamt att sälja restprodukter för bioenergiändamål
Jag kan inte finansiera en anläggning för att producera bioenergi på min gård (ex halmpanna)
Det finns inte tillräckligt stort intresse från köpare att köpa in mina restprodukter
Annat
Jag ser inga hinder
Om annat, skriv gärna vad.

Q25 Odla mer intensivt Kan du tänka dig att bidra till bioenergi genom att odla mer intensivt för att öka skörden?
Ja
Nej
Jag vet inte

Q26 Vilka grödor skulle du kunna tänka dig att odla mer intensivt av för bioenergiändamål?
Spannmål
Oljeväxter
Andra matgrödor
Vall eller djurfoder
Fleråriga energigräs
Energiskog (ex salix och poppel)
Annat
Om annat, skriv gärna vad.

Q27 Om nej: Vilka hinder ser du i att odla mer intensivt för att bidra med biomassa till bioenergi?

Fritext

Q28 Vad ser du som de största fördelarna med att odla för bioenergi på din mark? Välj upp till tre faktorer.
Det ger en säker avkastning
Det bidrar till samhällets energiförsörjning
Jag kan sprida ut risken i växtföljden på det jag odlar
Jag kan vara mer självhushållande på energi
Det gynnar ekosystemtjänster (ex vilthabitat och pollinatörer)
Jag får tillbaka viktiga restprodukter (ex till gödsling)
Jag tror det kommer bli mer lönsamt framöver
Jag kan söka stöd och bidrag
Annat
Jag ser inga fördelar.
Om annat, skriv gärna vad

Q29 Vilka ser du som de största nackdelarna/hindrena för att odla för bioenergi på din mark? Välj upp till tre faktorer.
Jag får inte tillräckligt betalt för energigrödor/restprodukter för bioenergi.
Det konkurrerar med annan produktion.
Det finns inte tillräckligt med ekonomiskt stöd för att odla bioenergi.
Jag har inte verktygen eller maskinerna för att odla för bioenergi.
Det finns svårigheter med logistik kring ex. skörd/lagring/transport.
Det för bort näring från jorden.
Det passar inte in i min växtföljd.
Jag behöver mer kunskap om hur man gör.
Annat.
Jag ser inga nackdelar.
Om annat, skriv gärna vad.

Q30 Vilka tre faktorer skulle motivera dig mest att öka din bioenergiproduktion?
Högre marknadspris för energigrödor/restprodukter
Mer långsiktigt ekonomiskt stöd
Lättare att söka ekonomiskt stöd
Bättre tillgång till verktyg/maskiner som behövs för hantering av energigrödor (ex. sådd/skörd)
Mindre regelverk kring odling för bioenergi.
Mer rådgivning i val och användning av bioenergigröda.
Högre efterfrågan på bioenergi i samhället.
Bättre/närmare infrastruktur för att ta hand om och omvandla energigrödor och rester till bioenergi.
Annat
Inget kan motivera mig
Om annat, skriv gärna ut vad.

Q31 I vilken kommun bedriver du jordbruk?

Jag föredrar att inte svara
Bjuv
Bromölla
Burlöv
Båstad
Eslöv
Helsingborg
Hässleholm
Höganäs
Hörby
Höör
Klippan
Kristianstad
Kävlinge
Landskrona
Lomma
Lund
Malmö
Osby
Perstorp
Simrishamn
Sjöbo
Skurup
Staffanstorp
Svalöv
Svedala
Tomelilla
Trelleborg
Vellinge
Ystad
Åstorp
Ängelholm

Örkelljunga
Östra Göinge

Q32 Vad är din ålder?

Jag föredrar att inte svara.
Under 25
25-30
30-40
40-50
50-60
60-70
70-80
80+

Q33 Hur identifierar du ditt kön?

Man
Kvinna
Jag föredrar att inte svara

Q34 Valfritt: Vill du lägga till någon ytterligare kommentar om ämnet? Tryck på skicka in för att skicka in dina svar.

Appendix C – Quotes in Swedish

1. Sayings from interviews (S1-S6)

”Den största fördelen är ju att vi ökar beredskapen i Sverige egentlige, om man ska titta stort på det. Här vi har […] vi en energibuffert som finns i fält, som går att nyttja vid behov. Finns inte behovet så förbättrar vi jorden och finns behovet så […] är (det) bara fördelar.” (S1)

”Jag ser det lite som att vi har potential till att kunna producera både mat och energi i svenskt jordbruk. Det är förkastligt att inte utnyttja den potentialen. Det har hänt rätt mycket i omvärldens den senaste månaden och vi ser att här finns ett behov och det stärker vårt land också om vi kan få dels producera maten och energin själva. Så jag tror att det ligger i tiden.” (S2)

”Skulle man få betalat lika bra för livsmedel som bioenergi så finns det kanske en liten tendens att man isf skulle falla på livsmedelssidan för att man kanske tycker att det är det mest korrekta just nu att producera livsmedel. Vi har möjlighet att producera energi från andra områden men livsmedlet har vi bara jordbruket.” (S3)

”Det finns två grejer som är du kan tjäna pengar på idag, och det kommer göra det lång tid framöver. Det är att producera el och skaffa dig sånna här koldioxidrätter som du får om biokolpanna. Alltså alla företag vill ju få klimat-noll i avtryck, och då är det bara frågan hur ska du på ett lantbruk kunna få ut sådana grejer för att få pengar av det. Alltså i slutändan handlar ju alla de här grejerna i företaget om att du måste ju tjäna pengar på det du gör.” (S4)

”Jag är personligen emot allt det här med stöd egentligen. Ge oss betalt för grejerna vi producerar. Så skiter vi i den här välgörenhetsdelen. Det är lixom, det blir hållbarare företag om vi får rätt betalt för grejerna.” (S5)

”När jag såg min mellangröda så kan du ju i princip nyttjas tre olika saker; antingen så kan man ju ha djur som betar ner den om det skulle vara foderbrist eller att man skördar det till djur. Alternativet så är ju biogasen, om det är lägligt, men skulle det vara att det är hemskt våt höst som man inte vill köra i fälten så kan jag ju låta bli, och då förmultnade på fält istället och blir till jordförbättring eller mulluppbyggnad i fält så […] med rätt val så är där ingen baksida egentligen till något alternativ. Men det gäller att hitta en mottagare som är lika flexibel.” (S6)

2. Comments from survey (C1-C20)

”Matproduktionen måste vara prio, eftersom hungriga människor i ett litet land som saknar självförsörning blir farligt på sikt. Energi blir sekundärt.”(C1)

“På jordbruksmark behöver vi producera livsmedel, mest hållbart är det med animalier på lång sikt, bördigheten på marken ska utvecklas och ge mervärden”(C2).

”Jag behöver hela min odling för djurfoder och bete till mina köttdjur” (C3)

”Vi måste förse Sverige med livsmedel”(C4)

”Det är nästan omöjligt att få det skördat i dag. Ingen som kan eller tycker det är lönsamt längre. Mycket tråkigt!” (C5)

”Energiskogen jag har har varit en mycket dålig affär” (C6)

”Den låga arealen behövs till enbart fruktodlingen för att uppnå lönsamhet.” (C7)

”Har för liten arial odlar mat till grisarna” (C8)

”Mervärdet är för lågt för den energi man får ut, animalier ger mer som livsmedel, och hållbarhet som biologisk mångfald och kolinlagring” (C9)

”Vansinne att föra bort energi från mark, när energi kan utvinnas mer effektivt med kärnkraftverk.” (C10)

”Två stora problem med mellangrödorna är kostnad för frö, tid och diesel men även för att köpa maskiner för att etablera på ett snabbt och smidigt sätt. Det är ju oftast full skörd när mellangrödan ska etableras och då är vi mer än fullt upptagna” (C11)

”Alltså, jag vill ju behålla det som växer på åkern, eller få tillbaks annat biomaterial. Bördigheten är avgörande och mullhalten är en viktig faktor. Därför vill jag inte egentligen odla till energi på det viset. Eller så måste vi hitta grödor som bygger massiva mängder rötter, och så skördar vi ovanjordiskt och rötterna blir kvar och ökar bördigheten.” (C12)

“För liten och ofta dålig areal för att lägga tid på att så och skörda något där, trädorna är ofta trädor av just den anledningen. Fältkanterna är för omständiga och kostsamma att så och odla.” (C13)

”Insatskostnaderna är idag för höga dvs gödning och diesel” (C14)

”Svårt att odla mer intensivt än vad som redan görs. Framförallt med rådande omvärldsläge och brist/kostsamma insatsvaror”(C15)

”katastrof för miljön och sämre kvalite på halmståts hållbarhet”(C16)

”Intensivare odling rimmar illa med ekologisk odling, och kan leda till ökad energiförbrukning/ha vilket tar ut nyttan med mer biomassa”(C17)

”Åkrarna är för små och i dåligt skick”(C18)

”Jag odlar så intensivt jag kan (i nuläget) redan. Klart jag försöker förbättra mitt odlande kontinuerligt men det är mest ökad bördighet som kan ge högre skörd nu. (C19)

”Mer intensivt skulle kräva maskininvesteringar och ev påverka miljö mer. De arealer jag har passar bra för extensivt bete och vallfoder.”(C20)

Appendix D – Tables and Figures

1. Tables

Table 1 Incentives (all farmers)
Factors which farmers (N=174) experience are incentives with growing biomass for bioenergy purposes, when asked to choose up to three of ten factors. (Q28)

Incentives with factors to produce biomass for bioenergy	Numbers of persons answering yes	Percentage yes out of available options (%)
It contributes to society's energy supply	75	21
I can be more self-sufficient in energy	51	14
I think it will be more profitable in the future	51	14
It benefits ecosystem services (e.g., game habitats and pollinators)	46	13
I see no benefits	42	12
I get back important residual products (e.g., for fertilization)	38	11
I can spread the risk in the crop rotation on what I grow	33	9
I can apply for support and subsidies	10	3
Other factors	6	2
It provides a secure return	5	1

Table 2 Incentives (farmers with ongoing production)
Factors which farmers who produce bioenergy on their farms (N=17) experience are incentives with growing biomass for bioenergy purposes, when asked to choose up to three of eight factors. (Q8)

Incentives with producing biomass for bioenergy purposes	Number of persons answering yes	Percentage yes out of options (%)
It contributes with energy to the society	8	23
I can produce heat or electricity on my farm	7	20
It can be sold for a good price	6	17
I can use my land more efficiently	5	15
I will be able to sell it for a good price in the future	4	11
It fits in the crop rotation	2	6
I can apply for subsidies	1	3
Other	1	3

Table 3 Barriers (all farmers)
Factors which farmers (N=174) experience are barriers with growing biomass for bioenergy purposes, when asked to choose up to three of ten factors. (Q29)

Barriers and negatives for producing biomass for bioenergy	Number of persons answering yes	Percentage yes out of options (%)
It competes with other types of crop production	81	21
I do not get paid enough for energy crops/bioenergy residues.	73	19
Nutrition is removed from the soil.	52	13
I do not have the tools or the machines to grow for bioenergy.	40	10
I need more knowledge	38	10
There are difficulties with logistics around e.g. harvesting/storage/transport.	34	9
There is not enough financial support to grow bioenergy.	32	8
It does not fit in my crop rotation	19	5
Other	12	3
I don't see any negatives.	9	2

Table 4 Motivational factors

Factors which farmers (N=174) experience as motivational factors to start or increase biomass production for bioenergy purposes, when asked to choose up to the three factors. (Q30)

Motivational factors for producing biomass for bioenergy	Number of persons answering yes	Percentage yes out of options (%)
Increased market prices for energy crops and residuals	102	31
More long-term financial support	42	13
Higher demand for bioenergy in society.	42	13
Better/closer infrastructure for taking care of and converting energy crops and residues into bioenergy.	39	12
Less regulations regarding cultivation for bioenergy.	35	11
Nothing can motivate me.	33	10
Better access to tools/machines needed for handling energy crops (e.g., sowing/harvesting)	22	7
More guidance for energy crop production.	29	8
Another factor.	10	3
Easier access to financial support	10	3

Table 5 Residuals for bioenergy

Percentage of farmers who get agricultural residuals (N=137) when asked if they would consider using it for bioenergy purposes. (Q23)

	Straw	Haulm	Manure	Other
I get the residual product and ***would consider*** using it for bioenergy purposes.	36	19	31	11
I get the residual product but ***would not consider*** using it for bioenergy purposes.	19	10	12	2
No, I don't get this type of residuals	37	65	54	69
I don't know	7	6	3	19

Table 6 Intermediate crops

Motivational factors for farmers to grow intermediate crops for biomass production when asked to choose up to three factors. (Q19)

Motivations to grow intermediate crops for bioenergy purposes	**Number of persons answering yes**	**Percentage yes out of options** (%)
If I got better paid for the intermediate crops	60	33
If there was more interest in purchasing intermediate crops	33	18
If I received support or grants to sow and harvest the intermediate crops	20	11
If it was less costly to sow and harvest	17	9
If I could get better advice on how to grow and harvest intermediate crops	16	9
If I can sow or harvest them in a way that affects the soil less.	13	7
If the facilities purchasing the intermediate crops were closer	10	6
Other	6	3
If the facilities that buy in the intermediate crops were more flexible in how often and how much they want.	4	2
I don't know	2	1

2. Figures

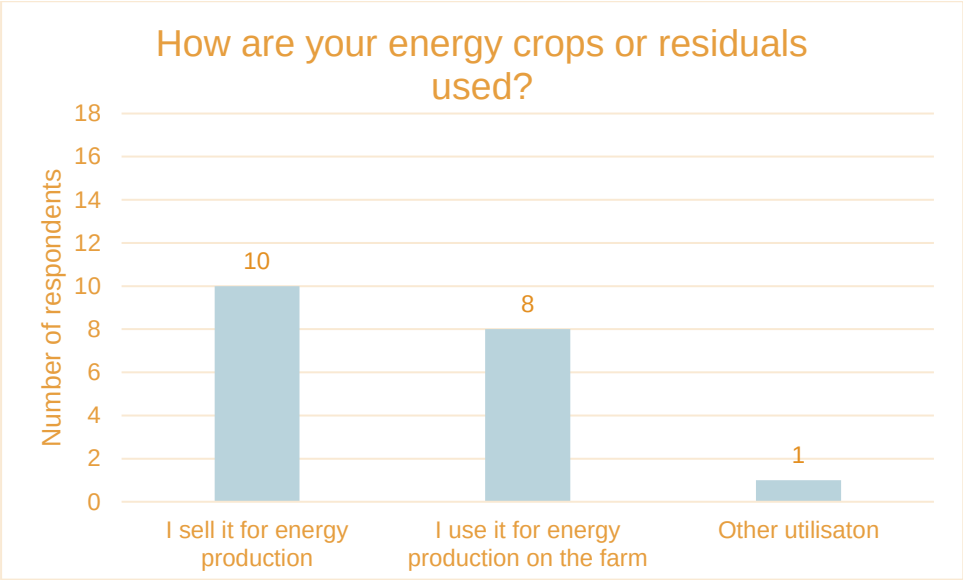

Figure 1 Usage of bioenergy
How farmers using energy crops and residuals for bioenergy (N=17) are using their feedstock, for external or on-site energy production (Q7).

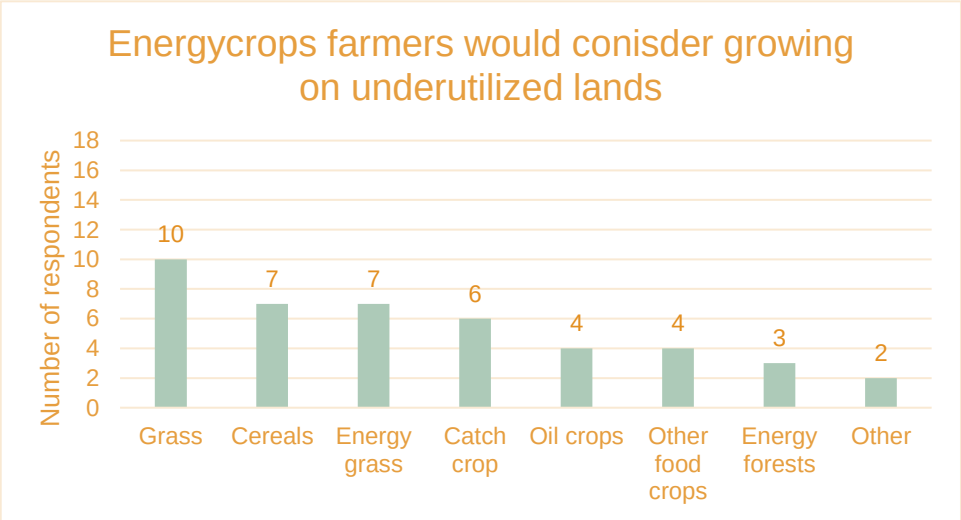

Figure 2 Underutilized lands
Energy crops which farmers (N=17) would consider growing on their underutilised lands. (Q22)

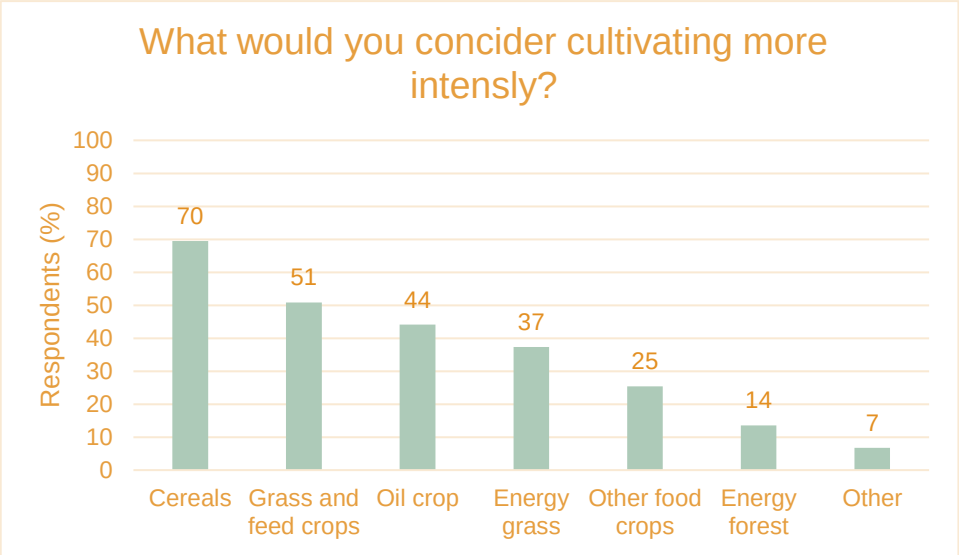

Figure 3 Crops for intensified production
Crops which farmers (N=59) who would consider growing more intensely for bioenergy purposes, would consider cultivating. (Q26)