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MAPPING ENERGY CROP CULTIVATION AND IDENTIFYING MOTIVATIONAL FACTORS AMONG SWEDISH FARMERS

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ABSTRACT

Based on a meta-study, the paper describes the existing options, areal extents, and Swedish farmers' conditions for energy crop production promoted by the governments to mitigate and adapt to climate change. The drivers of and barriers to cultivating various energy crops are described in terms of a variety of motivational factors. The approach used peer-reviewed and grey literature using three internet sources. Questions addressed include the energy crops available to Swedish farmers and how well established they are in terms of areal extent. What drivers of and barriers to growing energy crops do farmers perceive? How do various motivational factors for these drivers and barriers correspond to the adoption of certain energy crops? The results indicate that 13 energy-related crops are available, of which straw (a residue), oil crops, and wheat are the most extensively produced in terms of cultivated area. Results confirm earlier research findings that converting from annual to perennial crops and from traditional crops or production systems to new ones are important barriers. Economic motivations for changing production systems are strong, but factors such as values (e.g., aesthetics), knowledge (e.g., habits and knowledge of production methods), and legal conditions (e.g., cultivation licenses) are crucial for the change to energy crops. Finally, there are knowledge gaps in the literature as to why farmers decide to keep or change a production system. Since the Swedish government and the EU intend to encourage farmers to expand their energy crop production, this knowledge of such motivational factors should be enhanced.

Key words: land-use change, drivers, barriers, farmers' incentives, energy crop cultivation, crop residue

1. INTRODUCTION

The national intention to convert Swedish energy use from fossil fuels to renewable energy has been reinforced by the climate change debate and the general acceptance of the concept of sustainable development. As a member of the European Union (EU), Sweden has since 2007 had an overall binding target of converting its existing energy supply to 20% renewable by 2020 [1]. Furthermore, the EU has set a binding target that at least 10% of gasoline and diesel consumed in the transport sector should be from bioenergy by 2020. As for all member states, Sweden's target have been adapted to national circumstances. Sweden's target was set at 49% of total consumed energy from renewable sources by 2020 (up from 39.8% in 2005) - the highest proportion of any of the 27 member states [2]. Due to climate change, the temperature is projected to increase by up to 7°C in northern Sweden and precipitation patterns are expected to change, with more rainfall expected in the west than in the drier east [3]. Consequently, Swedish agriculture will be exposed to increased risk of damage from insects, fungi and viruses and new demands for irrigation and drainage systems [4]. Greenhouse gas (GHG) emissions from agriculture in Sweden in 2007 were reported as 8.54 Tg of carbon dioxide equivalents (CO_2 eq.), while lowered to 8.47 in 2008 [5] contributing to less than 10% of national total emissions [6]. These figures mean that Swedish agriculture emits less than 0.1% of the total global land use CO_2emissions (6 Pg y-1) [7]. Despite Sweden's small contribution in global terms, there are demands for the agriculture sector to change. Producing more energy-related products or energy crops on traditional agricultural land, i.e., "energy farming" [8], is one strategy. Producing energy crops could reduce emissions from the land [9] and offset GHG by replacing the use of fossil fuel. At present, approximately 2% of Sweden's arable land is used for energy production [10]. Several studies indicate that energy crop production from the agricultural sector will increase in the future [3, 11]. The Swedish agricultural sector produced the equivalent of 1-1.5 TWh in 2006 [3, 12]. From model runs [4], it has been calculated that agriculture could contribute with 15-30 TWh depending on the economic and political measures put in place. The Federation of Swedish Farmers (LRF) has made a committed to increasing this to at least 5 TWh in the near future [13]. A great potential for increases in energy crop cultivation has also been identified at the European level [8, 14].

The United Nations Framework Convention on Climate Change (UNFCCC) along with international organizations such as the International Energy Agency (IEA) and the Food and Agriculture Organization (FAO) argue that bioenergy is a key strategy to mitigate climate change [15]. At the same time, the inherent problem in using limited land resources to produce renewable energy in a situation of high commodity prices and continuously growing world population should not be underestimated. It has been argued that especially in developing countries, there is a risk for 'further exploitation of poor regions rather than providing them benefits' [16]. Large-scale conversion of land for food and feed production into sites for production of bioenergy crops may have negative social and ecological effects e.g. as regards to food security, subsistence of small-scale farmers and preservation of biodiversity [17]. Still, production of energy crops is one important strategy to mitigate GHG emissions by replacing the use of fossil fuels.

Earlier studies of the conditions necessary for land use or production change at the Swedish and international levels have demonstrated the importance of economic incentives for the individual actor [18, 19]. For the Swedish case, economic evaluations of investment in energy crop production yield contradictory results. Despite the potential profit, existing subsidies, and relatively large interest on the part of farmers in energy crop cultivation [18], the extent of agricultural energy crop production remains rather limited [20, 21]. Moreover, there are many varieties of energy crops to chose from, each with their own particular cultivation opportunities and limitations and sets of drivers and barriers.

This paper aims to improve our understanding of the preconditions for farmers to begin producing energy crops, which serve both climate change mitigation and adaptation purposes. The specific research questions are: i) What energy crops are available to Swedish farmers and how well established are they in areal extent? ii) What drivers of and barriers to growing energy crops do farmers perceive? iii) How do various motivational factors underlying the drivers and barriers relate to the adoption of selected energy crops?

This paper's findings form the basis of a framework for research (namely the project competitively strengthened agriculture communication about climate change and new possibilities conducted from Linköping University) into the communication and hence motivational factors underlying farmers' land use choices in relation to energy crops. The results will highlight the knowledge gap concerning why farmers choose to change their land use, including motivational factors. In terms of increasing energy crop production - a Swedish government goal - our analysis also serves as a basis for policy decisions regarding the enhancement of drivers and removal of barriers.

2. MOTIVATIONAL FACTORS AS DRIVERS AND BARRIERS – EARLIER STUDIES

Through an economic assessment of various production options for arable land, Börjesson [9] found that energy crop production would give the farmer a higher net profit than would traditional production, primarily through reduced costs. However, in a choice experiment-study including grain, reed canary grass (*Phalaris arundinacea*), hemp (*Cannabis sativa*) and salix (Salix is a genus and refer to species such as willow and sallow), Paulrud and Laitila [18] found that a compensation of up to 215 € ha^{-1} (conversion rate (March 18, 2011): 1 € = 9,31 SEK) would be necessary for a farmer to convert from a traditional crop to salix. These differences in results, apart from obvious changes in market conditions between 1999 and 2007, likely depend on the particular drivers and barriers included in the studies. Berg et al. [11] pinpointed the lack of standardized calculation methods for short- and long-term comparisons between traditional and energy crops; in particular overhead costs are treated differently. Paulrud and Laitila [18] included five factors apart from net profit: form of cultivation (contract or not), flexibility of land use (annual, 10 or 20 years), traditional cultivation technology (yes or no), landscape effects (height of <2, 2-4 or 4-8 m), and subsidies (yes or no). The present paper is more explorative in investigating whether these factors are the most important, and what other factors may influence farmer decisions.

Despite the potential profit, existing subsidies, and relatively strong interest from farmers in energy crop cultivation [18], the extent of such production is rather limited [21]. Except from Paulrud and Laitila [18], who include non-economical incentives converted into monetary terms, it seems that earlier studies have focused on economic incentives, and that these alone cannot explain farmer behavior. Domac et al. [14] found that focus on the quantification of economic incentives also guides much general research into the implementation of bio-energy projects, leaving a knowledge gap regarding the involved social, cultural, institutional, and environmental issues from the individual actor's point of view.

Studies of the public understanding of environmental issues have demonstrated that there is often a gap between peoples' opinions and actions [22, 23]. This means that although actors may know about environmental issues, they might not act in ways that contribute to environmental sustainability [24]. The reasons for this vary, possibly because many environmental problems are characterized by complexity and uncertainty, often being global in character and with effects that are distant in time and space [23, 25]. Hence, it is important to analyze not only actors' stated opinions, but also the barriers preventing people from taking action as well as the drivers encouraging them to do so [23, 24].

Barriers and potentials and hence motivational factors for actors to engage in environmental protection measures can also be applied in analyzing farmers' choices in terms of engaging in energy crop production. Trudgill [26] identified six types of barriers namely, agreement, knowledge, technological, economic, social and political, and administrative barriers, as hindering increased energy crop cultivation. The Global International Water Assessment (GIWA)-approach [27] addresses four institutional layers that together form the decision context for decision-makers in water management, namely, socio-cultural rules, formal rules of the game, governance rules, and resource allocation mechanisms. Price incentives on the market for energy crops (traditional and/or new) could change instantly if new circumstances arose (e.g., increased/decreased wheat demand for energy production or changed global food prices).

In comparison, Blennow and Persson [28] found that, among Swedish private forest owners – another type of land users, adaptation to climate change was influenced by their belief in climate change. Furthermore, individuals who had not adapted to climate change, even though they believed in it, expressed a lack of understanding of how they could adapt or a lack of belief in the available ways to adapt. Although there has been little or no research into the links between belief in climate change and knowledge of adaptation measures among Swedish farmers, their attitudes and behavior likely resemble those of the studied forest owners.

Furthermore, drivers and barriers can be separated into the proximate causes and underlying driving forces of individual decisions regarding land use changes [19]. Proximate causes are the motivational factors directly experienced by farmers; for example, increased demand for a product on an available market driving a change in land use. Underlying driving forces are indirect and more process oriented, such as climate change.

This paper aims to identify a range of barriers and drivers by conducting a content analysis of a predefined body of grey and peer-reviewed literature. These barriers and drivers will be categorized into four broad groups of motivational factors; i.e., values, legal, knowledge and economic factors. All these factors are important to farmers making decisions regarding whether or not to produce energy crops. We also aim to explore to what extent each type of motivational factor likely serves as a driver of or barrier to the adoption of certain energy crops.

3. METHODS

This meta-study builds on other Swedish studies of energy crop production that drew on both the peer-reviewed and grey literature. Our method involved three literature searches: i) Google scholar search motor for peer-reviewed studies, ii) The Swedish government's portal for official reports (i.e., Swedish Government Official Reports so called SOUs), and iii) www.bioenergiportalen.se, a portal for sector organizational reports. Our search included the words bioenergy, energy crop, agriculture, attitude, and Sweden, and covered the 1990-October 2009 period. The search was done in January 2010. If the located documents mentioned any of the following - assessment of energy crop extent, condition, and rationale (versus, e.g., biogas production, phenological tests, energy output, and solar energy), information on crops grown in Sweden, information on reasons for choosing whether or not to grow energy crops (i.e., motivational factors), or farmers characteristics - the document was regarded as relevant to the analysis and was included. A full list of the material found via the different searches is given in Appendix A.

In the study, we have chosen to use the concept "energy crop" in the meaning of crops cultivated both for direct (i.e., hemp, willow etc.) and indirect energy generation (i.e., grains that can be used in ethanol production). In this definition of energy crop, we also include residues from other crops, such as for example straw.

4. Results

4.1 Energy crops available for Swedish farmers

According to the data found in the meta-study, 13 energy crops are available to Swedish farmers today (Table 1). Of these 13 crops, straw (a field residue of cereal production and not a crop per se) covers the largest area, i.e., 30, 000 ha. Production of this "crop" uses traditional farming practices and subsidies where available for the studied period (even though changes were made in 2010). There are several heating plants burning straw, including two major ones in Skåne. Oil crops and wheat cover approximately 25, 000 ha each, mainly in southern Sweden. Here traditional methods are used and subsidies are available for growing these for energy production. Salix covers 14-15, 000 ha, with a strong representation around Mälardalen; the production technique for this crop was new in the 1990s and subsidies of 45 € ha^{-1} are available.

Table 1 -Available energy crops in Sweden including annual rotation, areal extent, geographical focus, end use, crop history, and subsidies/market conditions.

Crop	Rotation (annual)	Areal (ha)	Geog. Focus	End use	Crop history	Subsidies/Market conditions
Oil crops	1	>25, 000 [3]	South (Skåne) dominates [18]	Biodiesel, ethanol, and biogas [29]	Traditional	Rural Prog. Subsidies available for local systems [3] Conventional market alternative
Wheat	1	25, 000	South (Skåne) dominates [18]	Ethanol for transport	Traditional energy burning, 1980 [3]	Conventional market alternative
Oats	1	5000 [18]	South (Skåne) dominates [18]	Heating (more benefits than from wheat)	Traditional energy burning, 1980 [3]	Conventional market alternative
Hemp (Cannabis sativa)	1	600; 368, [30] 290 [20]	Most parts of Sweden [30, 31]	Heating [31]	Illegal until 2003 [20, 30, 31] used for energy production since 2007 [18]	EUR 100 ha^{-1}; uncertain market [32]
Grass (prairie + elephant)	1	300		Biogas	New	
Sugar beets (Beta Vulgaris)	1	0 [3]	Rarely grown for energy use [33]	Ethanol and biogas	Traditional	Production planned to decrease in area. Subsidies approximately EUR 9 M 2006-2010 [3]. Conventional market alternative
Corn	1	On test [34]		Biogas	Traditional. Inspired from Germany [34]	Conventional market alternative
Straw (90% residual product) 4	1	30,000 [3]		Heating at farm level. Widely used in Denmark [3]	Traditional	Two district heating plants (Skåne); approx. 25 smaller heating plants [3] Rural Prog. Subsidies available [3] Conventional market alternative
Ley crops	0.5 [34] to 7	300 [18]		Heating, electricity, transport fuel [3], and biogas	Traditional	Primarily for farm level biogas production Conventional market alternative
Reed canary grass (Phalaris arundinacea)	1 to 10 [34]	600 [18]-3500 [3] (only fraction for energy)	North dominates [34]	Briquettes/ pellets for heating	New	Clone development – Bamse [34] Rural Prog. Subsidies available [3] No established market
Salix	Harvest: 3 [34] to 6 [35] Perennial: 20-25 [8]	14, 000-15, 000 [8, 36]	South of Dalälven, Strong in Mälardalen	Heating	Since 1990s [3]	Subs. EUR 45 ha^{-1} [11] agro fuel. Establishment subs. EUR 550 ha^{-1} [37] Pilot system for ethanol [3] Potential resource for 2nd gen transport fuel gasification [3]
Poplar (Populus tremula)	15-20 [34]	~ 100 [34]	Plains of Skåne, Halland, and Götaland (south) [34]		Since 1990s	Much hybrid development in N.Am. Establishment subs. EUR 550 ha^{-1} [37] Rural Prog. Subsidies available [3]

Hybrid Aspen (Populus tremula L. x P. tremuloides Michx)	25 [34]	100 [3]	Coast in north		New	Establishment subs. EUR 550/ha [37] Rural Prog. Subsidies available [3]

As can be seen in Table 1, cultivation areal, geographical focus, and end use vary widely between crops and groups of crops. To some extent, motivational factors related to the history of the crop, i.e., whether it is traditional or new, and existing subsidies and market conditions may explain the differences in areal extent, but the strength of these relationships is not explored in the literature. Biophysical parameters such as climate and soil conditions may account for many of the geographical differences in crop adoption. Paulrud and Laitila's [18] investigation of farmer valuations of the "side effects" of various energy crops inspired us to conduct a qualitative and deeper exploration of the motivational factors that may function as drivers and barriers for farmer choices in this context.

4.2 MOTIVATIONAL FACTORS FOR PRODUCING ENERGY CROPS - DRIVERS AND BARRIERS FROM THE FARMER'S PERSPECTIVE

Four broad groups of motivational factors relating to values, legal conditions, knowledge, and the economy have been identified (Table 2). Along with these, we found a variety of more specific factors that may serve as drivers of or barriers to individual farmers when considering the adoption of a certain energy crop.

Table 2 - Identified motivational factors found to determine whether or not farmers engage

MOTIVATIONAL FACTORS	POSSIBLE BARRIERS AND DRIVERS
Values	1) Aesthetic • Attractive landscape [11, 18, 38] • Hunting opportunities (e.g. going from annual cropping systems to perennial plantation systems) [39] 2) Moral • Fields for food: 32% state that "you cultivate to grow food – not energy" [18] • Fields for preservation [33] 4) Ecological (could indirectly also be an economic factor if it brings a service with advantages or involves subsidies) [10, 33] • Reduced nutrient leaching [10, 38] • Less pesticides use [10] • Increased biodiversity [38] • Wind shelter against erosion and snow [38] • Organic soil component recovery [38] • Cadmium uptake [10] • Energy efficiency [29, 40, 41] 5) Quality of life • Self-rule, development [33] • Lack of time [33] • Age reasons [33] • Cultivation for own needs [33]
Legal	1) Property rights • Tenure conditions for perennial crops [8, 11, 18] 2) Cultivation licence/specification of variety (hemp) [31, 38] 3) Complicated regulation systems [33]
Knowledge	1) Knowledge of cultivation methods [11, 18] 2) Knowledge of alternative crops [11] 3) Policy support (e.g., research, and extension) [8, 11] 4) Knowledge of the market: access, sell, agreements, and contracts [33] 5) Energy knowledge [33] 6) Machines and equipment [30]
Economy	1) Risk and risk management • Risk [18] and perceived risk (i.e., market risks, production risks, and political risks) [11, 18, 33] • Risk management (i.e., possibilities for a crop portfolio perspective) [11] 2) Cost of changing production system [18, 33] 3) Economy of scale[11] and vertical integration in the biomass supply chain [8, 11, 31] 4) Time perspective (discount rate) [18] 5) Net profit [18, 30, 31, 33] 6) Market conditions • existence and type of market for output [8, 30, 42] • contract farming as a requirement for receiving subsidies (salix) [11, 18] 7) Economic policies • Common Agricultural Policy of the European Union [11, 18] • Rural Development Programme support [10] 8) Alternative use of relatively expensive production factors • land (i.e., other crops [8, 36, 38] and fallow [8, 18, 36]) • labour [11, 38] 9) Productions costs [42]

As shown in the Table 2, the four groups of motivational factors include numerous aspects and conditions affecting farmer decisions concerning energy crop adoption. For different types of crops, different motivational factors may exert influence in a positive, neutral, or negative direction, i.e., a certain motivational factors may serve as a barrier to one crop but a driver of another. The results in Table 2 also indicate that research into the reasons why farmers change production systems has been rather limited and often very specific with regard to a certain crop or motivational factor and with a focus on economic factors.

In the following, we aim to identify the relationships existing between types of energy crops and different motivational factors. To structure the analysis, we will use four specific crops to exemplify crop types, namely, cereals that can be used in ethanol production (i.e., wheat), hemp, and salix (also used by Paulrud and Laitila [18]) and the newer perennial crop, hybrid aspen (*Populus tremula L. x P. tremuloides Michx.*).

The first crop, wheat, is an annual crop that has been cultivated for centuries in Sweden mainly for food and that has largely shaped the economic and technical structure of Swedish farm enterprises, creating a highly valued cultural landscape. The continued cultivation of wheat, but now for energy production, might be associated with various advantages stemming from motivational factors for the farmer. Factors empirically documented as drivers of cultivation of wheat and other cereals for ethanol production include aesthetic considerations and value arguments [18], opportunities to lease land for cultivation [8, 10], knowledge of cultivation methods, use of existing machinery [18], and better risk management from the perspective of the "crop basket" portfolio of the farm [11].

Hemp, on the other hand, is a very recent crop, and although annual and having fewer landscape effects than do cereals, thus enabling the provision of Common Agricultural Policy fallow subsidies [8], a number of motivational factors serve as barriers to its adoption. Legal restrictions, lack of knowledge of cultivation methods, costs of changing the production system, limited market opportunities, and no economies of scale are such factors found in the literature [30, 42].

The third crop, salix, is a perennial crop that has been grown in Sweden for energy purposes since the 1990s. The conversion from traditional food crops to salix is connected with several barriers, including the fact that it is perennial and requires new machinery [18]. Moreover, negative landscape effects and limited opportunities to lease land for salix production serves as barriers [18], as does the risk of damaging in field drainage. Several positive effects of salix, such as environmental considerations and improved hunting opportunities [10, 38], may serve as drivers for its adoption, and these are further supported by research and extension on cultivation methods [8].

The fourth crop, hybrid aspen, is a perennial crop only recently introduced into the production system in Sweden. No studies of this crop were found in our search that held information on the motivational factors constituting drivers and barriers.

Table 3 - Drivers or barriers for four crops (annual/perennial and traditional/non-traditional) among farmer in terms of values, legal, knowledge, and economic motivational factors

		Annual		***Perennial***	
	Motivational factors	***ENERGY GRAIN***		***SALIX***	
		Drivers	***Barriers***	***Driver***	***Barriers***
Traditional	***Values***	Attractive landscape [11, 18]	Fields for food [18]	Landscape [38] Hunting opportunities [39] Reduced nutrient leaching [10, 38] Less pesticides use[10] Increased biodiversity [38] Wind shelter against erosion and snow [38] Organic soil component recovery [38] Cadmium uptake [10] High energy efficiency [40, 41]	Attractive landscape [11, 18] Fields for food [18] Greatly dependant on fertilizers but in general lower environmental impact than annual crops such as wheat [41]
	Legal				Tenure conditions for perennial crops [8, 11, 18]
	Knowledge	Knowledge of cultivation methods [11, 18]		Policy support (e.g., research and extension) [8, 11]	
	Economy	Risk management [11] Common Agricultural Policy [11, 18] Alternative use of land (i.e., fallow)[8, 18, 36]		Economy of scale [11] and vertical integration in the biomass supply chain [8, 11, 36] Existence and type of market for output [8] Contract farming as a requirement for receiving subsidies (salix) [11, 18]	Cost of changing production system [18] Alternative use of labour [11, 38]
Non-traditional		***HEMP***		***HYBRID ASPEN***	
	Values	Appropriate for ecological farming [20] Renewable fuel [31]	Fields for food [18]		
	Legal		Cultivation licence [38]		
	Knowledge	An emerging field	Lack of mechanical equipment [30, 42] Little knowledge, e.g., yield, harvest time, and refinement [42]		
	Economy	Alternative use of land (i.e. fallow) [8] Market for briquetting [42] Increased market demand [30, 42]	High production cost [42]		

Table 3 reveals that salix is a relatively well-researched energy crop, compared with both wheat and hemp, not to mention hybrid aspen. Studies often focus on a single crop [36, 43], or concentrate on a particular aspect of energy farming [38]. Very few studies take a more integrated perspective on a wider range of crop alternatives and motivational factors relevant to the farmer considering energy farming. This explains the many empty spaces in Table 3 compared with the wide range of motivational factors presented in Table 2. For each motivational factor and crop, a qualified hypothesis could be formulated regarding the direction of the effect on farmers' decisions (i.e., driver or barrier), but such hypotheses remain to be tested empirically. Moreover, the strength of various drivers and barriers, and their likely effects on different strata of the farming community, remain largely under researched. Rosenqvist et al. [43], for example, statistically analysed the characteristics of individual farmers who adopted salix cultivation, comparing this group with a strategic sample of farmers who did not. The only example of a more holistic study found in our body of literature is that of Paulrud and Laitila [18], who used a methodologically strict quantitative approach (i.e., a choice experiment) to investigate the effect of a limited number of motivational factors on a limited number of crops. Building a more comprehensive understanding of what affects farmer adoption of energy crops calls for a more explorative and qualitative approach.

The motivational factors discussed here were identified from the perspective of the individual farmer considering a conversion to energy crop cultivation. They all exert a direct influence on the in situ outcome, but often the motivational factors stem from trends and developments at the national or even global level. Energy crop production must be addressed using an integrated policy approach that incorporates energy, agriculture, forestry, and industrial policy [8]. The separation between proximate and underlying forces [19] may help sharpen the analysis. Thus, underlying driving forces, such as the Swedish government's desire to increase energy crop production and associated policies, such as a CO_2 tax, indirectly influence farmers' decisions by increasing demand and thereby prices for energy crops [8, 36]. Likewise, global food and energy prices affect farmers' choices through price signals.

5. Discussion

There is clearly a knowledge gap in our understanding of the various groups of motivational factors and how they are assessed by individual farmers. More specifically, this concerns the direction of motivational factors associated with various crops, their relative strengths, and whether different strata of farmers assess motivational factors differently, as well as the identification of proximate causes and underlying forces. As a first step toward filling this gap, an explorative investigation using focus groups of farmers and interviews with farm advisors, will be conducted in two Swedish agricultural regions as part of the K3 project. This qualitative approach may then be followed by a quantitative study, involving, for example, a multivariate contingent valuation or choice experiment analysis to identify the key factors or group of factors affecting farmers' choices.

The study also raises some questions regarding the adaptive capacity of the Swedish agricultural sector, which has long been considered in crisis, at least with regard to employment and earnings. Clearly, the opportunities created by increased national and global demand for energy crops enhance risk management and portfolio thinking for farmers, who can benefit from a wider choice of crops when deciding whether to stay in traditional food crop production or convert to energy crops. Strengthening this adaptive capacity still calls for a further improved understanding of the involved motivational factors to develop effective policies at the national and European levels.

On the other hand, increased global food prices, and the liberalization of energy markets (leading to reduced subsidies for pilot projects) may be underlying driving forces hampering the continued development of energy crop production.

6. CONCLUSIONS

This analysis leads to the following conclusions;

- There are currently 13 energy crops available to Swedish farmers. The three most extensive energy crops produced in Sweden are straw (a residue), oil crops, and wheat, each covering between 15, 000-25, 000 ha.
- Although the economic incentives for changing production system are strong, factors concerning values, knowledge, and legal conditions are crucial for a change in production system.
- There has been no systematic investigation in the literature of why farmers decide to stay with a production system or change it, or of what motivational factors serve as drivers of or barriers to the cultivation of specific crops. To promote farmers to expand their production of energy crops, as stated by the Swedish Government and EU, this knowledge gap needs to be filled.

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