Energy Policy 209 (2026) 114980

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Assessing farmers' willingness to sell straw for energy and material applications in Sweden

Kristina Blennow[a,b,*], Elin Anander[a], Lovisa Björnsson[c], Pål Börjesson[c]

[a] Department of Landscape Architecture, Planning and Management, Swedish University of Agricultural Sciences, Sweden
[b] Department of Physical Geography and Ecosystem Science, Lund University, Sweden
[c] Division of Environmental and Energy Systems Studies, Lund University, Sweden

ARTICLE INFO

Keywords:
Straw supply
Agricultural residue
Farmer's decision-making
Barter trade
Price sensitivity
Non-economic factors
Agricultural policy

ABSTRACT

This study examines farmers' willingness to sell straw for energy and material applications in Scania, Sweden. Using interviews and surveys, we tested three empirical consequences derived from the premise that missing data on farmers' willingness to sell straw for energy may misrepresent the biomass supply in potential assessments. Findings reveal willingness to sell straw depends on end use, with farmers preferring benefits like manure in barter arrangements over bioenergy. Land tenure is key; those leasing over 50 % of their land are more likely to be willing to sell. Contrary to expectations, straw supply is not highly price-sensitive; competing uses like animal bedding influence decisions. Up to 57 % (95 % CI: 42–75) of cereal and oilseed land could be made available for energy, though agronomic and competing use limit this potential. These results challenge viewing straw as a residue and highlight the need for region-specific policies reflecting land tenure, local practices, and agronomic priorities. Integrating nutrient recycling, diversified straw uses, and agroecosystem planning could enhance biomass availability and agricultural sustainability. Further research should assess effectiveness, including carbon farming regulations. This study offers insights for aligning bioenergy goals with agricultural sustainability in biomass policy.

1. Introduction

The European Green Deal mandates a 55 % reduction in greenhouse gas emissions by 2030 compared to 1990 levels (European Council, 2025). A key component of this strategy is an increase in renewable energy sources, targeting a 45 % share by 2030 (European Union, 2023a, 2023b). In 2023, renewables accounted for 24.5 % of the European Union (EU) energy use, with biomass being the largest contributor accounting for half of this (EEA, 2025).

However, the composition of biomass used to meet these targets is undergoing a transformation. Policy frameworks, such as the EU Renewable Energy Directive (European Union, 2023a), emphasise prioritising biomass types with minimal competition with the material sector and avoiding unsustainable bioenergy pathways. For instance, biofules and bioliquids from food and feed crops are capped at 2020 levels or a maximum of 7 % of total final use of energy in the road and rail transport sectors. Instead, the directive promotes the use of by-products, waste, and residues, including straw, identified as a long-term sustainable feedstock.

Straw is frequently highlighted as a major contributor to biomass potential in the EU (see e.g. Imperial College, 2021). Assessments of this potential often follow a top-down approach, relying on agricultural statistics and estimates of biomass that can be technically and sustainably removed (e.g. Scarlat et al., 2019; Janiszewska and Ossowska, 2022). These studies typically distinguish various types of potential, such as theoretical, technical, environmental, and economical, based on assumptions about removability. However, despite their sophistication, these assessments fundamentally rely on the availability of land for cultivating straw-producing crops. Importantly, they often overlook a critical factor: the role of farmers in determining the actual availability of straw for biomass markets.

For example, Townsend et al. (2018) conducted a survey to investigate the use and potential supply of wheat straw for bioenergy. Their findings revealed that even with generous payment offers, a significant proportion of straw currently incorporated into fields would not be sold, highlighting the constraints on straw availability due to farmers'

* Corresponding author. Department of Landscape Architecture, Planning and Management, Swedish University of Agricultural Sciences, Sweden.
E-mail addresses: kristina.blennow@slu.se (K. Blennow), elin.anander@hotmail.com (E. Anander), lovisa.bjornsson@miljo.lth.se (L. Björnsson), pal.borjesson@miljo.lth.se (P. Börjesson).

https://doi.org/10.1016/j.enpol.2025.114980
Received 7 April 2025; Received in revised form 16 October 2025; Accepted 15 November 2025
Available online 24 November 2025

preferences and current practices. Additionally, while higher straw prices could incentivise increased supply, the study demonstrated substantial variability in farmers' willingness to participate in straw markets, reflecting a potential limitation in biomass availability for bioenergy feedstock.

The research by Anander et al. (2024) on the potential for biomass production from *Populus* spp. on agricultural land illustrates the risks of relying solely on biophysical land data. Their study found that land often classified as "abandoned" in top-down assessments may still serve important functions for farmers, such as crop rotation or other agricultural practices, leading to an overestimation of land available for biomass production. Similar findings were presented by Thomson Ek et el. (2024). Anander et al. (2024) also demonstrated that less than 50 % of farmers with unsubsidised arable land would consider cultivating tree species for biomass, challenging assumptions about the availability of agricultural land for biomass feedstocks. This highlights the need for biomass assessments to integrate landowner perspectives to accurately estimate the supply of biomass and avoid misleading expectations.

Similarly, studies of other biomass resources, such as roundwood, have shown the importance of landowner perspectives in determining the availability of biomass feedstocks. For instance, Blennow et al. (2014) found that European forest owners' willingness to supply biomass for energy was not easily explained by price changes and market conditions. Furthermore, their study concluded that the projected share of forest biomass needed to meet EU renewable energy targets could not be met based solely on the current willingness of forest owners to supply biomass. Such findings emphasise the gap between theoretical biomass potentials and the actual decisions of landowners, suggesting that landowner intentions and preferences should be incorporated into biomass potential assessments.

For instance, a study by Giannocarro et al. (2017) found that although over half of farmers in Italy were willing to sell their cereal straw, many demanded prices higher than the current local market rates. Similarly, in the U.S., Lynes et al. (2016) identified key factors influencing farm managers' decisions to harvest crop residues, underscoring the need for targeted policy measures. Given that most agricultural land in the EU is privately owned (Eurostat 2023), these findings suggest that farmers' willingness to sell straw can significantly impact the actual availability of biomass for bioenergy.

The potential for increasing biomass supply for energy is also influenced by economic factors such as price incentives. Gérard and Jayet (2023) argues that higher prices and new market opportunities for lignocellulosic biomass could lead farmers to account for crop residues in their production choices. While a price increase may have limited effects on residue supply, it can influence land allocation, yields, and input use, raising important questions about the environmental consequences of such policy measures. These findings align with the broader argument that economic incentives are crucial for stimulating biomass production, but they also highlight the need for careful consideration of policy coordination between bioenergy and agri-environmental objectives.

In Sweden, Börjesson (2021) analysed the potential for increased biomass supply from various agricultural and forestry systems. He estimated that Sweden could increase biomass supply to 55–80 TWh annually by 2050, equivalent to 30 %–50 % of current bioenergy supply, although this potential is influenced by environmental constraints and policy decisions. Approximately one-third consists of biomass from agriculture, with significant contributions from crop residues like straw. However, the availability of biomass from crop residues such as straw may decline over time due to changes in agricultural practices, land use, and regulations related to carbon farming. This suggests a dynamic interplay of factors that must be considered when evaluating Sweden's long-term biomass potential. From a policy perspective, there is also a need for integrating economic incentives and policy measures that align with both agricultural goals and bioenergy needs.

In this study, we focus on updating the availability of land for supplying straw from cereal and oilseed crops from a Swedish perspective, recognising that changes in this factor can affect all potential estimates, regardless of assumptions about soil carbon retention or biodiversity needs. To identify factors influencing the potential supply of straw from a farmer's perspective, we conducted an exploratory pre-study involving eight semi-structured interviews with cereal farmers in Scania, southern Sweden (Text S1). The sample included both farmers who currently sell straw and those who do not, capturing a range of experiences and management strategies. Interviews revealed that farmers' willingness to sell straw is influenced by the intended end use of the straw, land ownership and leasing arrangements (including restrictions on leased land), and straw price. Importantly, straw often holds agronomic value, such as soil enrichment, which may outweigh purely economic considerations, and decisions frequently fall along a spectrum rather than simple yes/no choice. These qualitative insights informed the design of a subsequent survey sent to a larger group of farmers in southern Sweden, ensuring that the questions captured key factors influencing farmers' decisions and conceptual reasoning underlying the empirical tests.

The pre-study design employed a problem-feeding approach (Thorén and Persson, 2013), where the issues and insights from initial farmer interviews were "fed" into the design of the larger quantitative survey. This interdisciplinary approach, applied here in a participatory and transdisciplinary setting (Persson et al., 2018), ensures that local experiences and knowledge help shape the research questions, hypotheses, and interpretation of results. By integrating qualitative insights with quantitative inquiry, the method supports a more grounded understanding of the barriers and incentives farmers face in the context of biomass production.

This perspective aligns with the findings of Thomson Ek et al. (2024), who emphasised the importance of economic incentives such as market prices and subsidies in stimulating the production of bioenergy crops. Additionally, the work of Giannocarro et al. (2017) supports this by highlighting how market prices influence farmers' decisions to sell crop residues, including straw, for bioenergy production. Lynes et al. (2016), and Anander et al. (2024) reinforce the idea that farmer preferences and economic considerations, such as land leasing and price expectations, are pivotal to determining the actual supply of biomass for energy.

However, previous Swedish studies have primarily focused on bioenergy crops or general biomass supply rather than straw specifically (Ostwald et al., 2013; Thomson Ek et al., 2024) or on cross-country comparisons of farmers' preferences for agri-environmental schemes (Hasler et al., 2019). The present study therefore extends this literature by providing the first empirical assessment of Swedish farmers' willingness to supply cereal and oilseed straw, and by explicitly analysing how land tenure arrangements and end-use differentiation shape farmers' willingness to sell, two aspects that have received limited attention in prior work. These findings also complement related European research on farmers' willingness to sell crop residues in other settings (e.g., Wilson et al., 2014; Giannocarro et al., 2017), which highlight similar economic, agronomic, and logistical trade-offs.

1.1. Research context and objective

This study investigates the willingness of Swedish cereal and rapeseed farmers to sell straw for bioenergy and bioproducts, with a focus on the county of Scania, a major cereal- and oilseed-producing region in southern Sweden. Scania was selected due to its high agricultural intensity, limited livestock farming, and well-developed infrastructure (Ekman et al., 2013). Building on the pre-study insights, we aim to assess the availability of land in Scania for supplying cereal and oilseed straw for energy and material applications.

Specifically, we test three empirical consequences derived from the conceptual premise that 1/the absence of data on farmers' willingness to sell straw for energy purposes may lead to a misrepresentation of the biomass supply from cereal and oilseed straw in biomass potential assessments:

a) among respondents willing to sell straw, the fraction willing to sell varies across different end uses of the delivered straw,
b) it is more common for farmers leasing at least 50 % of the land they cultivate to be willing to sell straw compared to those leasing less than 50 %, and
c) the price of straw significantly correlates with respondents' willingness to sell.

Informed by the results, we assess the availability of land in Scania for the supply of cereal and oilseed straw for energy and material applications. The results of this study provide insights into the market potential for straw as a feedstock for bioenergy and bioproducts in Scania, Sweden. It also includes an updated estimate of the availability of land for straw supply, which contributes to an assessment of the theoretical straw potential and is proportional to the technical potential. These findings enhance our understanding of the factors influencing farmers' decisions to participate in bioenergy markets and support the development of effective policies for the utilisation of agricultural residues in sustainable energy production.

2. Material and methods

2.1. Study area

Scania County, located in southern Sweden (Fig. 1), is characterised by its extensive agricultural land coverage (45 %) (Statistics Sweden, 2023) and a high concentration of agricultural enterprises (Table 1). The arable land in Scania is the most fertile in the country, with agricultural production predominantly centred on annual crops, particularly cereals (Swedish Board of Agriculture, 2025). However, significant variation in land use exists within the county. Lowland coastal areas are predominantly dominated by agricultural land (60–81 %), whereas northern central areas are largely forested (5–19 %), with the Intermediate region exhibiting a mix of these land uses (Swedish Board of Agriculture, 2025) (Fig. 1). Animal husbandry (cattle and milk production) is most common in the forested and intermediate regions and least common in the lowland region (Erlandsson, 1999). In 2020, the registered arable land area in Scania amounted to 435 kha, representing 17 % of Sweden's total arable land area spanning 2.5 million ha (Swedish Board of Agriculture, 2025), excluding pastureland. Scania contributes the largest part of the straw biomass potential, equivalent to approximately 40 % of the total domestic potential of straw for energy purposes, according to Börjesson (2021).

Table 1
Number of farms and arable land area by farm size category in Scania in 2020 (Swedish Board of Agriculture, 2025) and in the sample, along with area-based weights for upscaling.

Farm size (ha)	Farms in Scania in 2020 (n)	Arable land in Scania (ha)	Farms in sample (n)	Arable land in sample (ha	Area-based weight
0–2.0	749	227	–	–	–
2.1–5.0	1044	3958	2	6	660
5.1–10.0	1421	10 199	2	12	850
10.1–20.0	1110	15 756	11	194	81
20.1–30.0	584	14 412	9	237	61
30.1–50.0	701	27 498	11	474	58
50.1–100.0	862	61 727	33	2550	24
100.1 –	1112	301 184	54	15 058	20
Total	*7583*	*434 961*	*122*	*18 530*	–

2.2. Survey

2.2.1. Survey design and sample selection

Building on the insights obtained from the explorative pre-study (see Text S1) and the literature review, an unstratified, broad, internet-based survey was conducted to obtain a diverse sample of farmers. A random sample of 2558 farmers, representing 50 % of all main members of The Federation of Swedish Farmers (LRF) in Scania, were selected and invited via e-mail by LRF to participate in a web-based survey. The parent member group comprises approximately 85 % of all agricultural holdings registered in Scania's farm register in 2020 (Swedish Board of Agriculture, 2025).

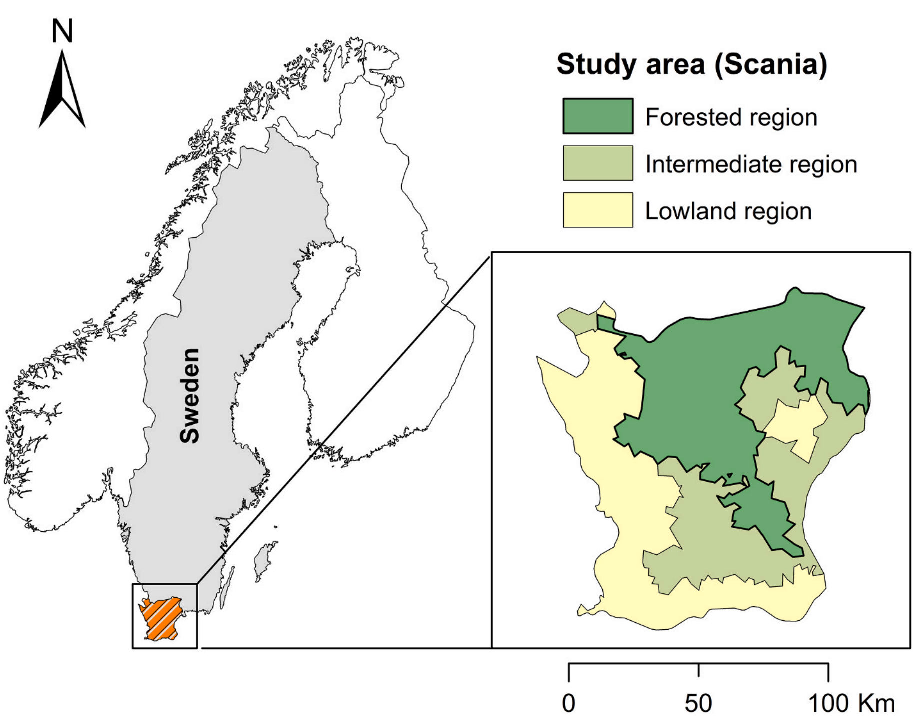

Fig. 1. The study area, Scania, is located in southern Sweden. The colour coding indicates three dominant types of land use. Made with Natural Earth and reproduced from Anander et al. (2024).

Table 2
Questions with response options analysed in the present study. See Supplementary Information for the complete questionnaire.

Number	Question	Response option
Q.1	In which harvest zone is the land you cultivate located? [a]	Aggregated into three regions: Forested region Intermediate region Lowland region I do not know
Q.2	How many ha of arable land does the farm you manage encompass? (Include both owned and leased arable land, but exclude arable land you lease out.)	It does not have any arable land It has ha of arable land
Q.3	How many ha of the arable land is leased?	I do not lease any arable land I lease ___ha of arable land
Q.4	How many ha of your leasing contract(s) are covered by straw harvest restrictions?	Number of ha
Q.5	What area of a) cereals (winter wheat, spring wheat, rye, winter barley, spring barley, oats, winter triticale, and mixed grains for maturity) b) oil crops (winter rapeseed, spring rapeseed, winter turnip rape, spring turnip rape, and oil flax) was cultivated on the farm you managed in 2020? (Answer in hectares. If the crop was not cultivated, enter the number 0)	a/Number of ha b/Number of ha
Q.6	On the farm that you managed in 2020, what area did you not harvest any cereal or oilseed straw?	
Q.7	If there was a demand and the straw could be sold at a profit, does it matter for what it is intended to be used for? Please tick one or more of the following options.	I would consider selling straw:… to livestock use if I get the manure back… to livestock use without getting the manure back… to heat production… as a feedstock intended for high qualitative energy carriers (e.g. liquid fuels)… as a feedstock intended for new products (e.g. bio-based plastics) … I would not sell the straw regardless of the intended usage
Q.8	What is the minimum price* (cents of EUR per kg) you would consider selling your straw for? *The selling price refers to baled straw in large bales collected from the farmyard. The production cost for baled straw in 2018 was estimated to be 50–60 EUR per tonne of straw (5–6 cents of EUR per kg).[b] Source: Rosenqvist (2018)	I would not sell my straw regardless of the price Don't know The lowest selling price (cents of EUR per kg) is:

[a] The detailed farm locations were initially collected based on multiple harvest zones. For the purpose of this analysis, these zones were aggregated into three broader regions: Forested region, Intermediate region, and Lowland region (Table S1).
[b] The accepted price is given in "öre" where 100 öre (equivalent to 1 SEK) approximated 0.1 Euro during the period from February to April 2021 (1 EUR = 10.14 SEK).

The survey was conducted in Swedish, with the questionnaire developed and hosted using the Netigate (2024) survey tool. The questionnaire included a cover letter (see Supplementary Information) that explained the study's objectives and emphasised that participation was voluntary. The survey contained 34 questions and none of the questions were mandatory to answer (see Supplementary Information). The questions analysed for this study focussed on the location, size, and tenure of the farm; the size of areas used for cereal and oilseed crops in 2020; the cereal and oilseed areas for which straw wan not harvested in 2020; and the end used for which the straw could potentially be sold for profit, assuming demand existed and the minimum price requested under those circumstances.

2.2.2. Data collection and response rates

The survey was deployed on February 17, 2021, and remained open until April 23, 2021. A reminder about participation was issued once to all the farmers in the sample. A total of 174 respondents submitted responses to the questionnaire, yielding a response rate of 7 %. Of these, the responses of 31 respondents were excluded due to incomplete information. A refined sample of 143 responded to the questions used in this study (6 % response rate), representing 2 % of the farming community in Scania. Among the remaining 143 respondents, 21 did not cultivate cereals or oilseed crops in 2020 and were therefore excluded from the analysis. The final analytical sample thus comprised 122 respondents (Table 3).

Although modest, this response rate is in line with other recent survey-based studies of farmers' attitudes and decision-making, where response levels below 10 % are common (Nepal et al., 2020; Rommel et al., 2022). Similar challenges with recruitment and mode-dependent response rates have been reported by Hasler et al. (2019), who found lower participation in online surveys compared to mixed or face-to-face approaches.

2.2.3. Data preparation

The sample data underrepresents smaller farms, as evidenced by a lower proportion of farms in the smaller size categories compared to the population data from the Swedish Board of Agriculture (2025) (Table 1). The survey sample data included observations on total farm arable land area (Q.2 in Table 2) and cereal and oilseed crop area in 2020 (Q.5 in Table 2). Area-based weights were calculated for each farm size bin by dividing the population areas by the total sample area (Table 1). These weights were then assigned to the sample data according to the farm size bin into which each observation fell. This scaling ensured that the area predictions reflected the total population. However, it should be noted that farms in the smallest size class were not represented in the sample.

The survey included questions requiring totals and corresponding subsets. To resolve inconsistencies, totals took precedence over subsets unless missing.

2.3. Statistical analysis

In this study, P.1 represents a conceptual premise about the potential misrepresentation of biomass supply if farmers' willingness to sell straw is not accounted for. This premise cannot be tested directly. Instead, we evaluate its plausibility indirectly by testing three empirical consequences (P.1a–c) derived from it. Bayesian statistical methods are applied to these empirical consequences, allowing estimation of posterior probabilities and credible intervals for group differences and relationships. This approach provides an interpretable, probabilistic framework for assessing the support for each empirical consequence and, by extension, the conceptual premise.

Bayesian statistics were employed due to their suitability for small sample sizes. Unlike frequentist approaches, which rely heavily on large sample sizes for reliable inference, Bayesian methods can provide robust estimates and credible intervals even with limited data (e.g. McElreath, 2016). This flexibility allows for more nuanced interpretation of results,

Table 3
Distribution of farms in the sample across regions (as shown in Fig. 1), along with their mean farm sizes (n = 118).

Region	Count	Mean farm size (ha)
Forested region	8	80
Intermediate region	38	118
Lowland region	72	179

especially when data are sparse or unevenly distributed across categories. Additionally, Bayesian analysis facilitates direct probabilistic statements about parameters, making it particularly useful for understanding uncertainty and comparing outcomes.

Following Jeffreys (1939), and assuming weakly informative prior distribution, the evidence strength was interpreted as described in Table 4. Weakly informative priors were used to stabilise parameter estimation and reflect minimal prior knowledge. While Jeffreys' scale was originally formulated with non-informative priors, its interpretation remains valid under weakly informative priors, as they impose negligible influence on the posterior distributions in this context.

2.3.1. Hypothesis testing and inference

To examine differences between groups of respondents, we conducted Bayesian binomial and Bayesian proportion tests. To compare differences between samples, we used the Bayesian Estimation Supersedes the *t*-test (BEST). This method estimates posterior distributions for group means and standard deviations and quantifies the probability that the mean value in one group exceeds another.

These tests were performed using a non-informative prior with a prior probability of 0.5 and were implemented using the R package "Bayesian First Aid" (Bååth, 2014).

To evaluate differences in the maximum area available for harvesting cereal and oilseed straw across respondent groups (Q.7 in Table 2) based on the total scaled area cultivated with cereal and oilseed in 2020 (Q.5 in Table 2), a Bayesian permutation test was conducted. This test accounts for overlapping group membership and uses posterior sampling to estimate probabilities and credible intervals for group comparisons.

The analysis involved the following steps: (1) weighted group statistics, including mean, total weight, and total harvestable area, were calculated for the observed data; (2) permutations of the data were performed to generate distributions of group-specific harvestable areas under the null hypothesis; (3) posterior samples were generated for each group using a normal distribution centred on the group-specific permuted totals, with the standard deviation proportional to the magnitude of the total. This approach implicitly assumes weakly informative priors based on the permuted data, reflecting the null hypothesis distribution; (4) Bayesian probabilities, mean differences, and 95 % credible intervals (CI) were computed to compare specific groups of interest; and (5) a consistency check was performed to ensure the validity of the analysis. This check included verifying that the posterior probabilities were within a valid range (0–1), ensuring that the credible intervals were logical (with lower bounds not exceeding upper bounds), and identifying any discrepancies between observed and permuted results.

To analyse the relationship between respondents' minimum price of cereal and oilseed straw (Q.8 in Table 2) and their willingness to sell straw (fraction of land area cultivated with cereals and oilseed in 2020 where straw was excluded from harvesting without being subject to harvesting restrictions, Q6 in Table 2), we employed a Bayesian robust correlation analysis following Bååth (2014). The analysis was implemented in R via custom JAGS model using rjags (Plummer, 2025) and coda packages (Plummer et al., 2006). This approach models the joint distribution of the two variables with a multivariate t-distribution, providing robustness to outliers and heavy-tailed data. Weakly informative priors were specified for the means, standard deviations, correlation coefficient, and degrees of freedom. Markov Chain Monte Carlo (MCMC) sampling was used to estimate posterior distributions of the correlation coefficient and other model parameters. Posterior samples were summarised as medians with 95 % credible intervals. Posterior predictive draws were used to visualise uncertainty in the relationship via 50 % and 95 % credible ellipses.

Table 4
Evidence strength according to Jeffreys (1939), assuming non-informative priors.

Evidence strength	Posterior probability
Null hypothesis supported	<0.5
Bare mention	$0.50 < p < 0.77$
Substantial evidence	$0.77 < p < 0.91$
Strong evidence	$0.91 < p < 0.97$
Very strong evidence	$0.97 < p < 0.99$
Decisive evidence	>0.99

The open-source software R Project for Statistical Computing v. 4.4.1 (R Core Team, 2024) was used for all statistical analyses.

All Bayesian analyses were conducted to estimate posterior probabilities and credible intervals, thereby providing robust and interpretable measures of uncertainty.

A Sankey diagram was constructed using the "networkD3″ library in R (Allaire et al., 2017). The diagram visualises the distribution of respondents' stated choices for straw use and the corresponding cultivated land areas, with flows scaled proportionally to represent the areas allocated to various end-use categories. Input data included the scaled land area cultivated with cereals and oilseed in 2020, stratified by respondents' stated choices for straw use and minimum price levels with fractions determined using bootstrapping methodology (Q.6–Q.8 in Table 2).

3. Results

Three empirical consequences of P.1, which states that the absence of data on farmers' willingness to sell straw for energy purposes may lead to a misrepresentation of the biomass supply from cereal and oilseed straw in biomass potential assessments, were tested.

3.1. 1a/among respondents willing to sell straw, the fraction of respondents willing to sell varies across different end uses of the delivered straw

Under the assumption that there was demand and the straw could be sold at a profit, an estimated share of **80 %** (95 % CI: 73–87) of respondents expressed a willingness to sell straw (Q.7 in Table 2).

An estimated 52 % (95 % CI: 44–61) of all respondents were open to selling straw for at least one alternative related to bioenergy or new products, but an estimated 20 % (95 % CI:13–27) were not willing to sell straw for any end use. We tested empirical consequence 1a/, which states, among respondents willing to sell straw, the fraction of respondents willing to sell varies across different end uses of the delivered straw. Our analysis found very strong evidence (posterior probability = 98.5 %) that the willingness to sell depended on the intended end use of the straw (Fig. 2) (Table 5). The effect was also reflected in the scaled maximum land area available for each alternative end use. Our analysis found substantial evidence that the maximum available area differs between alternative end uses (Fig. 2) (Table 6). The scaled maximum land area was calculated as the total area cultivated with cereals and oilseed in 2020, adjusted for the area the respondents stated they would never sell the straw from and the leased area under straw harvest restrictions. The largest land area was managed by those willing to sell straw for livestock use, provided they received manure in return, and those who favoured selling for high quality energy use.

3.2. 1b/It is more common for those leasing at least 50 % of the arable land they cultivate to be willing to sell straw compared to those leasing less than 50 %

In Sweden, the average fraction of leased arable land was 46 % in 2023 (43 % in Scania) (Swedish Board of Agriculture, 2025). A similar proportion of the respondents' total arable land area was leased (44 %) (95 % CI: 32 %–60 %), with only 4 % (95 % CI: 2 %–8 %) of the leased area subject to restrictions on harvesting straw (Q.3–Q.4 in Table 2) (Table S2). Approximately 31 % (95 % CI: 23 %–39 %) of the respondents leased more than 50 % of the land they cultivate.

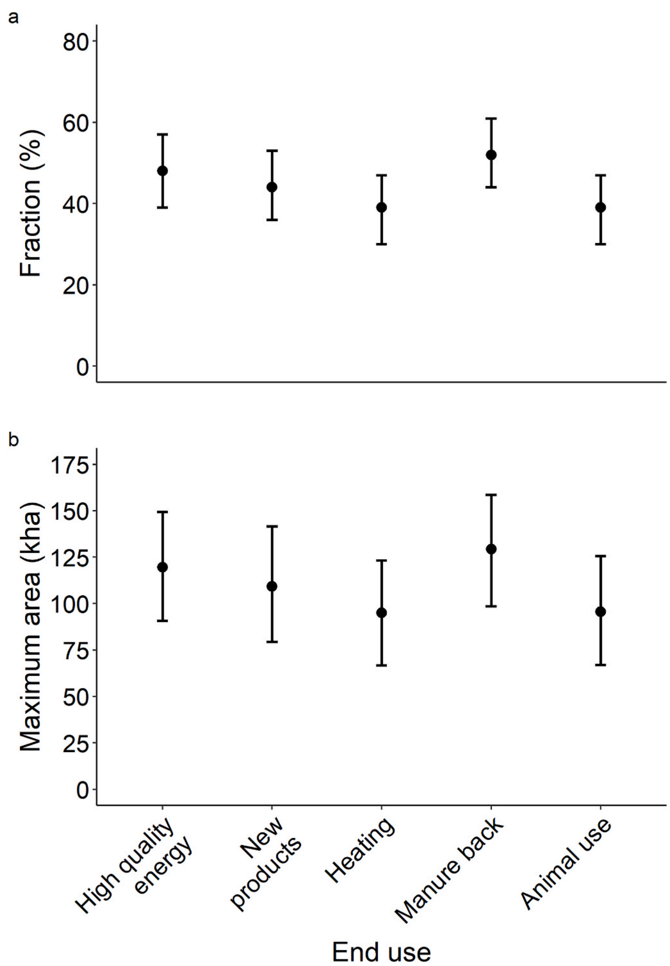

Fig. 2. Estimated relative frequency of willingness to sell straw by end use: (a) fraction of respondents (%) willing to sell (Q.7 in Table 1), and (b) estimated maximum land area available for each alternative, reflecting the total cereal and oilseed area in 2020, adjusted for non-sellers, restrictions. Each dot represents a posterior estimate from the Bayesian model, and vertical lines indicate 95% credible intervals. Respondents could select multiple end uses. Total sample size = 122.

We tested empirical consequence 1b/, which states it is more common for those leasing at least 50 % of the arable land they cultivate to be willing to sell straw compared to those leasing less than 50 % using a Bayesian proportions test. The results indicate very strong evidence (posterior probability = 98.3 %) that respondents leasing more than half of their arable land are more willing to sell straw to at least one end use (Table 7). This difference persisted even when considering at least one of the specific end uses new products, high-quality energy carriers or heating, with a posterior probability of 99.8 %.

3.3. 1c/the price of straw significantly correlates with respondents' willingness to sell

Among the 64 farmers open to selling straw for heating, high-quality energy carriers, or new products, 36 specified a minimum acceptable price. We tested the empirical consequence 1c/, which states that the price of straw significantly correlates with respondents' willingness to sell. A Bayesian robust correlation analysis (Bååth, 2014) was used to analyse the relationship between fraction of area cultivated with cereals and oilseed in 2020 and respondents' willingness to sell straw. The analysis accounted for adjustments, including areas for which the straw was already harvested and leased areas under straw harvest restrictions. The correlation was assessed in relation to respondents' specified hypothetical minimum price (Fig. 3) (Table S3).

Table 5
Results of a Bayesian proportions test comparing the proportion of respondents willing to sell straw for each end use. Note that respondents could select multiple alternative end uses (Q.7 in Table 2). The total sample size of 122 refers to the number of respondents surveyed, and the proportions are calculated from the raw count of respondents in each group.

End use	*Estimated relative frequency of respondents willing to sell straw*	*95 % Credible interval (lower–upper)*	*End use comparisons (posterior probability)*[a]
High quality energy	0.48	(0.40–0.75)	73.9 % (High quality energy > New products) 93.8 % (High quality energy > Heating) 93.8 % (High quality energy > Livestock use)
New products	0.44	(0.36–0.53)	81.5 % (New products > Heating) 81.9 % (New products > Livestock use)
Heating	0.39	(0.30–0.47)	50.2 % (Heating > Livestock use)
Manure back	0.52	(0.44–0.61)	73.7 % (Manure back > High quality energy) 89.9 % (Manure back > New products) 98.5 % (Manure back > Heating) 98.5 % (Manure back > Livestock use use)
Livestock use	0.39	(0.30–0.47)	–

[a] Posterior probabilities reflect the likelihood that the proportion of respondents willing to sell straw for one end use exceeds that of another.

The analysis revealed a weak, not statistically significant negative correlation ($\rho = -0.03$) between the minimum acceptable hypothetical price per kilogram of straw and the willingness to sell straw. While there is some indication of a negative relationship, it is weak and not significant, implying that other factors beyond price likely play a more substantial role in farmers' decisions to sell straw.

We also tested for a difference in minimum price between regions (Table 8). The analysis accounted for already harvested straw and leased areas with straw harvest restrictions. The results suggested substantial evidence (79.9 % probability) that the minimum price was higher in the Intermediate region compared to the Lowland region.

3.4. Assessing land availability for straw-based energy and new material applications

Within the sampled farms, 71 % (302 kha when scaled to the parent population), was used for the cultivation of cereals and oilseed in 2020 (Table S4). Straw was harvested from 36 % (95 % CI: 28 %–45 %) of this scaled cultivated area (Table S4). However, the rate of straw harvesting varied between farms. The results suggest strong evidence ($p = 0.96$) that the rate of straw harvest was higher on farms in the combined Forested and Intermediate regions compared to those in the Lowland region, although with substantial variation in the results (Fig. 1) (Fig. 4) (Table S5).

The value of straw to individual farmers can, to some extent, indicate their willingness to supply. This value encompasses both the potential revenue from selling the straw and other benefits, such as soil fertility

Table 6
Results of a Bayesian permutation test comparing the scaled maximum land area available for harvesting cereal and oilseed straw for each end use. The analysis assumes that each respondent favourable to harvesting straw for a specific end use would harvest straw on an area corresponding to their cultivated area of cereals and oilseed in 2020. (Total sample size = 98). Note that respondents could select multiple alternative end uses (Q.7 in Table 2).

End use	*Estimated scaled maximum area available (kha)*	*95 % credible interval (upper–lower) (kha)*	*End use comparisons (posterior probability)*[a]
High quality energy	120	(90–151)	71.6 % (High quality energy > New products) 89.8 % (High quality energy > Heating) 89.3 % (High quality energy > Livestock use)
New products	110	(80–141)	78.0 % (New products > Heating) 76.7 % (New products > Livestock use)
Heating	96	(66–126)	–
Manure back	130	(99–159)	65.8 % (Manure back > High quality energy) 78.6 % (Manure back > New products) 90.7 % (Manure back > Heating) 89.6 % (Manure back > Livestock use)
Livestock use	95	(67–128)	50.6 % (Livestock use > Heating)

[a] Posterior probabilities reflect the likelihood that the maximum available land area for one end use exceeds that of another.

Table 7
Comparing the willingness to sell straw to at least one end use by the share of total arable land area leased tested using Bayesian proportions tests (n = 122).

Willingness to sell straw	*Estimated relative frequency among respondents leasing ≥50 %*	*95 % credible interval (%)*	*Comparison (posterior probability)*[a]
Yes, to at least one end use	0.90	(0.80–0.98)	98.3 % (More than half leased > half or less leased)
Yes, to new products, high quality energy and/or heating	0.72	(0.58–0.85)	99.8 % (More than half leased > half or less leased)

[a] Posterior probability reflects the likelihood that willingness to sell straw among respondents leasing ≥50 % of their land exceeds that of respondents leasing ≤50 %.

advantages of leaving it in the field. However, the absence of an active market means that non-harvesting, where straw is left in the field to decompose, should not necessarily be interpreted as a refusal to sell. To assess the potential supply of straw, we surveyed farmers about their willingness to sell under various conditions, assuming buyers were available, the straw could be sold at a profit and using the scaled land area cultivated with cereals and oilseed in 2020 as the basis (Q.7 and Q.8 in Table 2). We found that a maximum of 57 % (95 % CI: 42–75) of the area was available for energy purposes on the market (Table S6).

While the Bayesian robust correlation analysis revealed no significant relationship between the hypothetical price and willingness to sell straw, the Sankey diagram (Fig. 5) offers additional context by illustrating the distribution of respondents across price categories and end-use preferences.

4. Discussion

This study highlights key factors influencing the availability of cereal and oilseed straw for bioenergy and bioproducts in the county of Scania, Sweden. These findings contribute to the growing body of research highlighting the importance of farmer preferences, land tenure arrangements, and market dynamics in determining the practical realisable potential biomass supply. Specifically, we tested three empirical consequences of P.1/, which posits that the absence of data on farmers' willingness to sell straw for energy purposes may lead to a misrepresentation of the biomass supply from cereal and oilseed straw in biomass potential assessments. Using these results, we assessed the availability of land in Scania, for the supply of cereal and oilseed straw for energy and material applications. This research provides insights into farmers' decision-making regarding biomass markets and provides evidence to inform the development of effective policies for the sustainable utilisation of agricultural residues in energy production. The data was collected in 2021, prior to the implementation of incentives aimed at increasing the storage of carbon in soils and biomass to meet requirements related to Land Use, Land Use Change, and Forestry (LULUCF) regulations (see European Union, 2023c), including carbon credits etc., which may potentially affect the future conditions for straw harvesting.

4.1. 1a) among respondents willing to sell straw, the fraction willing to sell varies across different end uses of the delivered straw

Bioenergy and new material applications were supported by slightly more than half of the farmers. Empirical consequence 1a), stating that among respondents willing to sell straw, the fraction willing to sell varies across different end uses of the delivered straw was corroborated with a posterior probability of 98.5 %, suggesting very strong evidence in favour of the relationship (Fig. 2) (Table 5). Farmers showed greater willingness to supply straw for uses providing ancillary benefits, particularly receiving manure in barter arrangements (Fig. 2). Strong evidence for differences between other end uses also challenges fundamental assumptions about market functioning.

These findings suggest that even in a market setting without barter arrangements, farmers' motivations to sell may depend significantly on the intended end use of the product. This observation aligns with previous studies indicating that producers' decisions are influenced by factors beyond immediate financial incentives (e.g. Blennow et al., 2014; Anander et al., 2024) and underscore the complexity of supply decisions in agricultural and forestry markets, where non-economic factors can play a significant role in shaping market behaviour.

These results are exploratory and based on farmers stated willingness, which may not fully correspond to actual straw supply under real market conditions; therefore, estimates of land availability for energy use should be interpreted as indicative rather than definitive.

4.2. 1b) It is more common for farmers leasing at least 50 % of the land they cultivate to be willing to sell straw compared to those leasing less than 50 %

Empirical consequence 1b), stating that it is more common for farmers leasing at least 50 % of the land they cultivate to be willing to sell straw compared to those leasing less than 50 % was corroborated with a posterior probability of 98.3 % suggesting very strong evidence in favour of the association (Table 7).

This outcome may be explained by several interrelated factors (cf. Lynes et al., 2016). One key consideration is the motivation behind land management practices. Farmers leasing a substantial portion of their land may not view long-term soil fertility as a priority, since their tenure

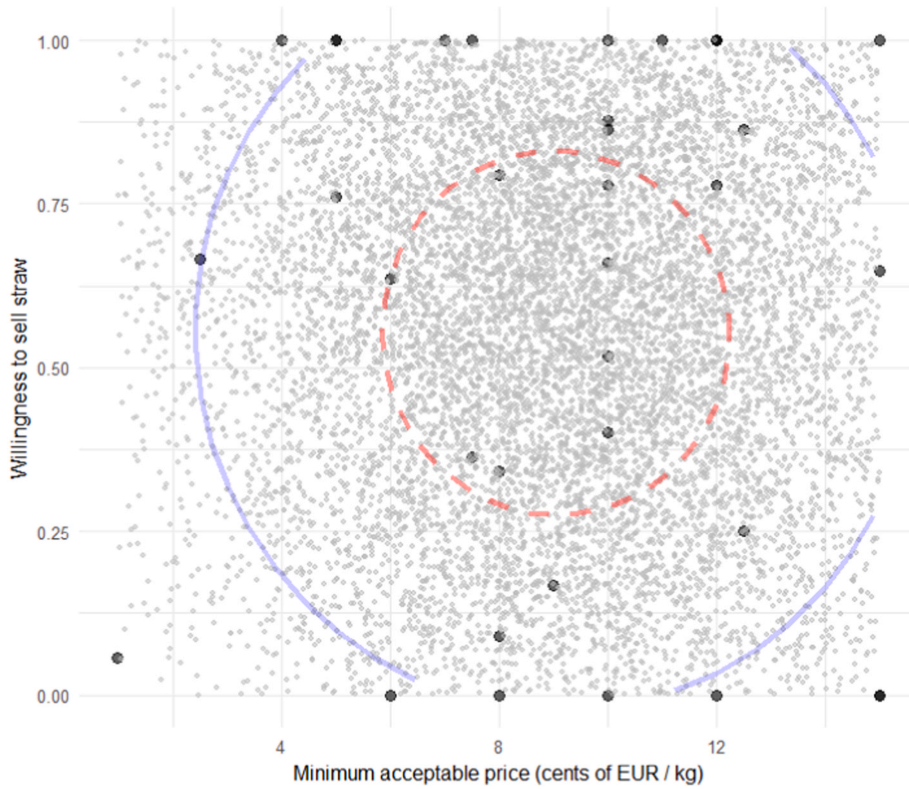

Fig. 3. Relationship between the minimum acceptable hypothetical price per kg (Q.8 in Table 1) and the respondents' willingness to sell straw (fraction of land area cultivated with cereals and oilseed in 2020, Q.6 in Table 2). Posterior draws from the Bayesian robust model are represented as points, with 50% (dashed ellipse) and 95% (solid ellipse) credible regions, illustrating uncertainty in the relationship. Only respondents willing to sell straw for heating, high-quality energy carriers, or new products are included in the analysis (n = 36). For details, see Table S2.

Table 8
Differences in minimum price across regions in Scania, Sweden, using the Bayesian Estimation Supersedes the *t*-test (BEST) (n = 34) (Q.1 and Q.8 in Table 2). The analysis accounted for the factors already harvested straw and leased areas with straw harvest restrictions and excluded two respondents who had not provided their geographical location.

Region	*Mean minimum price (EUR cents)*	*95 % Credible interval (lower–upper)*	*Comparison posterior probability*[a]
Forested region (n = 0)	No data available	–	–
Intermediate region (n = 9)	10	(8–13)	79.9 % (Intermediate region > Lowland region)
Lowland region (n = 25)	9	(8–11)	20.1 % (Lowland region > Intermediate region)

[a] Posterior probability indicates the likelihood that the minimum price in one region exceeds that in the other.

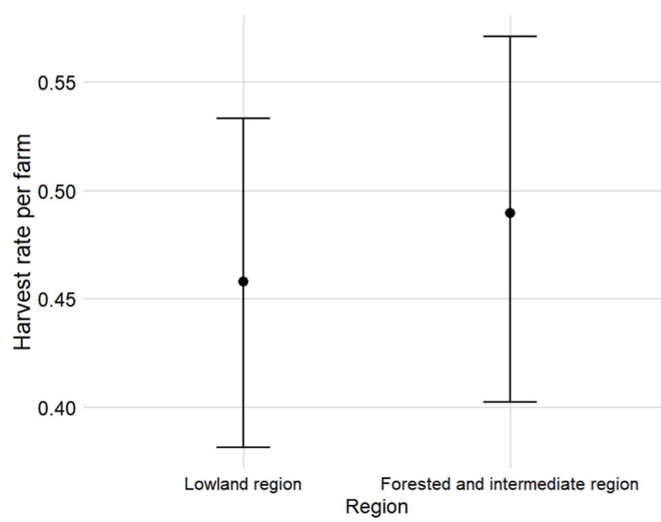

Fig. 4. Rate of farm-based cereal and oilseed straw harvest by region in 2020 estimated using a Bayesian zero-one inflated beta model. Estimates represent posterior means, with 95% credible intervals (CIs) (Table S3). Due to the small sample size in the Forested region (Table 3) and the lack of a significant difference between the Forested and the Intermediate regions, the two regions were merged.

is typically shorter than that of landowners. Consequently, they may be more willing to sell straw, viewing it as an additional source of income. In contrast, farmers owning most of the land they cultivate may feel more responsible for the land's long-term productivity and, as a result, may choose to retain the straw for its agronomic benefits, such as improving soil health and organic matter. This interpretation is supported by the results of Thomson Ek et al. (2024) who found negative environmental consequences, such as soil depletion, to be a major factor constraining the availability of straw in Sweden.

Further, this trend was consistent across different end-uses of straw, such as for new products or high-quality energy carriers, with a posterior probability of 99.8 % (Table 7). This suggests that farmers' motivations extend beyond immediate financial gain, potentially reflecting concerns about how their agricultural practices may affect future soil productivity.

Moreover, the study indicates that straw is not simply viewed as a residue but rather as a valuable agronomic resource that is integral to

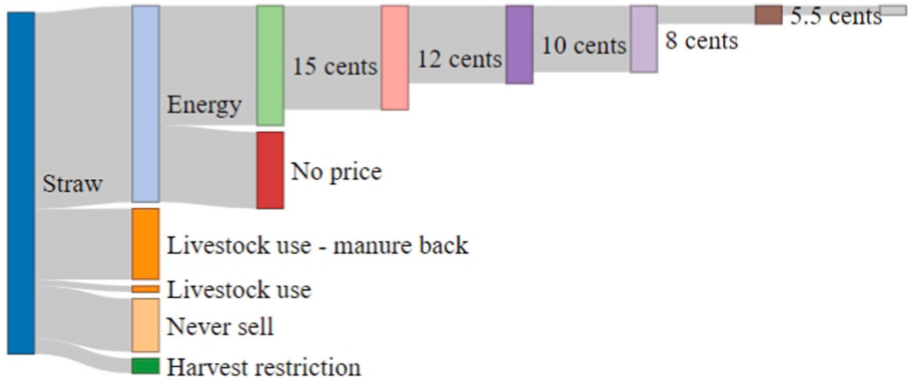

Fig. 5. Sankey diagram illustrating the distribution of maximum areas for which respondents were willing to sell cereal and oilseed straw for energy-related end uses ("Heating" and/ or "High-quality energy") at various minimum prices in cents of EUR. Each respondent chose at least one energy-related end use, but they may have also selected other uses such as "Livestock use – manure back" or "Livestock use." "Maximum" implies the highest area allocated for energy use, even if other uses were chosen. The diagram also shows exclusive end uses other than energy ("Livestock use – manure back", "Livestock use", or "Never sell"; no respondent exclusively selected "New products"). The plot highlights the classification of these respondents based on their stated choices, illustrating the average bootstrapped proportions across the respective categories. The scaled land area cultivated with cereals and oilseed in 2020 (Q.7 and Q.8 in Table 2) is used as the basis for the analysis. For raw data and uncertainty estimates, see Table S4.

farming practices. This highlights the importance of understanding the broader, non-economic motivations that influence farmers' decisions. For example, farmers with manure applications as an integral part of their agricultural practices or who hold long-term land tenure may be less inclined to sell straw, as they prioritise maintaining soil health and fertility.

4.3. 1c) the price of straw significantly correlates with respondents' willingness to sell

Empirical consequence 1c), stating that the price of straw significantly correlates with respondents' willingness to sell was not corroborated. The Bayesian robust correlation analysis revealed a weak and statistically insignificant negative relationship ($\rho = -0.03$) between the hypothetical minimum price farmers would accept for straw and their willingness to supply straw, providing insufficient evidence to support the expectation that price significantly influences supply decisions (Fig. 3).

Economic theory suggests that higher prices should incentivise farmers to sell more straw, with those less inclined to sell requiring higher prices. However, our results suggest that price is not the primary determinant in farmers' willingness to sell. This finding contrasts somewhat with the perspective of Thomson Ek et al. (2024), who emphasised the importance of economic incentives, such as market prices and subsidies, in stimulating market availability of plant residues. Although economic incentives were considered important, our study highlights that non-economic factors, such as agronomic concerns, competing uses like animal bedding, and other farm-specific considerations, play a larger role in farmers' decisions than price alone.

In line with Gérard and Jayet (2023), while price increases may have limited direct effects on straw supply, they could influence broader factors such as land allocation and input use. This highlights the need for carefully coordinated policies that consider both economic incentives and the environmental consequences of bioenergy production.

These results align more closely with findings from Townsend et al. (2018), who observed that even generous payments for straw did not significantly increase supply, as a considerable portion of straw was still retained for other uses, such as incorporation into the soil.

In our study, while price was not a significant motivator, regional differences in price expectations highlighted variations in market conditions. For instance, farmers in the Intermediate region (Fig. 1) (Table 8), where animal husbandry is prevalent, demanded higher prices likely due to competing uses for straw, such as bedding. These regional disparities reinforce the need for regionally tailored policies that consider local farming practices and priorities when designing biomass supply strategies.

Giannocarro et al. (2017) observed similar pricing behaviour among Italian farmers, who demanded straw prices exceeding local market rates, reflecting price resistance in emerging bioenergy markets. Our findings indicate a parallel trend in Sweden, where farmers often require premium prices for straw. However, unlike the Italian context, Swedish farmers appear more influenced by non-economic factors, such as the perceived long-term soil fertility benefits of retaining straw. This is consistent with our findings in Sections 4.1 and 4.2, where owners of land were less inclined to sell straw than those leasing it (Table 7).

4.4. P.1/the absence of data on farmers' willingness to sell straw for energy purposes may lead to a misrepresentation of the biomass supply from cereal and oilseed straw in biomass potential assessments

Our research addressed P.1/, stating that the absence of data on farmers' willingness to sell straw for energy purposes may lead to a misrepresentation of the biomass supply from cereal and oilseed straw in biomass potential assessments. Although this premise cannot be tested directly, we examined three empirical consequences derived from it to assess its plausibility. We also recognise that changes in the availability of land can affect all potential estimates, regardless of assumptions about soil carbon retention or biodiversity needs. The findings indicate that farmers' willingness to sell straw is influenced by the intended end use, with preference given to uses offering additional benefits, such as barter arrangements or agricultural contributions, rather than those focused solely on bioenergy (Fig. 2). Land tenure plays a significant role, with farmers leasing over 50 % of their arable land more likely to participate in straw markets (Table 7). Contrary to expectations, straw supply is not highly price-sensitive, as the rate of harvest for cereals and oilseed did not correlate with the hypothetical price farmers would accept for selling straw for energy purposes (Fig. 3). Competing uses, such as animal bedding and straw's role in soil fertility, are more critical in shaping farmers' choices.

Taken together, these results provide partial support for the premise by illustrating that non-economic and structural factors, rather than price alone, govern the actual availability of straw for energy use. While the observed lack of price sensitivity does not directly confirm the premise, it reinforces the broader argument that simplifying assumptions in biomass potential assessments risk misrepresenting the true supply. These findings therefore highlight the need for regionally tailored assessments and policies that consider local farming practices, land tenure structure, and farmers' non-economic motivations.

4.5. Assessing land availability for straw-based energy and new material applications

While cereals and oilseed was cultivated on a large proportion of the arable land in 2020, straw was harvested (removed) from only 36 % (95 % CI: 29 %–45 %) of this land for all end uses, indicating significant potential for increased supply (Table S4). The harvest rate varied considerably between farms (Fig. 3) and was, on average, higher in the Forested and Intermediate regions, where animal husbandry is more prevalent, compared to the Lowland region (Fig. 4).

As discussed in Sections 4.1–4.4, several factors influence the supply. While the straw from 16 % (95 % CI: 11–21) of the land used for cereals and oilseed would not be sold regardless of the intended end use, at least 20 % (95 % CI: 14–28) of the total cultivated land area would be available only on the condition of receiving manure in return. However, up to 57 % (95 % CI: 42–75) of the cultivated area could potentially be made available for energy applications if prices were sufficiently high (Fig. 5) (Table S6). These figures represent the maximum potential areas available for energy use, assuming that hypothetical price incentives are strong enough to overcome other constraints, such as competing uses for straw and agronomic priorities. Given the small and potentially biased sample, this extrapolation should be interpreted as exploratory and indicative rather than a precise estimate of regional straw availability.

The relationship between price and willingness to supply straw is weak and statistically insignificant (Fig. 3), suggesting that price alone is not the primary factor in determining straw availability. Instead, competing uses for straw, such as its role in animal husbandry and its agronomic benefits, appear to be more influential in shaping farmers' decisions. While higher prices could hypothetically incentivise additional supply, non-monetary motivations play a greater role in limiting straw availability. In regions with higher rates of animal husbandry (such as the Forested and Intermediate regions; see Fig. 1), farmers may be less willing to divert straw for bioenergy uses due to these competing demands.

Biomass potential studies often set a maximum removal rate of straw at the field level to safeguard soil fertility and carbon storage. For example, the recommendation by Imperial College (2021) assume that a maximum of 40–50 % of field residues can be safely removed. However, our findings demonstrate that biomass potential assessments must consider not only field-level removal constraints but also farmers' willingness to harvest and sell the removed straw. The availability of land for straw harvest varies not only between farms (Fig. 3) but also between regions (Fig. 4). While the willingness to sell straw was less price sensitive than expected, it was influenced by the intended end use (Fig. 2), competing uses (Fig. 2), and land tenure arrangements (Table 7).

4.6. Policy implications

This study highlights the need to integrating farmer perspectives into biomass potential assessments to develop effective policy strategies. The problem-feeding framework (Persson et al., 2018) provides a nuanced understanding of the decision-making behind straw supply. This approach complements top-down biophysical assessments by addressing factors influencing farmer behaviour, thereby reducing the risk of misrepresenting biomass availability.

4.6.1. Land tenure, end use, and market incentives

Land tenure significantly influences farmers' willingness to sell straw. Farmers leasing a large share of their land are more likely to sell. However, willingness to sell also depends on the intended end use. Many farmers are more inclined to sell straw for livestock bedding or local use rather than for bioenergy, reflecting concerns about soil fertility and long-term sustainability. Policies should account for these differences by offering tailored incentives, such as nutrient recycling schemes that compensate for agronomic losses, particularly in regions where straw is essential for animal bedding. Additionally, policies could explore contracts that differentiate between bioenergy and agricultural uses, ensuring that straw markets align with broader sustainability goals.

4.6.2. Beyond price-based policies

Contrary to expectations, straw supply is not highly price sensitive. Instead, competing uses, barter arrangements, and agronomic concerns shape farmers' decisions. This suggests that price-based incentives alone may be insufficient. As proposed by Giannocarro et al. (2017) for Italy, policymakers could explore long-term contracts, sustainability certifications, and targeted subsidies that acknowledge both economic and agronomic considerations.

4.6.3. Region-specific policy design

Straw supply constraints vary regionally due to differences in land tenure, farming systems, and local markets. Policies must reflect these variations, particularly in areas with high demand for straw in animal husbandry. Supporting integrated agroecosystem planning, where straw markets align with broader sustainability goals, can improve biomass availability while safeguarding soil health.

4.7. Limitations and future research directions

This study has several limitations that should be acknowledged. First, the relatively low survey response rate, while comparable to other recent farmer studies, may lead to nonresponse bias if non-participating farmers differ systematically from respondents. Second, the analysis is based on stated attitude rather than observed behaviour; therefore, actual market participation may deviate from the expressed willingness to sell straw. Third, although Bayesian methods provide robust estimates with small samples and explicitly quantify uncertainty, the credible intervals for some parameters remain wide, reflecting data limitations. Furthermore, the study focuses on a single region, which may limit generalisability to other agricultural contexts with different structural or policy conditions. Finally, the cross-sectional design precludes conclusions about temporal dynamics in farmers' decision-making.

Future research should address these limitations by combining survey data with behavioural or longitudinal observations, expanding geographic coverage, and linking stated attitudes to revealed market outcomes. Moreover, studies could explore how economic and non-economic incentives, such as carbon credits, LULUCF regulations, and nutrient return schemes, shape farmers' decision-making and align local practices with broader agricultural and bioenergy goals. Integrating socio-economic, agronomic, and policy perspectives will be crucial for developing more realistic estimates of sustainable straw supply.

5. Conclusion

By integrating farmers' perspectives, we complement top-down biophysical assessments, emphasising the importance of understanding landowners' motivations, constraints, and economic realities for effective biomass policy development. Three key findings emerge:

1. Influence of intended end use: Farmers' willingness to sell straw is strongly influenced by the intended end use of the straw. They are more likely to participate in straw markets when the trade offers additional benefits, such as receiving manure through barter arrangements or using straw for agricultural purposes, rather than selling it solely for bioenergy or material production alone. This suggests straw should not be viewed merely as a residue but as a valuable resource with competing uses, requiring careful consideration in biomass assessments.

2. Impact of land tenure: Land tenure significantly affects farmers' decisions to sell straw, with those leasing over 50 % of their arable land more likely to supply straw. Policies should therefore account for land tenure, as motivations for straw supply vary by ownership and management practices.
3. Price sensitivity (exploratory): Straw supply appeared less responsive to price than expected. However, this conclusion is based on a small subsample (n = 36) of farmers reporting minimum acceptable prices and limited numbers within regional categories. Consequently, that the estimates of price sensitivity should be considered explorative and indicative, rather than robust evidence. Competing uses and agronomic considerations are likely more influential, but further research with larger samples is needed to confirm these patterns. Some regional differences were observed, such as higher price demands in areas with more animal husbandry, however, these patterns are based on small subsamples and should be interpreted as tentative insights rather than robust evidence.

Regarding land availability, up to 57 % (95 % CI: 42 %–75 %) of land used for cereals and oilseed could theoretically be made available for energy under high price incentives. This estimate should be interpreted cautiously, as it relies on stated willingness rather than actual behaviour and small, potentially biased subsamples, Non-economic factors, such as competing straw uses and agronomic priorities, will likely constrain actual supply. These results suggest that, while price incentives may play a role, policies would likely benefit from considering local farming conditions and other factors, recognising that regional patterns observed here are indicative and based on a small subsample.

In conclusion, these findings suggest the need for policies that integrate economic, agronomic, and personal factors, ensuring biomass supply is both economically viable and environmentally sustainable. Estimates of straw availability and price responsiveness are tentative and should be interpreted as exploratory insights, supporting the development of more nuanced and context-specific biomass assessments.

CRediT authorship contribution statement

Kristina Blennow: Writing – original draft, Visualization, Project administration, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Elin Anander:** Writing – original draft, Methodology, Investigation. **Lovisa Björnsson:** Writing – review & editing, Methodology, Conceptualization. **Pål Börjesson:** Writing – review & editing, Methodology, Conceptualization.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT in order to edit the English language. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Funding

This work was supported by the Swedish Energy Agency [grant number 45808-1] (to K.B., P.B. and L.B.) and [grant number P2021-00045] (to P.B. and L.B.).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

We are grateful to all interviewees and questionnaire respondents in the county of Scania for their invaluable contributions. Additionally, we would like to thank The Federation of Swedish Farmers (LRF) for their support in facilitating the participation of potential respondents in the survey and the Swedish Board of Agriculture for access to data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.enpol.2025.114980.

Data availability

The data can be accessed from the Swedish National Data Repository (https://doi.org/10.5878/egc3-xk28) by anyone with a legitimate interest in the data, as long as the transfer of data complies with the Swedish and European regulations on data protection.

References

Allaire, J., Gandrud, C., Russell, K., Yetman, C.. _networkD3: D3 JavaScript network graphs from R. R package version 0.4. https://CRAN.R-project.org/package=networkD3. https://doi.org/10.32614/CRAN.package.networkD3.

Anander, E., Börjesson, P., Björnsson, L., Blennow, K., 2024. Farmers' willingness to introduce short-rotation tree plantations on agricultural land: a case study in southern Sweden. Biomass Bioenergy 191C, 107424. https://doi.org/10.1016/j.biombioe.2024.107424.

Blennow, K., Persson, E., Lindner, E., Faias, S.P., Hanewinkel, M., 2014. Forest owner motivations and attitudes towards supplying biomass for energy in Europe. Biomass Bioenergy 67, 223–230. https://doi.org/10.1016/j.biombioe.2014.05.002.

Bååth, R., 2014. Bayesian first aid: a package that implements bayesian alternatives to the classical test functions in R. Proc. UseR! 2014-the Int. R User Conf. 86. https://user2014.r-project.org/files/Abstracts.pdf.

Börjesson, P., 2021. The potential of an increased supply of domestic biomass in a growing Swedish bio-economy – an update. Lund University, Department of Environmental and Energy Systems Study (In Swedish.) Accessed 250109. https://lucris.lub.lu.se/ws/portalfiles/portal/96470174/B_rjesson_P._2021._Rapport_nr_121_Milj_och_energisystem_Lunds_universitet.pdf.

EEA, 2025. Share of Energy Consumption from Renewable Sources in Europe. European Environment Agency. https://www.eea.europa.eu/en/analysis/indicators/share-of-energy-consumption-from?activeAccordion=546a7c35-9188-4d23-94ee-005d97c26f2b. (Accessed 10 February 2025).

Ekman, A., Wallberg, O., Joelsson, E., Börjesson, P., 2013. Possibilities for sustainable biorefineries based on agricultural residues – a case study of potential straw-based ethanol production in Sweden. Appl. Energy 102, 299–308.

Erlandsson, U., 1999. Näringsliv. In: Germundsson, T., Schlyter, P. (Eds.), Atlas Över Skåne. Almqvist & Wiksell, Uppsala, pp. 133–136 (In Swedish.).

European Council, 2025. Fit for 55. Council of the European Union. https://www.consilium.europa.eu/en/policies/fit-for-55/. (Accessed 19 February 2025).

European Union, 2023a. Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, regulation (EU) 2018/1999 and directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing council directive (EU) 2015/652. Series L. Official Journal of the European Union.

European Union, 2023b. Regulation (EU) 2023/839 of the European Parliament and of the Council of 19 April 2023 amending Regulation (EU) 2018/841, and Regulation (EU) 2018/1999. Series L. Official Journal of the European Union.

European Union, 2023c. Regulation (EU) 2023/841 of the European parliament and of the council of 19 April 2023 amending regulation (EU) 2018/841 as regards the scope, simplifying the reporting and compliance rules, and setting out the targets of the member states for 2030, and regulation (EU) 2018/1999 as regards improvement in monitoring, reporting, tracking of progress and review. Series L. Official Journal of the European Union.

Eurostat, 2023. Farms and Farmland in the European union-statistics. Stat. Off. Eur. Union, Luxembourg. Last Updat. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farms_and_farmland_in_the_European_Union_-_statistics#Farms_in_2020Accessed20241210.

Gérard, M., Jayet, P.-A., 2023. European farmers' response to crop residue prices and implications for bioenergy policies. Energy Policy 177, 113561. https://doi.org/10.1016/j.enpol.2023.113561.

Giannocarro, G., Bernardo, C., de Gennaro, B.C., DeMeo, E., Prosperi, M., 2017. Assessing farmers' willingness to supply biomass as energy feedstock: cereal straw in Apulia (Italy). Energy Econ. 61, 179–185. https://doi.org/10.1016/j.eneco.2016.11.009.

Hasler, B., Hansen, L.B., Olesen, J.E., Witzke, H.P., Kurppa, S., Pyykkönen, P., et al., 2019. Farmers' preferences for nutrient and climate-related agri-environmental schemes in the Baltic Sea region. Ambio 48 (11), 1327–1339. https://doi.org/10.1007/s13280-019-01242-6.

Imperial College, 2021. Sustainable Biomass Availability in the EU, to 2050. Imperial College London, Consultants, London.

Janiszewska, D., Ossowska, L., 2022. The role of agricultural biomass as a renewable energy source in European union countries. Energies 15, 6756. https://doi.org/10.3390/en15186756.

Jeffreys, H., 1939. Theory of Probability, second ed. Oxford University Press.

Lynes, M.K., Bergtold, J.S., Williams, J.R., Fewell, J.E., 2016. Willingness of Kansas farm managers to produce alternative cellulosic biofuel feedstocks: an analysis of adoption and initial acreage allocation. Energy Econ. 59, 336–348.

McElreath, 2016. Statistical Rethinking. A Bayesian Course with Examples in R and Stan. CRC Press.

Nepal, S., Tran, L.T., Hodges, D.G., 2020. Determinants of landowners' willingness to participate in bioenergy crop production: a case study from Northern Kentucky. Forests 11, 1052. https://doi.org/10.3390/f11101052.

Netigate, 2024. Mapping energy crop cultivation and identifying motivational factors among Swedish farmers. In: Ostwald, M., Jonsson, A., Wibeck, V., Asplund, T. (Eds.), Biomass Bioenergy 50, 25–34. https://doi.org/10.1016/j.biombioe.2012.09.058. https://www.netigate.net/. (Accessed 26 February 2024), 2013.

Ostwald, M., Jonsson, A., Wibeck, V., Asplund, T., 2013. Mapping energy crop cultivation and identifying motivational factors among Swedish farmers. Biomass Bioenergy 50, 25–34. https://doi.org/10.1016/j.biombioe.2012.09.058.

Persson, J., Johansson, E., Olsson, L., 2018. Harnessing local knowledge for scientific knowledge production: challenges and pitfalls within evidence-based sustainability studies. Ecol. Soc. 23, 38. https://doi.org/10.5751/ES-10608-230438.

Plummer, M., 2025. _rjags: Bayesian Graphical Models Using MCMC_. https://doi.org/10.32614/CRAN.package.rjags.

Plummer, M., Best, N., Cowles, K., Vines, K., 2006. CODA: convergence diagnosis and output analysis for MCMC. R. News 6, 7–11. https://www.r-project.org/doc/Rnews/Rnews_2006-1.pdf. (Accessed 9 January 2025).

R Core Team, 2024. R: a Language and Environment for Statistical Computing Found. Stat. Comput, Austria, Vienna. https://www.r-project.org/. (Accessed 9 January 2025).

Rommel, J., Sagebiel, J., Baaken, M.K., et al., 2022. Farmers' risk preferences in 11 European farming systems: a multi-country replication of Bocquého et al. (2014). Appl. Econ. Perspect. Pol. 45, 1374–1399. https://doi.org/10.1002/aepp.13330.

Rosenqvist, H., 2018. Kalkyler för energigrödor 2018, Swedish Board of agriculture, Jönköping, Sweden (In Swedish.). http://webbutiken.jordbruksverket.se/sv/artiklar/ovr443.htm.

Scarlat, N., Fahl, F., Lugato, E., Monforti-Ferrario, F., Dallemand, J.F., 2019. Integrated and spatially explicit assessment of sustainable crop residues potential in Europe. Biomass Bioenergy 122, 257–269. https://doi.org/10.1016/j.biombioe.2019.01.021.

Statistics Sweden, 2023. Land use in Sweden 2020 (In Swedish). https://www.scb.se/contentassets/3c2419244f5043429cf2a0b1f6a57efd/mi0803_2020a01_sm_mi03br2301.pdfAccesses. (Accessed 9 January 2025).

Swedish Board of Agriculture, 2025. Storleksgrupp jordbruksmark, variabel och År, Swedish board of agriculture, Jordbruksföretag och areal efter Län, År 2005-2022. Agricultural Holdings and Area by County, Size Group of Agricultural Land, Variable and Year), Swedish Board Agric. Jönköping, Sweden. https://statistik.sjv.se. (Accessed 9 January 2025).

Thomson Ek, H., Singh, J., Winberg, J.-, Brady, M.V., Clough, Y., 2024. Farmers' motivations to cultivate biomass for energy and implications. Energy Policy 193, 114295. https://doi.org/10.1016/j.enpol.2024.114295.

Thorén, H., Persson, J., 2013. The philosophy of interdisciplinarity: sustainability science and problem-feeding. J. Gen. Philos. Sci. 44, 337–355. https://doi.org/10.1007/s10838-013-9233-5.

Townsend, T.J., Sparkes, D.L., Ramsden, S.J., Glithero, N.J., Wilson, P., 2018. Wheat straw availability for bioenergy in England. Energy Policy 122, 349–357. https://doi.org/10.1016/j.enpol.2018.07.053.

Wilson, P., Glithero, N.J., Ramsden, S.J., 2014. Prospects for dedicated energy crop production and attitudes towards agricultural straw use: the case of livestock farmers. Energy Policy 74, 101–110. https://doi.org/10.1016/j.enpol.2014.07.009.