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BEATLES
BEHAVIOURAL CHANGE TOWARDS
Climate-Smart Agriculture

Co-creating Behavioural Change Towards Climate-Smart Food Systems

D2.2 Lab experiments v2

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Authors

First Name	Last Name	Beneficiary
Kassa	Tarekegn Erekalo	UCPH
Tove	Christensen	UCPH
Søren Marcus	Pedersen	UCPH
Sigrid	Denver	UCPH
Dimitrios	Skordos	AUA
Marilena	Gemtou	AUA

In case you want any additional information, or you want to consult with the authors of this document, please send your inquiries to:

Quality Reviewers

First Name	Last Name	Beneficiary
Marcel	Kornelis	WUR
Marilena	Gemtou	AUA

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Executive Summary

This deliverable D2.2 report is based on 3 lab experiments (Lab4, 5, and 7) that were carried out to test the effect of selected decision-making factors (interventions) on behaviour change towards more climate-smart agriculture among farmers, future farmers, and stakeholders. Lab 4 was conducted with farmers from Denmark with three experimental groups: control, tax on conventional farming, and market premium price for CSA production using real monetary incentives. For this experiment, data from 251 sampled farmers were collected by randomly allocating them to one of the experimental groups. Lab 5 was conducted with farmer students from Denmark and Spain with one treatment and one control group. For this experiment, the treatment was a social norm messaging using role model young farmers. We used the data from 329 respondents, randomly assigned to one of the experimental groups. Lab 7 involves various stakeholders in a workshop set up. A pre-post experimental setting was implemented by providing a demonstration of the economic and environmental impact analysis webtool as a proxy for training, with altogether 38 respondents from Denmark and Greece.

The findings from lab 4 show that both of the economic instruments (tax and price premium drive farmers towards climate-smart land allocation as compared to the control, with the price premium having a slightly stronger positive effect. Also, being motivated by profit maximization might not be a barrier to CSA land allocation as long as there are also environmental benefits guaranteed. However, farmers motivated by profit maximization in their land allocation were less likely to allocate land to CSA, suggesting a tailored financial tool such as premium contracts could incentivize behavioral change in this group. In Lab 5, the effect of social norm nudge on CSA land allocation as compared to control groups was not statistically significant. However, a positive effect of social norms was found in within-subject comparisons, where a statistically significant increase in CSA allocation among individuals was observed after receiving the social nudge. Furthermore, farmer students who associated climate benefits with CSA and who stated to prioritize climate benefits (or both climate and profit) over profit also allocated more land to CSA than those focused solely on profit. The findings from lab 7 did not show a statistically significant effect of webtool demonstration across the three outcome variables (attitude to use the tool, intention to use the tool, and interest in sharing data). However, most participants recognized the value of a decision support tool. Many of the participants expressed their willingness to recommend such tools to farmers and other stakeholders.

Overall, deliverable D2.2 provides valuable insights into how behavioral interventions—economic incentives, social norms, and training—can influence farmers, future farmers, and stakeholders' decisions related to CSA implementation. While the effects vary in magnitude, the findings support the potential of and need for targeted, context-specific interventions to promote sustainable agricultural practices.

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List of Terms and Definitions

Abbreviation	Definition
CSA	Climate smart Agriculture
UC	Use cases
DK	Denmark
ES	Spain
LT	Lithuania
DE	Germany
NL	The Netherlands

Table 1: Terms and Definitions

1. Introduction

Work package 2 (WP2) is about the Design and Implementation of behavioural experiments. Altogether, 8 lab experiments are carried out in WP2 to investigate the potential effect of selected decision-making factors (interventions) on stakeholder behaviour towards more climate-smart agriculture. An overview of the 8 experiments is provided in Table 2.

Table 2: Overview of over 8 lab experiments in WP2

EXPERIMENT	INTERVENTIONS	STATUS	Number of participants
Consumer experiments			
LAB1-3 (consumer surveys, treatment vs control)	CSA information (general production information to consumers), dynamic social norm priming, fair trade information, CSA information+dynamic social norm, CSA + fair trade information, dynamic social norm+fair trade information, CSA information+dynamic social norm+fair trade information	D2.1.v1 reported	3606
Farmer experiments			
LAB4 (farmers DK survey, treatment vs control)	Tax conventional, market premium for CSA production	D2.2v2	251
Agricultural or farmer students' experiments			
LAB5 (farmer students DK and ES survey, treatment vs control)	Social norm priming refers to role models	D2.2	329
LAB6 (agricultural students DE, NL, LT survey treatment vs control)	Subsidy for CSA farming	Next reporting period	
Other stakeholder experiments			
LAB7 (various stakeholders, workshops, pre-post setting)	Training (demonstration of the tool)	D2.2	38
LAB8 (advisors survey, treatment vs control)	CSA information (general information about CSA production, for advisors)	Next reporting period	

Of the 8 behavioral lab experiments presented in Table 2, LAB 1-3 was reported in BEATLES deliverables D2.1 Lab experiments v1 (July 2024). Since data collection is still ongoing at the time of writing (June 2025), the experiments in LAB6 and LAB8 will be reported in the coming deliverable D2.3 (December 2025).

The design, data collections, and documenting analyses for LAB4, LAB5, and LAB7 will be described in turn below allocating one chapter per experiment.

2. Reporting of LAB 4 experiment

2.1. Background for lab 4

The agricultural sector requires special attention within Denmark's Green Tripartite Agreement for achieving net zero by 2050 as part of the Green Transition targets. Of the targets, the agreement also focuses on the reduction of nitrogen leaching from the agricultural sector to comply with the EU Water Framework Directive, aiming for a reduction of 10,800 tons of nitrogen runoff by 2027[1]. Agroecological soil fertility improvement farming practices are potential climate-smart agricultural practices (Erekalo et al., 2024) to reduce N2O emissions from soil that result from the use of chemical fertilizers (Plaza-Bonilla et al., 2015; Stagnari et al., 2017). In addition, precision agricultural technologies are another CSA that has a high potential to reduce chemical fertilizer usage(Papadopoulos et al., 2024). To reduce nitrogen emissions from chemical fertilizers, legume-based cropping systems, such as crop rotation, intercropping, and cover cropping, are agroecological alternatives that can fix atmospheric nitrogen (Plaza-Bonilla et al., 2015; Stagnari et al., 2017). Nowadays, legume-based crop production is gaining traction (Stone et al., 2025) and was also prioritized in Denmark's strategy for green proteins for both animals and humans (MFAFD, 2023). The implementation of legume-based cropping has the potential to minimize environmental pollution associated with nitrogen (N) leaching and volatilization (Nadeem et al., 2019). In addition to environmental benefits, the implementation of legume-based cropping has great potential for providing more sustainable and nutritious food and feeding humans and livestock (Costa et al., 2021; Cusworth et al., 2021; Notz et al., 2023). The use of these also increases the organic carbon content (SOC) in the soil and reduces the use of agrochemicals (Kocira et al., 2020; Notz et al., 2023). Thus, increased farmers' adoption of agroecological farming practices, especially focusing on legume-based cropping, significantly contributes to the EU's Farm to Fork objectives on GHG emissions reduction from the implementation of chemical fertilizers (Heyl et al., 2023).

Although a subsidy already exists for farmers to be received as compensation for some of the costs associated with implementing climate-smart farming practices, the existing literature suggests that the adoption rate remains low (Greiner et al., 2009; Price & Leviston, 2014). This suggests looking for alternative policy instruments that could supplement and encourage farmers to adopt sustainability practices. As a policy instrument, the introduction of a green tax is one of the strategies to reduce nitrogen emissions (Johne et al., 2023). Denmark is a forerunner in introducing an agricultural emissions tax to reduce the use of unsustainable farming practices[2]. This introduced green tax aimed to encourage farmers to prioritize sustainable practices that have a lower climate impact (Expert Group for a Green Tax Reform, 2024). However, policy analysis based on farmers' responses to the proposed policy remains uncertain due to economic and behavioural constraints associated with the planned policy.

[1] https://concito.dk/node/3817
[2] https://climateadaptationplatform.com/denmark-is-first-country-to-tax-agriculture-emissions/

On the other hand, accompanying the demand side solutions with the supply side solutions, like increased consumers' willingness to pay a premium for climate-smart agricultural production methods, were suggested solutions (Scherer & Verburg, 2017) due to feedback loop to encourage implementation of sustainable farming practices (Pedersen et al., 2024). Value chain-based (VC) forms of contract solutions were suggested for improving the adoption of climate-friendly agricultural practices (D'Alberto et al., 2024). As part of its action plan, the Danish government aims to strengthen the plant-based value chain by promoting the food sector through a combination of supply-side and demand-side measures (MFAFD, 2023). This would create a market incentive for food produced through climate-friendly farming practices. In summary, by testing loss aversion through a tax on conventional practices and gain via market incentives, this study evaluates how both demand- and supply-side economic instruments can increase the adoption of climate-smart agriculture via land allocation tasks, thereby informing effective and acceptable policy options for targeted policy. Does it matter for farmers whether incentives are provided as green taxes or market incentives to enhance the adoption of CSA? This aims to test the effect of two economic instruments on CSA land allocation decisions using a lab-in-the-field experimental approach.

The specific objectives are:

- To assess how providing information about the green tax on the use of chemical fertilizers affects the CSA land allocations
- To assess whether informing farmers that consumers are willing to pay a premium for sustainably produced agricultural food products and attaching tax-equivalent value to the incentive for CSA can influence CSA land allocation decisions, thereby strengthening the market-driven adoption of sustainable practices.

2.2. Methodology

2.2.1. Experimental design and method of data collection

A lab-in-the-field experiment was designed to resemble a simulation business game and was conducted with a group of representative Danish farmers. The experiment was self-administered, where an online data collection method via a web-based survey was employed to evaluate how Danish farmers allocate 100 hypothetical hectares of land between conventional and climate-smart agriculture (CSA) practices under different economic conditions across two rounds, namely round 1 (R1) and round 2 (R2). We used SurveyXACT (https://www.survey-xact.dk/) to set up the online questionnaire, and the recruitment of sample farmers and the distribution of randomized survey links for data collection were handled by the research company ASPECTO (https://www.aspecto.dk/) through its national farmer panel for Denmark. Based on age, farm size, production type, and geographic location, which were selected as representative, a total of 251 farmers were randomly allocated into three experimental groups: control, green tax (Treatment 1), and market price premium (Treatment 2).

As presented in the experimental design in Fig. 1, the land allocation decision was implemented in two rounds, each representing a hypothetical growing season. In round 1 (Baseline), all participants were asked to allocate 100 hectares of farmland between the two farming practices based on their individual goals and the profit points associated with each. Since we are following a lab-in-the-field setting, to enhance behavioral realism and external validity, we have used profits based on gross margin assumptions. In this setup, conventional farming was assigned a profit point value of 8,000 DKK profit points per hectare. In contrast, CSA was valued at 6,800 DKK profit points per hectare, including 300 DKK profit points per hectare in environmental bonus. The profit points of 8,000 DKK per hectare were purposely assigned to reflect a realistic proxy for a typical Danish cereal farming gross margin[3]. This was adopted from national farm budget models; gross margins for cereal crops such as wheat, barley, and rye typically range from 5,000 to 13,000 DKK per hectare, depending on crop type and soil quality, with 8,000 DKK representing a reasonable average for conventional cereal production in Denmark (SEGES, 2025). For lower profit for CSA, we assumed a 15% lower profit margin of CSA by taking an approximated 13.13% lower gross margins of organic compared to conventional (Riar et al., 2024) as an empirically grounded proxy. Importantly, the profit points were identical across the three experimental groups in this round (For full description of experimental instructions, farming scenarios, experimental groups descriptions, and post experiment questionnaire, see appendix 2).

In Round 2, participants were randomly assigned to one of three experimental groups and presented with different interventions: tax, market premium, and neutral information (for the control group).

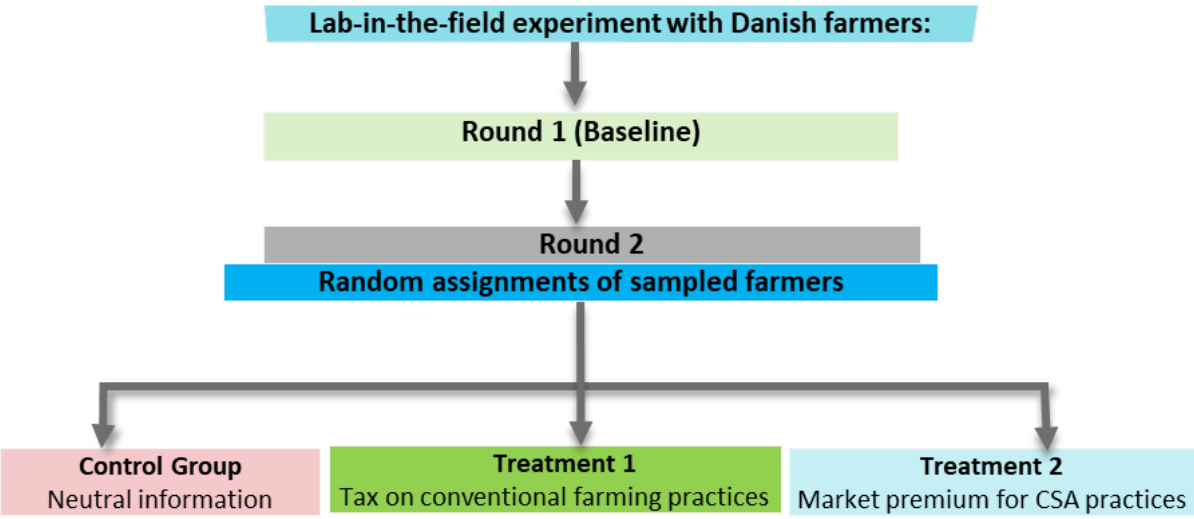

Figure 1: Experimental design of lab 4

In this experiment, the participants were provided with real monetary incentives when making their land allocation decisions. Each respondent who participated in this experiment received a fixed show-up fee. In addition, they all participated in a lottery where winners earned additional money based on profit points calculated based on how

[3] Gross margin= production value minus variable input costs (excluding labor and machinery costs).

they allocated land between the two farming practices. We informed the participants at the beginning of the experiment to base their land allocation decisions on their farming preferences and production goals. We also presented the message that indicated the trade-off between the two farming practices, encouraging participants to weigh short-term profitability against long-term sustainability. In addition, the availability of lottery winnings and random round choices was presented in the instructions. The participants had a 5% chance of winning the lottery for a monetary payments and random round choice to maximize participant engagement while helping ensure that every decision round is taken seriously (as any round could determine the payments). While our experiment does not follow a fully incentive-compatible mechanism, it incorporates a real monetary incentive linked to participants' decisions through a lottery-based payment system. Recent evidence from behavioral economics supports the use of such probabilistic incentive systems. For instance, Ahles et al. (2024) show that using a 10% or even 1% chance of payout in random-incentive online experiments produces statistically indistinguishable results from fully paid schemes, while significantly mitigating hypothetical bias. Similarly, Aydogan et al. (2024) demonstrate that a double-random incentive approach—where only some participants are paid for one of their randomly chosen decisions—yields valid preference elicitation under risk and ambiguity. These studies provide strong methodological support for using lottery incentives in online experiments with real economic tasks.

2.2.2. Description of treatments

In this experiment, we focused on two interventions where participants received information about economic policy instruments that we expected to influence land allocation decisions. The first was a regulatory intervention framed as a loss (a green tax on conventional farming practices), and the other was a market incentive framed as a gain (a market premium for food products produced using climate-smart agriculture). The same monetary value (700 DKK/ha) was used for both interventions by including dynamic uncertainty to simulate real-world conditions (e.g., potential future changes in tax or premium levels).

Treatment 1, a green tax on the implementation of conventional farming practices, was presented as:

Green tax on conventional farming practices
"To promote sustainable agricultural practices and reduce environmental impacts, the government has introduced an agricultural emissions tax (including nitrogen leaching, nitrous oxide, and CO_2 emissions) on conventional farming practices based on expert recommendations. This tax is part of a broader strategy to encourage sustainable practices through environmental cost adjustment on conventional farming. This tax is applied due to conventional farming's significant relies on chemical fertilizers, which contribute to nitrogen leaching into aquatic ecosystems and CO_2 emissions during production and use. Suppose the tax is set at 700 DKK per hectare for farmers using conventional methods. Note that the government may revise the tax rate in the future, which could result in an increase, decrease, or removal, depending on policy evaluations and feedback."

Treatment 2, entering a contract guaranteeing a market premium price for CSA production method could serve as a demand-side incentive to enhance the adoption (Pedersen et al., 2024). This treatment was presented as:

Premium price for CSA

"Growing consumer awareness of sustainable agriculture has increased demand for climate-friendly food products. Suppose that you have the opportunity to enter into a contract to deliver climate-friendly products produced by implementing climate-smart agricultural practices. Imagine that these products will receive a special label called "climate-friendly produced food," making them eligible to be sold at a premium price. This premium reflects the market's willingness to pay more for sustainably produced goods. As a result, farmers who adopt climate-smart practices can receive a premium price of 700 DKK per hectare through contracts with food companies that offer certified climate-friendly labels. Note that the consumer's willingness to pay for climate-friendly products may increase or decrease in the future, depending on market trends."

2.2.3. Descriptions of the questionnaire structure

The survey instrument was divided into three key parts.

Part I included sociodemographic questions such as age, gender, education, farm size, production type, and region.

Part II, the main experimental section, included descriptions of both farming practices, an explanation of the profit point system, and two rounds of decision-making. This section also presented the treatments to the relevant groups and neutral information to the control group in Round 2. A decision task and a short comprehension quiz followed each round. The final question in this part asked participants to allocate their land between conventional and CSA farming practices, which served as the main outcome variable for the study.

The final section focused on post-experiment questions that captured farmers' attitudinal and behavioral profiles. These included items on risk tolerance, environmental attitudes, perceptions of uncertainty, and views on policy mechanisms.

Three versions of the questionnaire were developed, identical in structure except for the intervention presented in Part II. The original questionnaire was drafted in English and later translated into Danish. A pre-test was conducted in December 2024 with 25 farmers, recruited through the same data collection company. The purpose of the pre-test was to assess the survey's clarity and estimate completion time. Based on the feedback, several adjustments were made, including shortening some questionnaire items and simplifying the descriptions of the farming scenarios and treatment messages. The primary outcome variable, land allocation for CSA, was calculated by subtracting the land allocated to conventional farming from a fixed total of 100 hectares. This 100ha was chosen by approximating the land ownership in the Danish case, which had an average of 83ha, with more than 20% of farmers owning more than 100ha (Danish Agriculture & Food Council, 2023).

2.2.4. Data analysis

Our main outcome variable is the amount of land allocated for CSA. The outcome variable was measured in two ways 1) land allocated to CSA in round 2 comparing the three experimental groups 2) change in land allocated to CSA between round 2 and round 1. We employed both descriptive statistics, including frequency and means, and parametric statistical tests (ANOVA). The employed ANOVA was to assess between-group differences in CSA land allocation and the difference between the subjects' CSA land allocation between the two rounds within each group. A post hoc test, Turkey post hoc pairwise comparisons, was employed to identify which treatments had a significantly different effect on CSA land allocations. We have also tested for within-subject effects over time and interactions with treatment conditions. Finally, we conducted correlation analyses to explore associations between CSA land allocation in Round 2 (CSA in R2) and post-experimental attitudinal variables. The attitudinal variables included experience, which is based on the index value of 6 CSA practices implementation, three multi-item constructs (e.g., social norms, personal norms, risk aversion) derived from agreement statements and three single-item perception variables (e.g., tax perception, CSA awareness, uncertainty). This helped to identify psychological and perceptual drivers of CSA adoption behaviour beyond the experimental interventions.

2.3. Results

2.3.1. Distribution of land allocation

This subsection presents the distribution of land allocations (for descriptive statistics results, see the appendix 2 for Lab 4 results). The distribution of 100 ha of land allocation among sampled respondents shows that, in Round 1, the majority of land was allocated to conventional farming practices, with an overall mean of 85.7 hectares and only 14.3 hectares for CSA (Table 3). Following the intervention in Round 2, land allocation toward CSA increased across all groups, including a control group. Respondents in the premium price group exhibited the largest shift toward CSA, with average CSA allocation increasing from 14.55 hectares to 22.25 hectares. Also, respondents in the tax group increased CSA allocation from 13.43 hectares to 20.78 hectares. Furthermore, the control group respondents showed a marginal increase, with CSA land allocation rising from 14.88 hectares to 16.67 hectares between the two rounds.

Table 3: Land allocation across experimental groups and rounds

Experimental group	Round	Conventional (Mean ± SD)	CSA (Mean ± SD)
Control (N = 81)	R1	85.12 ± 13.09	14.88 ± 13.09
	R2	83.33 ± 14.32	16.67 ± 14.32
Tax group (N = 81)	R1	86.57 ± 12.40	13.43 ± 12.40
	R2	79.22 ± 15.17	20.78 ± 15.17
Premium price (N = 89)	R1	85.45 ± 12.47	14.55 ± 12.47
	R2	77.75 ± 14.36	22.25 ± 14.36
Total (N = 251)	R1	85.71 ± 12.61	14.29 ± 12.61
	R2	80.03 ± 14.75	19.97 ± 14.75

Note: R1= Round 1 and R2= Round2

The distributions of CSA allocations in R2 (displayed in Fig. 2) indicate that respondents under the two treatments have a higher mean than the control group respondents. Statistical tests are shown in the next section.

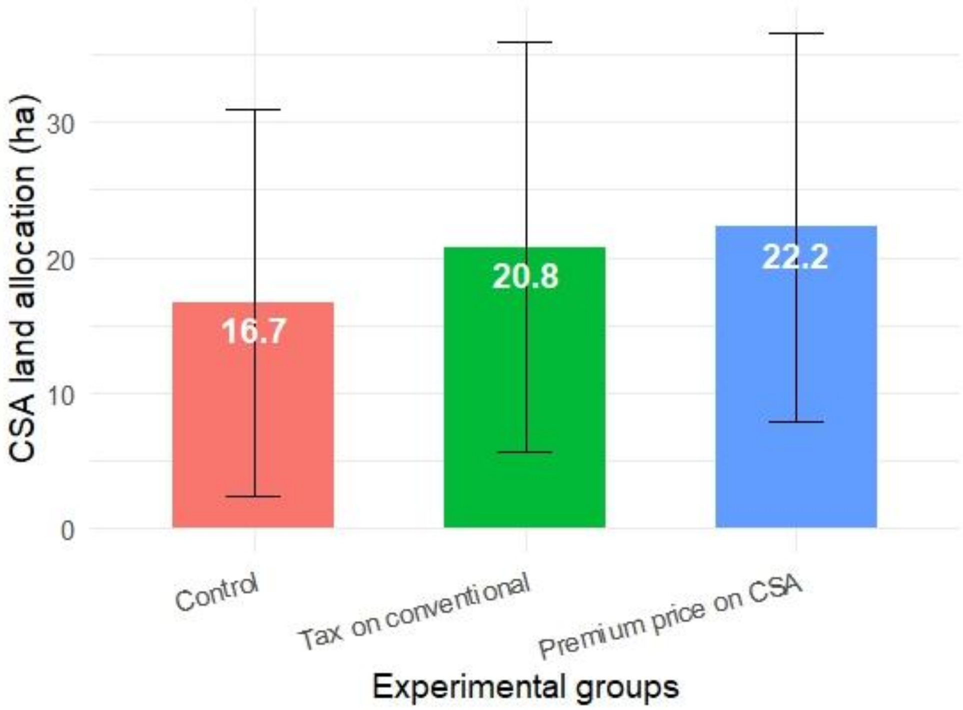

Figure 2: Land allocated for CSA after interventions by experimental groups.

2.3.2. Impact of green tax and market incentive on CSA adoption (interventions)

The treatment impacts were tested by employing ANOVA. The analysis results in Table 4 shows a significant difference in CSA land allocation in R2 under different experimental conditions ($p < 0.05$). The F-value of 3.27 suggests that the means of CSA land allocation differ between at least some of the groups.

Table 4: ANOVA results across outcomes

Source	SS	df	MS	F	p-value
Between Groups	1398.24	2	699.12	3.27	0.0395
Within Groups	52970.56	248	213.59		
Total	54368.80	250			
Bartlett's Test for Equal Variances: χ^2 (2) = 0.35, p = 0.840					

Since the ANOVA test does not provide information about which group has a significant difference from the control, we performed Tukey's post-hoc test to identify specific group differences. The result in Table 5 indicates that the premium price group differs significantly from the control group ($p < 0.05$). However, the test of significance for the difference between the two treatments and the difference between control and tax treatment was non-significant.

Table 5: Tukey Pairwise Comparisons

Comparison	Difference	Std. Err.	95% CI
Tax on Conv. vs Control	4.11	2.30	[-1.30, 9.53]
Premium Price vs Control	5.58	2.24	[0.29, 10.87]
Premium Price vs Tax on Conv.	1.47	2.24	[-3.82, 6.76]

We also examined how the decisions of farmers changed over two rounds and under different treatment conditions, considering that the same farmers were measured twice. As indicated by the interaction terms for Round × Tax on Conventional and Round × Premium on CSA (Table 6), both treatments significantly increased CSA adoption in Round 2. Specifically, in Round 2, the Tax on Conventional and the Premium on CSA led to increases in CSA adoption by approximately 5.6 and 5.9 percentage points, respectively. This finding highlights that respondents in both the tax and market incentive groups significantly increased their CSA land allocation in Round 2 compared to Round 1. In contrast, participants in the control group remained stable.

Table 6: *Predicted marginal means for CSA allocation from the repeated measures model*

Variable	Coef.	Std. Err.	p-value
2nd Round (vs 1st)	1.79	0.99	0.070
Tax on Conventional (main)	-1.44	2.13	0.499
Premium Price on CSA (main)	-0.33	2.09	0.876
Round × Tax on Conventional	5.16	1.40	0.000
Round × Premium on CSA	5.91	1.37	0.000
Constant	14.88	1.51	0.000

We further predicted the marginal means of land allocated across the rounds. The results shown in Figure 3 clearly show that the predicted average amounts of land allocated for CSA have increased over time. In Round 2, participants in both treatment groups significantly increased their CSA allocation. However, the participants' premium price group showed the largest relative shifts. These results highlight that both policy-driven regulation (taxes) and market-driven incentives (premium price contracts) can motivate farmers to transition into CSA; however, market incentives have a higher effect, as indicated by our results.

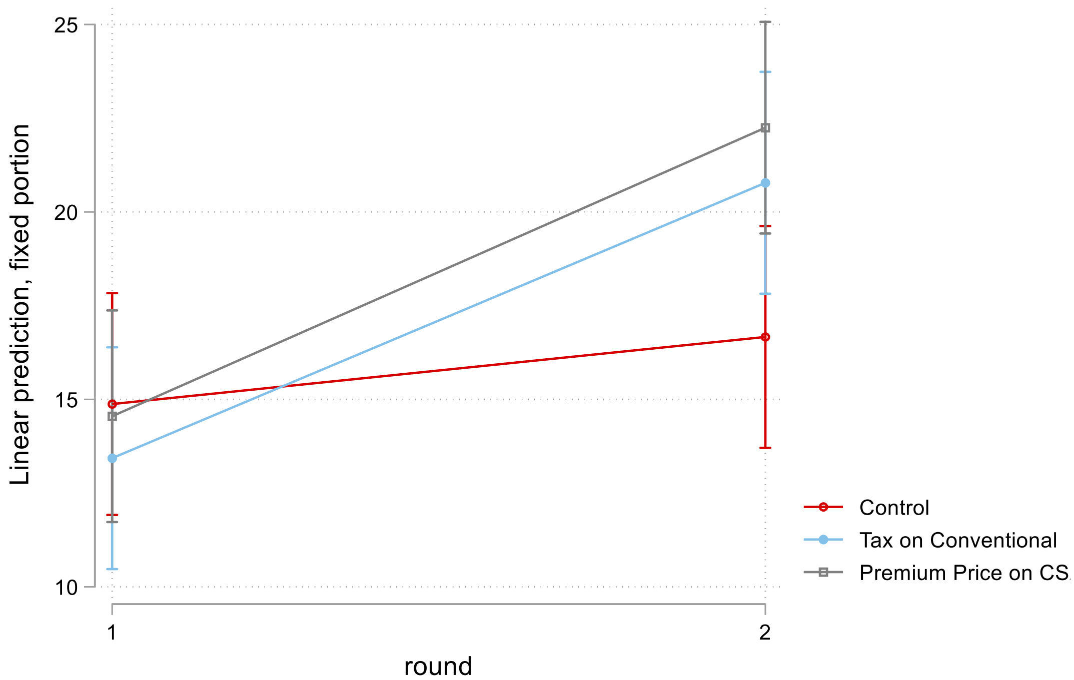

Figure 3 Predicted means of CSA allocation between rounds and groups with 95% CIs

2.3.3. Post-experiment survey questions analysis results

In these subsections, we present some post-experimental self-reported land allocation decision motives and perceptions on the provided treatments and correlations of some selected variables (see the appendix 2 for more details about post-experiment questions, descriptive statistics results on some attitudinal and perception questions related to general individual characteristics).

The results in Table 7 provide important insights into how respondents approach land allocation decisions concerning the trade-off between climate benefits and profit maximization in this experiment.

First, the respondents' agreement with the statement "I focused solely on minimizing climate impact when allocating the 100 hectares" was low across all three groups, with only 2.5% in the control group, 1.2% in the tax group, and 1.1% in the premium group indicating strong agreement. Conversely, agreement with the statement "Climate benefits and profit were equally important factors in my decision" was relatively higher, with 39.5% of the control group, 36.0% of the premium price group, and 29.6% of the tax group expressing support.

On the other hand, a significant number of respondents agreed with the statement "The climate benefits of climate-smart agriculture were not significant enough to outweigh the lower profit compared to conventional agriculture," with 75.3% of the control group, 72.8% of the tax group, and 79.8% of the premium group. Finally, moderate agreement was observed with the statement "I focused solely on maximizing profit when allocating 100 hectares," with 31% in the control group, 34.6% in the tax group, and 33.7% in the premium group.

Table 7: Extent of agreement with statements about the land allocation decisions motive in this experiment

Statement	Control	Tax	Premium	Total
I focused solely on minimizing the climate impact when allocating the 100 hectares	2.5%	1.2%	1.1%	1.59 %
Climate benefits and profit were equally important factors in my decision.	39.5%	29.6%	36.0%	35.06%
The climate benefits of CSA were not significant enough to outweigh the lower profit compared to conventional agriculture.	75.3%	72.8%	79.8%	76.1%
I focused solely on maximizing profit when allocating the 100 hectares.	31%	34.6%	33.7%	33.07%

Note: Responses were measured on a five-point Likert scale. Values represent the percentage of respondents who selected "Agree" or "Strongly agree."

Participants' self-reported decision-making approaches regarding how they allocated the hypothetical 100 hectares of land were compared with their actual CSA land allocation choices in the experiment. The result on Fig. 4 shows that respondents who stated to consider climate concerns or tried to balance climate and profit allocated more land to CSA compared with those who stated to consider profit-maximization or felt CSA's climate benefits were not sufficient and allocated less land.

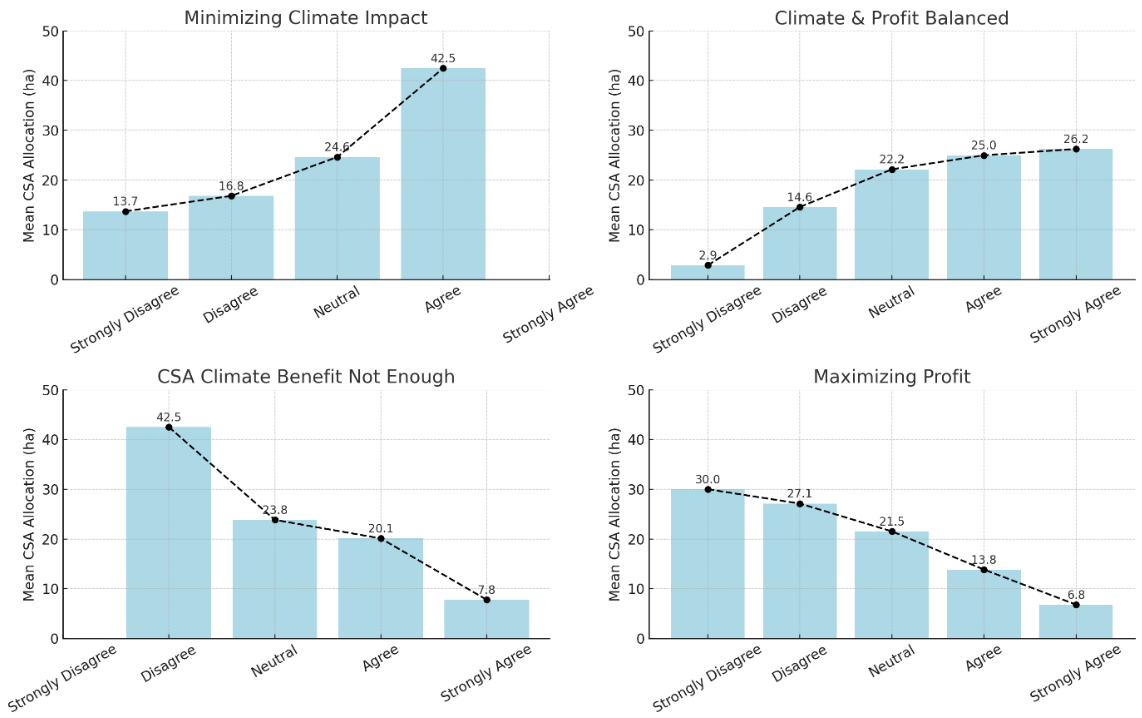

Figure 4: *CSA land allocation by post-experiment agreement with allocation motives*

We have asked the respondents about their perceptions of how the treatments affected their land allocation. The results in Table 8 show that 78.24% of the sampled farmers were influenced by the treatment. However, approximately 21.76% stated that the treatment did not affect their land allocation decisions.

Table 8: Perceptions of the two treatments

Perception Statement	Frequency	Percent
The treatment encouraged me to allocate more land to climate-smart practices.	45	26.47
The treatment somewhat influenced my decision to allocate land to climate-smart practices.	89	52.35
The treatment did not affect my land allocation decisions.	36	21.76
Total	170	100.00

2.3.4. *Correlations between CSA land allocation and selected post-experiment variables*

We conducted correlation analyses between CSA land allocated in Round 2 and a set of post-experiment behavioural and attitudinal variables. These relationships are visually summarized as a heatmap in Figure 5, where redbrown indicates a negative relationship and purple indicates a positive one, with colour intensity reflecting the strength of the relationship. The results show a positive correlation between CSA land allocated in R2 and past CSA implementation experience (0.1499), CSA adoption intention (0.1410), level of CSA awareness (0.1856), and personal norm (0.1883), indicating that these variables may enhance CSA land allocation decision-making. Even though CSA land allocation has a positive correlation with social norms (0.0953), it is weak and not as strong as other variables. The results also show significant negative correlations between CSA land allocation in R2 and policy uncertainty (-0.2099) and a negative attitude towards the proposed agricultural emission tax in Denmark (-0.2128). Although the CSA land allocation has negative correlations with market uncertainty (-0.1241) and risk aversion constructs (-0.0390), these correlations are not strong or significant.

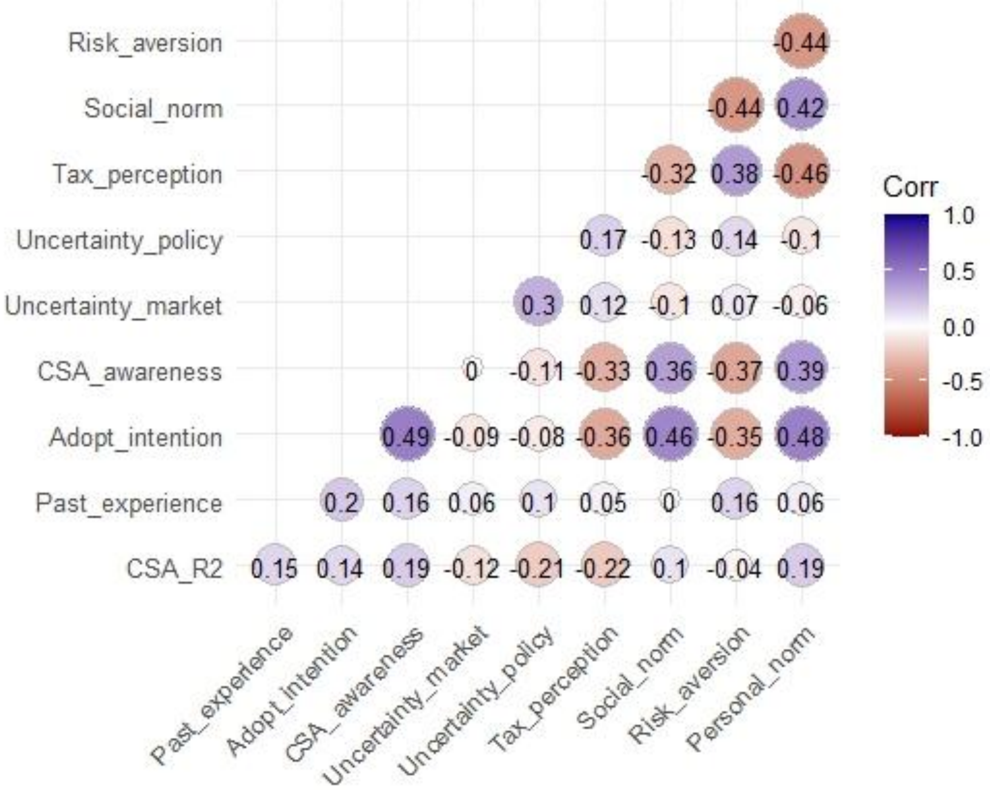

Figure 5: Correlation of CSA land allocation in R2 with behavioral and attitudinal variables

2.4. Concluding summary of Lab4

This experiment was conducted to test the effect of two economic instruments on farmers land allocation decisions: regulatory tax and market demand-based incentives formulated as a contract with a premium price. The treatments had very similar effects on increasing CSA land allocation with the premium pricing on CSA having a slightly higher effect – and statistically significant. This result indicates that demand-side market incentives could be a promising option for fostering farmers' transitions toward CSA. Comparison of round 1 and round 2 land allocations, that is, testing within-subject effects, showed statistically significant increases in CSA land allocation for both tax and price premium. Furthermore, correlations between CSA land allocation decisions and attitudinal variables indicate that prior CSA implementation experience, intention to adopt CSA, awareness of CSA, and personal norms were all positively and significantly associated with increased CSA land allocation. Conversely, substantial negative relationships were found between CSA land allocation and policy uncertainty as well as negative attitude towards of the agricultural emission tax.

From post-experiment questions, key insights regarding the decision-making trade-offs for CSA land allocation motives, farmers who were motivated by both the positive climate-impact of CSA land allocating and also motivated by profit maximization of allocating land to conventional agriculture allocated more land to CSA production than those focusing purely on profit maximization. Thereby, being motivated by profit maximization might not be a barrier to CSA land allocation as long as there are also environmental benefits guaranteed.. However, farmers motivated by profit maximization in their land allocation were less likely to allocate land to CSA, suggesting a tailored financial tool such as premium contracts could incentivize behavioral change in this group.

Farmers who doubted CSA's effectiveness were less inclined to adopt it. Field demonstrations, peer learning, and evidence of profitability could help build trust and shift perceptions. Finally, segmenting CSA support by motivational profiles for tailoring support strategies, business-model approaches for profit-driven ones, and value-driven narratives for climate-motivated farmers, could enable the effectiveness of interventions. Overall, fostering CSA adoption requires not only financial incentives but also behaviorally informed strategies that acknowledge the diverse motivations of farmers.

3. Reporting of LAB 5 experiment

3.2. Introduction

A transition toward climate-friendly farming practices is increasingly recognized as essential for sustainable agriculture and climate change mitigation. Climate-smart agriculture (CSA) encompasses practices that sustainably increase productivity, enhance resilience to climate change, and reduce greenhouse gas emissions (Erekalo et al., 2024). However, despite its benefits, CSA often faces low adoption rates due to upfront costs, uncertainty, and risk aversion among farmers (Gemtou et al., 2024; Long et al., 2016; Pedersen et al., 2024). While economic incentives, regulatory frameworks, and technological innovations have long been the focus of policy and research, there is growing recognition of the role that social norms can play in influencing farmers' behaviour (Banerjee et al., 2021; Constantino et al., 2022).

One promising strategy to address these barriers is to leverage social influence via role models—trusted individuals or peers whose actions are respected and emulated within their communities (Banerjee et al., 2021). A study by Foolen-Torgerson et al. (2023) found that social influence can subtly guide farmers towards more sustainable agricultural practices. Social norms can also shape individual decision-making by signalling what others do (descriptive norms) or what others approve of (injunctive norms) (Cialdini & Jacobson, 2021). In agricultural contexts, these norms may manifest when farmers observe peers adopting environmentally friendly practices and feel encouraged to follow suit, whether through peer validation, social pressure, or a desire to conform (Constantino et al., 2022; Hüttel et al., 2022). These social pressures have a higher impact on environmental best management practices adoption (Drescher et al., 2024). A strain of research suggests that using social norms in terms of highlighting the behaviour of peer farmers or community role models can be a lever to promote the adoption of CSA (Hüttel et al., 2022). When young and/or innovative farmers adopt CSA and are framed as role models, they may positively influence the behaviour of others, especially when combined with contextual relevance (Constantino et al., 2022; Wang et al., 2023).

This experimental study builds on this body of work by experimentally testing whether exposure to social norm information, framed around role model young farmers, will influence CSA land allocation decisions among young farmer students. Farmer students in Denmark and Spain are included in the study.

Hypothesis

Providing social norm information using the formulation of role models increases CSA land allocations compared to the control group.

3.3. Methodology

3.3.1. *Experimental groups and design*

This experiment was conducted based on a sample of farmer students from Denmark and Spain. In this experiment, we have two experimental groups: one treatment group (Social norm) and one control group. The survey was conducted online, with respondents randomly allocated to one of the groups. The overall design is illustrated below in Figure 6.

The experiments involved two rounds of decision tasks. Both groups received the same information in Round 1. In Round 2, the control group received information that was not related to the treatment. The information was formulated as neutrally as possible and was given to mimic the 'cognitive load' that the treatment was given. The treatment group received information emphasizing social norms.

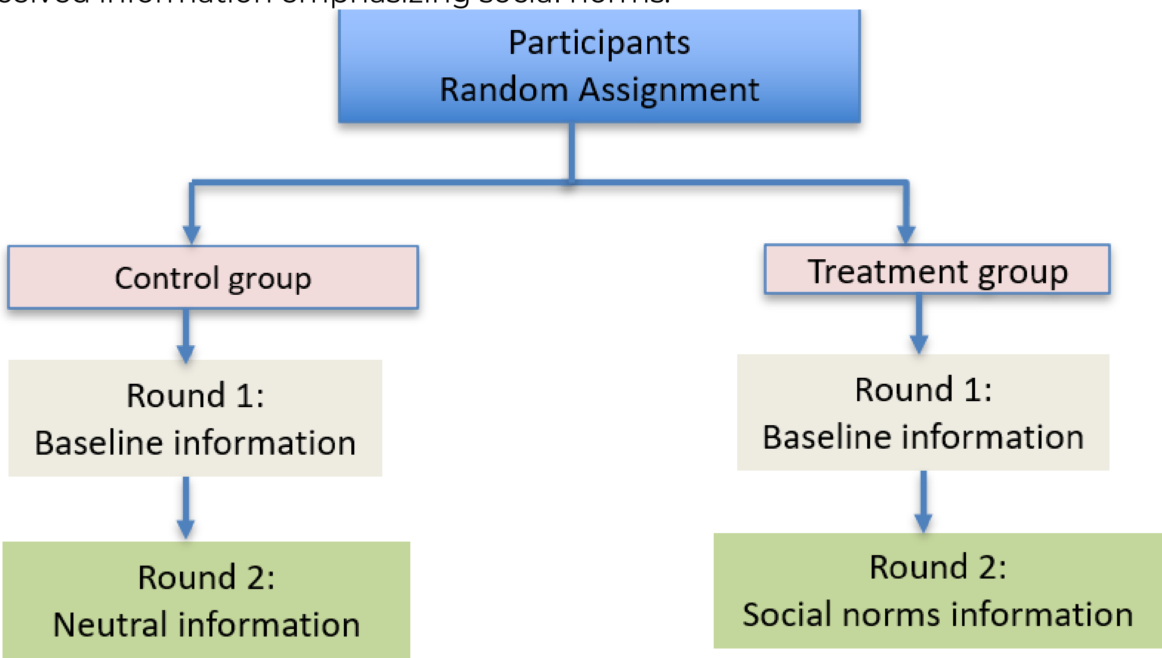

Figure 6: Overall experimental design in LAB5

3.3.2. *Description of the experiment*

The intention to adopt Climate-Smart Agriculture (CSA) was assessed using land allocation as the outcome variable. Respondents were presented with a hypothetical farming scenario in which they were asked to allocate 100 hectares of agricultural land between two practices: Conventional Agriculture and CSA. This task was introduced as part of an experimental setup designed to explore land-use preferences under different farming systems. Conventional farming practice was characterized by the use of chemical fertilizers, while CSA involved legume-based cropping, organic fertilizers, and precision fertilization (for detailed descriptions of farming practices, scenario presentation, see the questionnaire for Lab 5 in Appendix 3).

Following this farming practice scenario presentation, respondents received detailed instructions where they were asked to participate in two rounds of land allocation decisions, each round representing a growing season**.** Respondents were asked to allocate 100 hectares between the two farming practices based on their personal goals and real-life preferences. They were shown a profit calculation formula:

The profit points for each type of production are presented below:

- *For conventional practice, you earn 1100 Euro profit per hectare*
- *For smart climate practice, you earn 900 Euro profit per hectare*

The profit point for 100 hectares was calculated as: = 1100 Euro × (number of hectares allocated to conventional practices) + 900 Euro × (number of hectares allocated to climate-smart practices)

In the second round, respondents were presented with either neutral information (control group) or social norm-based information (treatment group).

The control group received the following neutral message:
Agriculture is a cornerstone of rural communities worldwide, providing food, raw materials, and livelihoods. Across various regions in Europe, there is a wide mix of small and large farms, with varying climates, landscapes, and soil fertility.”

The treatment group received the following social norm message:
“*Many young people across Europe are concerned about climate change. Young farmers who allocate part of their land for climate-smart agriculture contribute to protecting the environment and reducing climate change. These young farmers are role models in their communities, setting a strong example for sustainable farming. By choosing climate-smart agriculture practices, you would contribute to this collective effort to protect the environment and secure sustainable farming in the future.”*

3.3.3. *Sample size and data analysis*

For Lab 5, data were collected from a total of 378 students enrolled in agricultural technical vocational schools and agricultural universities in Denmark and Spain. During data cleaning, 49 responses were excluded due to either incomplete submissions or failure to correctly allocate 100 hectares between conventional agriculture and Climate-Smart Agriculture (CSA). This error indicated a lack of comprehension of the experimental instructions. The final analytic sample included 329 respondents: 195 from Denmark and 134 from Spain. The distribution of respondents across the two experimental groups—Control and Social Norm—is shown in Table 9. Regarding participants’ educational background, nearly all Danish students were enrolled in agricultural schools or colleges (97.4%), with only a few in other tracks. In contrast, the Spanish sample was slightly more diverse: while 88.1% were from agricultural institutions, 12 students (9.0%) reported being in non-agricultural educational programs, and a small proportion were enrolled in universities.

Table 9: Final sample size by country, experimental group, and educational background

Country	By the experimental group		By educational background			
	Control	Social norm	Agricultural school or college	University	Other	Total
Denmark	90	105	190 (97.4%)	1 (0.5%)	4 (2.1%)	195
Spain	57	77	118 (88.1%)	4 (3.0%)	12 (9.0%)	134
Total	147	182	308 (93.6%)	5 (1.5%)	16 (4.9%)	329

For analysis of collected data, both descriptive statistics, including frequency and means, and parametric statistical tests were employed. For parametric, a T-test was used to assess between-group differences in CSA land allocation since the outcome variable, the amount of land allocated for CSA, is continuous. Finally, we conducted correlation analyses to explore associations between CSA land allocation in Round 2 (CSA_R2) and post-experimental attitudinal variables**.**

3.4. Results

3.4.1. *Descriptive results*

In this section, we have presented some descriptive statistics for selected variables. Regarding the age distribution of respondents for lab 5, the mean age of participants (see table 10) was slightly higher in Denmark (21.2 years) compared to Spain (20.1 years), with ages ranging from 15 to 47.

Table 10: Age distribution of respondents

Country	Obs	Mean Age	Std. Dev.	Min Age	Max Age
Denmark (1)	195	21.22564	3.06	19	43
Spain (2)	134	20.13178	6.14	15	47
Total	329	20.78267	4.11893	15	47

Regarding farming experience (table 11), a majority of Danish participants had worked or currently work on a farm (71%), while Spanish participants showed more diversity, including a notable share of owning farms (15%) or seldom visiting farms (22%).

Table 11:Farming experience distribution of respondents

Farm Experience	Denmark	Spain	Total
I grew up on a farm	64	38	102
I grew up on a hobby farm	34	21	55
Often visited a farm	48	51	99
Worked or work on a farm	138	34	172
My own farm	3	20	23
Never or seldom visited a farm	7	29	36

Table 12 reports the farming system exposure; Danish respondents were more familiar with conventional systems, particularly in livestock and arable farming. Spanish students reported greater exposure to horticulture, agroforestry, and organic practices than their Danish counterparts.

Table 12: Production systems by country and farming type

Production Type	Country	Organic	Conventional	Both	Not relevant	Missing	Total
Livestock	Denmark	8 (4.1%)	134 (68.7%)	31 (15.9%)	15 (7.7%)	7 (3.6%)	195
	Spain	12 (9.0%)	48 (35.8%)	21 (15.7%)	24 (17.9%)	29 (21.6%)	134
Arable	Denmark	5 (2.6%)	126 (64.6%)	27 (13.8%)	30 (15.4%)	7 (3.6%)	195
	Spain	12 (9.0%)	58 (43.3%)	15 (11.2%)	20 (14.9%)	29 (21.6%)	134
Mixed (livestock & arable)	Denmark	8 (4.1%)	124 (63.6%)	31 (15.9%)	25 (12.8%)	7 (3.6%)	195
	Spain	8 (6.0%)	47 (35.1%)	20 (14.9%)	30 (22.4%)	29 (21.6%)	134
Horticulture (veg & fruits)	Denmark	8 (4.1%)	28 (14.4%)	8 (4.1%)	144 (73.8%)	7 (3.6%)	195
	Spain	17 (12.7%)	41 (30.6%)	13 (9.7%)	34 (25.4%)	29 (21.6%)	134
Agroforestry / Permaculture	Denmark	3 (1.5%)	27 (13.8%)	0 (0.0%)	158 (81.0%)	7 (3.6%)	195
	Spain	9 (6.7%)	31 (23.1%)	7 (5.2%)	58 (43.3%)	29 (21.6%)	134
Other Production Type	Denmark	4 (2.1%)	31 (15.9%)	3 (1.5%)	150 (76.9%)	7 (3.6%)	195
	Spain	10 (7.5%)	22 (16.4%)	10 (7.5%)	63 (47.0%)	29 (21.6%)	134

The students were asked about their job aspirations (see table 13). The students differed significantly: while 88% of Danish participants intended to become farmers, only 61% of Spanish participants reported the same. Conversely, a larger share of Spaniards (45%) expressed interest in "Other" career paths.

Table 13: Job preference distribution of respondents

Job Preference	Country	No	Yes	Total
Farmer	Denmark	23 (11.8%)	172 (88.2%)	195
	Spain	52 (38.8%)	82 (61.2%)	134
Advisor	Denmark	160 (82.1%)	35 (17.9%)	195
	Spain	126 (94.0%)	8 (6.0%)	134
Other	Denmark	165 (84.6%)	30 (15.4%)	195
	Spain	73 (54.5%)	61 (45.5%)	134

Finally, the respondents were asked about their awareness of CSA (see table 14). The awareness varied widely: 64% of Danish students had heard of CSA but knew little, while over 60% of Spanish students had never heard of CSA, reflecting a major difference in baseline knowledge between the two groups.

Table 14: Distribution of awareness of CSA

Country	Never Heard	Heard but Don't Know Much	Heard and Know Quite a Lot	Total
Denmark	59 (30.3%)	125 (64.1%)	11 (5.6%)	195
Spain	82 (61.2%)	51 (38.1%)	1 (0.7%)	134
Total	141 (42.9%)	176 (53.5%)	12 (3.6%)	329

3.4.2. *CSA-land allocation decision making*

In Round 1, the control and social norm groups allocated a relatively similar average of around 27 hectares to CSA. As they were allocated randomly, this result was expected. In Round 2, after exposure to either interventional information or neutral information, slightly increased CSA allocations for both control groups and intervention groups were observed (see Fig 7). Notably, the social norm group showed a greater increase, from 27.2 to 30.4 hectares, compared to the control group's increase from 27.3 to 28.3 hectares (Fig 7).

The figure suggests that the social norm message may have had a modest positive effect on CSA adoption. In contrast, the neutral information (or simply the repetition of the land allocation exercise) did not have an effect. These indicative conclusions will be tested in 3.4.3.

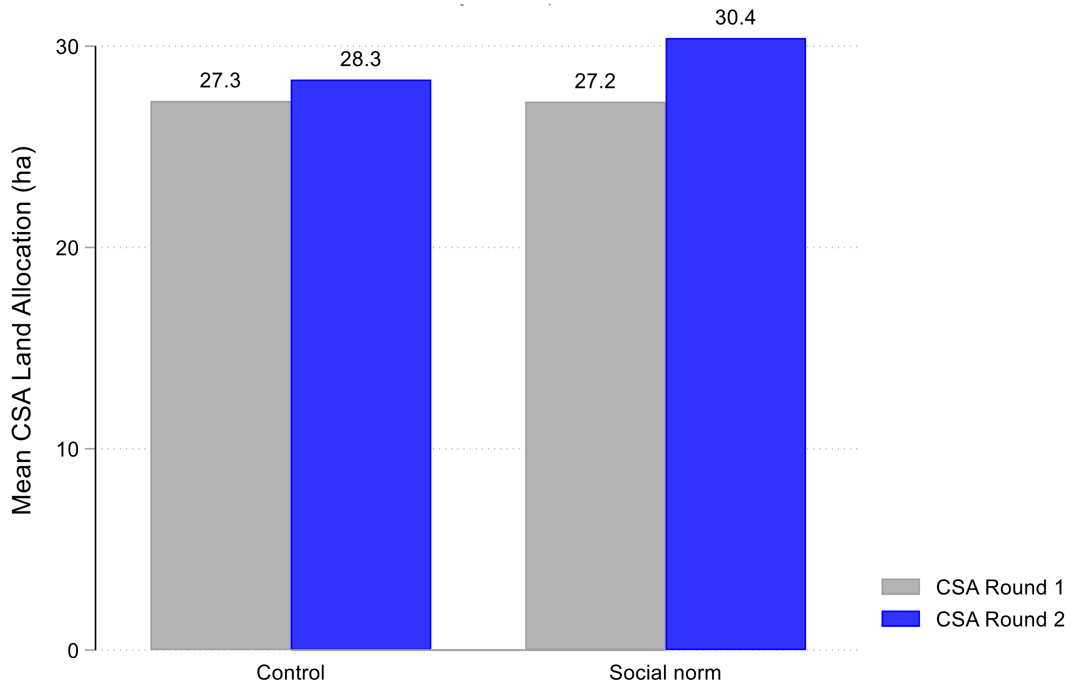

Figure 7: Land allocation by experimental groups

Looking at land allocation by not only experimental group but also by country (Table 15) shows that in Round 1, CSA land allocation was similar across groups, with Danish participants allocating slightly less land to CSA (26.0 hectares on average) than their Spanish counterparts (29.5 hectares on average). In the social norm group**,** Danes allocated 25.3 hectares while Spanish students allocated 30.2 hectares.

In Round 2, CSA allocation increased across all subgroups, with the largest increase observed among Spanish participants in the social norm group, rising from 30.2 to 35 hectares. This result highlights that the social norm intervention had no effect on the Danish farmer students but may have had a modest impact in Spain.

Table 15: Land allocation by experimental groups and country

Group	Country	N	R1_climatesmart	R2_climatesmart
			Mean ±SD	Mean ±SD
Control	DK	88	25.97 ± 21.85	26.61 ± 20.03
	ES	52	29.50 ± 20.57	31.23 ± 18.64
Social norm	DK	103	25.30 ± 22.14	27.44 ± 22.38
	ES	67	30.22 ± 23.20	34.97 ± 22.88
Total			27.26 ± 22.03	29.48 ± 21.41

3.4.3. *Effect of the social norm on CSA land allocation (intervention)*

We tested whether a social norm message could influence farmer students' decisions to allocate more land to CSA in two ways 1) comparing control and treatment in Round 2 and 2) comparing change in allocation (ΔCSA) from Round 1 to Round 2 for the two groups. The test result in Table 16 shows that a comparison of CSA land allocation in round 2 shows that the social norm group allocated slightly more land (30.41 ha) than the control group (28.34 ha) but not statistically significant (t = 0.84).

The test on the change in CSA land allocation from Round 1 to Round 2 (ΔCSA) shows that the social norm group increased their CSA allocation by 3.16 ha, compared to 1.37 ha in the control group, with a mean difference of -1.80 ha. Even though the test result is not statistically significant (t = 1.36), the effect size is relatively moderate.

Table 16: Within group comparison for CSA in Round 2 and ΔCSA (ha)

Comparison	Group	Mean (SD)	Mean difference	T-value (P value)
Between-group (Round 2)	Control	28.34 (19.58)	-2.07	0.84 (0.404)
	Social norm	30.41 (22.81)		
Between-group (ΔCSA)	Control	1.37 (12.46)	-1.80	1.36 (0.147)
	Social norm	3.16 (10.76)		

Note: Mean difference =Control − Social norm, ΔCSA =R2_CSA-R1_CSA

We have also tested within-group comparisons (pre-post analysis) to see whether the CSA land allocation differs with subjects between the two rounds. The within-subject comparisons result in Table 17 shows a statistically significant increase in CSA allocation for the social norm group (t = 3.84), while the control group's change was not significant (t = 1.29). Across all participants, the average CSA allocation rose by 2.36 ha from Round 1 to Round 2 (t = 3.58). These results suggest that the social norm message had a modest and statistically significant effect on participants' behaviour when analyzed within subjects, even though between-group differences were not statistically significant. These results highlight the potential of social norm-based interventions in promoting climate-smart practices, even if the effect sizes are modest and the statistical power is limited in between-group comparisons.

Table 17: Within-subject (pre-post) comparison CSA land allocation

Group	Mean R1	Mean R2	Mean diff	T-value (P-value)

Within-subject (All participants)	27.12	29.48	+2.36	3.58 (0.0009)
Within-subject (Control)	26.97	28.34	+1.37	1.29 (0.202)
Within-subject (Social norm)	27.24	30.41	+3.16	3.84 0.0004)

3.4.4. *Post experiment survey results*

After completing the land allocation tasks, participants were asked to reflect on their decision-making motives by indicating the relative importance they placed on climate impact versus profit. Across all responses (n = 307), the distribution of decision approaches was relatively balanced between the control and social norm groups, with a slight majority of each category coming from the social norm group (ranging from 54% to 57%) (Table 18). Only a small proportion reported focusing exclusively on climate impact, with 57.1% of those from the social norm group. A larger share (35 participants) said climate was more important than profit, with over half (54.3%) from the social norm group. The majority of participants fell into the middle-to-profit-oriented categories: 74; participants valued climate and profit equally (54.1% from the social norm group). 124 participants said profit was more important than climate (55.6% from the social norm group). 60 participants focused exclusively on maximizing profit (56.7% from the social norm group).

Table 18: Distributions of CSA land allocation decision motives by experimental groups

Decision making motives	Control (n)	Social Norm (n)	Total (n)
I focused exclusively on considerations of climate impact…	42.9%	57.1%	14 (4.6%)
Climate more important than profit…	45.7%	54.3%	35 (11.4%)
Climate benefit and profit loss equally important…	45.9%	54.1%	74 (24.1%)
Profit more important than climate…	44.4%	55.6%	124(40.4%)
I focused exclusively on maximizing profit…	43.3%	56.7%	60(19.5%)
Total	44.6%	55.4%	307 (100%)

Figure 8 shows a clear and consistent pattern: participants' average CSA land allocation aligned closely with their stated decision-making priorities. Those who prioritized climate over profit allocated significantly more land to CSA—ranging from 34.29 ha (climate-focused) to 45.86 ha (climate more important than profit). By contrast, participants who prioritized profit allocated substantially less—23.63 ha when profit was more important and only 17.72 ha when profit was the sole focus.

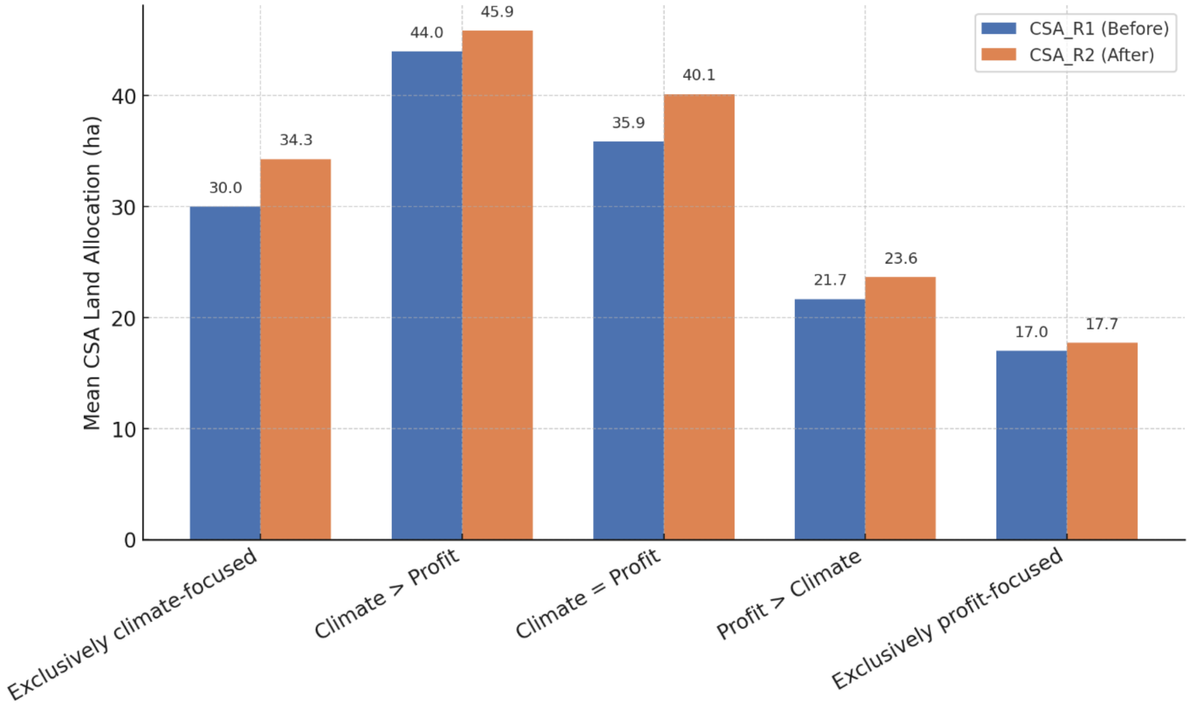

Figure 8: Average CSA land allocation by decision making motives

3.4.5. *Correlation of CSA land allocation with some behavioural and perception variables*

Figure 9 illustrates the relationship between CSA land allocation and some selected behavioural variables. The results show that CSA land allocation has the strongest associations with personal values (r = 0.273), indicating that those who believe in personal commitment to sustainable farming methods were more likely to allocate more land to CSA. Likewise, the future adoption decision of CSA (intention to adopt) (r = 0.229) was strongly correlated with the land allocation decision in the experiment. Moral obligation (r = 0.201), social pressure (r = 0.202), and increased awareness from the questionnaire (r = 0.201) also showed positive correlations with CSA land allocation. On the other hand, belief in climate responsibility had a moderate correlation (r = 0.153), while perceived peer behaviour was weakly correlated (r = 0.126). Trust in government support showed a smaller correlation (r = 0.123). In contrast, cost concerns and peer concerns about climate change were not significantly correlated to CSA allocation.

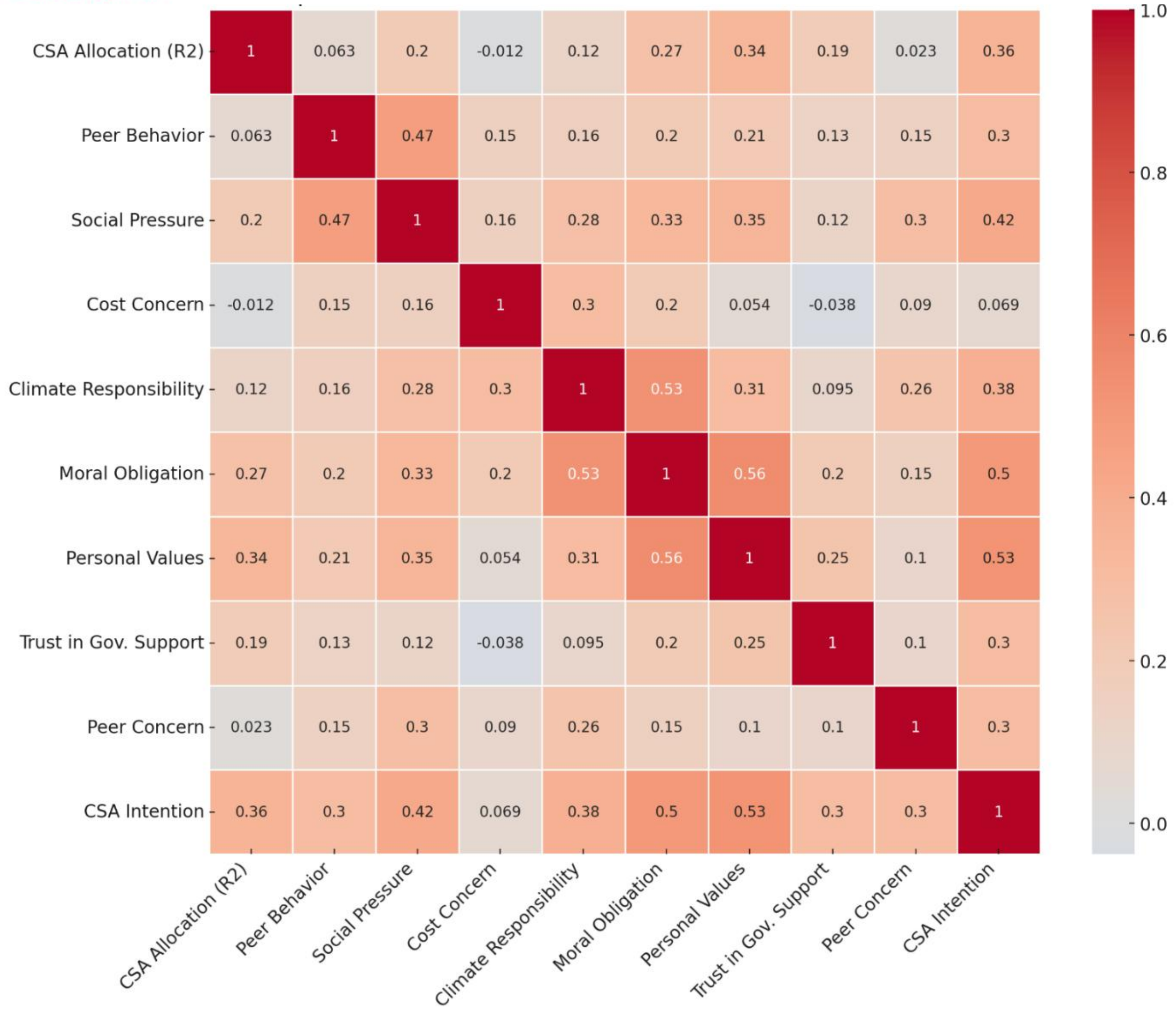

Figure 9: Correlation of CSA land allocation with some behavioural factors

3.5. Concluding summary of LAB5

This experiment tested the effect of social norm information framing among farmer students —specifically, a role model message about young farmers—on the adoption of CSA, measured through land allocation decisions between conventional and CSA practices. The role model social norm intervention produced a modest behavioural effect. While the difference in CSA land allocation between the treatment and control groups was not statistically significant, future farmers exposed to the social norm message significantly increased their CSA land allocation within subjects, from Round 1 to Round 2. This suggests that social norms can influence individual behaviour, even if the comparative effect across groups is small or not statistically robust.

Post-experiment analysis revealed that beyond the intervention, future farmers' (participant students') decision-making motives and priorities played a critical role. Participants who emphasized climate impact, focused—either exclusively or by prioritizing climate over profit—allocated the most land to CSA in both Round 1 and Round 2, compared to those who prioritized profit. Participants who indicated that profit was more important or that they were exclusively profit-focused consistently allocated the least land to CSA, with only modest increases across rounds.

This alignment between stated motives and observed behaviour reinforces the importance of underlying values in agricultural decision-making. Overall, these findings indicate that while social norm interventions may yield modest average effects that can shift in future farmers' behaviour within individuals. This highlights the potential of leveraging social norm-based interventions to drive climate-smart farming practices and technologies adoption.

4. Reporting of LAB 7 experiment

4.1. Introduction

Agricultural advisors play a critical role in supporting the adoption of climate-smart technologies (Pedersen et. al. 2024). Their position as trusted intermediaries allow them to influence farmers' awareness, understanding, and use of data-driven decision tools.

The BEATLES project initiated Lab 7 to examine how a targeted intervention—in this case, a demonstration of a Decision Support Tool (DST) - could influence advisors and close related stakeholders behavioral and cognitive readiness to promote digital agricultural tools. This intervention aligns with the broader objective of the BEATLES project to drive behavioral shifts in agricultural systems toward climate-smart practices through technological and advisory innovation.

Objective

The objective of this study was to assess whether a demonstration (as proxy of training) of a decision support tool (DST) influences stakeholders in regard to:

- ✓ Attitudes toward precision farming technologies, particularly robotic weeding/spraying.
- ✓ Intentions to use the DST (web tool) for decision-making for advisory and consultancy services.
- ✓ Perceptions of the tool's usability and value in enhancing the advisory services and for supporting climate-smart agriculture.
- ✓ Comfortability with sharing data via an online decision support tool

This specific task evaluates the effectiveness of a DST demonstration designed to enhance the adoption of robotic weeding and spraying systems – and to understand different stakeholders perception of how useful the tool is for advisors.

4.2. Methodology

4.2.1 Research design for this experiment:

The study followed a pre-post within-subject design:

Pre-Demonstration Survey: Participants responded to baseline questions to assess beliefs, intentions, and comfort with DST use.

DST Intervention Description

Following the baseline questionnaire, participants—primarily farm advisors—were shown a demonstration of the **Web-Based Decision Support Tool (DST)**. This tool is designed to assist farmers and stakeholders in evaluating the farm-level economic performance of autonomous robotic applications — including weeding and spraying systems — compared to conventional tractor-based operations.

The tool includes default economic data derived from field use cases across France, Greece, the Netherlands, and Spain, featuring:

- Mechanical weeding in vineyards (France)
- Autonomous spraying in table grapes (Greece)
- Mechanical weed control in sugar beets (Spain)
- Targeted spraying in apple orchards (Netherlands)

The demonstration emphasized how advisors can:

- Assess and communicate the economic/environmental impacts of robotic systems
- Support client decision-making with quantified data
- Evaluate the implications of data sharing within advisory workflows

Post-Demonstration Survey: Participants completed the same items as the pre-survey, along with additional questions evaluating:

- Perceived relevance of DSTs for stakeholders
- Usefulness of the webtool
- Likelihood to recommend DSTs to others

4.2.2 Data

A total of 43 agricultural stakeholders, primarily advisors, participated in the Lab 7 experiment (Table 19). However, 3 respondents didn't complete the pre- and post-questionnaires. Respondents varied in gender, professional background, and experience levels:

Table 19: Participants in the Lab 7 experiment were from Greece and Denmark.

Country	Frequency.	Percent
Greece	17	39.53
Denmark	26	60.47
Total	43	100.00

- ✓ Gender: 42.5% female, 55% male, 2.5% other/prefer not to say.
- ✓ Profession: 40% are university-based agricultural scientists, 35% are private advisors, 15% are environmental policymakers, and 10% are others.
- ✓ Country: 60.5% Denmark, 39.5% Greece
- ✓ Mean age: 48.3 years
- ✓ Mean advisory experience: 12.7 years

The within-subject pre/post-experimental design provides robust internal validity by using each participant as their control, minimizing between-subject variation. While it does not assess long-term adoption, it is well-suited to detect immediate cognitive and motivational shifts, which are critical for subsequent behavioral uptake.

Workshop in Denmark

The first experiment and workshop took place on Thursday, 23rd January 2025, at Teknologisk Institut in Aarhus, Denmark. During the workshop, a first presentation of the Robs4Crops project and the developed advisory webtool was introduced to provide an idea for the participants about the tool and its purpose (see www.agrobot-cba.eu). The tool is developed to help farmers and stakeholders calculate the farm-level economic performance of autonomous weeding and spraying systems. It was based on real-life data from the Robs4Crops project's four use cases (see www.robs4crops.eu).

The webtool experiment was conducted as part of an overall one-day workshop about digitalization in agriculture.

First, all participants were introduced to the experiment (with purpose and objectives). Hereafter, we provided a link and (QR code) to the first questionnaire round with questions regarding: Attitude that DSTs enhance the adoption of robotic spraying, Intention to use a DSTs professionally, and how comfortable participants are about sharing data via a DST.

Hereafter, we presented the webtool and its different features and options. In principle, all steps from choosing the production system, entering the data about farm characteristics, to printing out a PDF-fact sheet were presented to the participants.

In practice, it included a 5-minute presentation of the tool and its application and then a short 10-minute tutorial of the webtool. Just after the presentation, we distributed the second round of questions about the relevance of the webtool for advisory work, the Usefulness of the Webtool and the likelihood to recommend the tool to farmers/stakeholders.

We also provided a random number to all participants to be used for identity purposes. Answers were thereby kept anonymous. Participants were allowed about 10 min. to answer the questions (on their smart phones or lab-tops). The presentation and experiments were carried out in English.

Workshop in Greece

The same experiment took place in Greece on 27 March 2025. Here it was held as an online workshop, but it followed the same steps and principles as in Denmark.

For comparison, both experiments in Greece and Denmark included the same use case for the DST web-tool presentation, namely the Greek use case.

Measurement scale used

All responses were recorded using 5-point Likert scales.

Main outcomes (pre & post):

- How familiar are you with decision support tools for precision farming technologies?

- To what extent do you believe that economic and environmental assessment decision support tools (DSTs) can enhance the adoption of robotic spraying?
- How likely are you to integrate economic and environmental impact assessment DSTs into your professional activities (e.g., consultancy, training, advising farmers)?
- How comfortable are you with sharing farm-related data via an online decision support tool to enhance its functionality?

Post-only measures:

- To what extent do you now believe that the economic and environmental assessment DSTs can enhance the adoption of robotic spraying?
- How likely are you to integrate DSTs (such as the Webtool) into your professional activities (e.g., consultancy, training, advising farmers)?
- How relevant do you now think the economic and environmental impact of PA technologies DSTs are for stakeholders involved in farmer advisory, training, or consultancy?
- How comfortable are you with sharing farm-related data via an online decision support tool to enhance its functionality?
- How likely are you to recommend the economic and environmental impact of PA technologies DSTs (such as Webtool) to farmers and other stakeholders?
- How do you perceive the usefulness of today's Webtool demonstrated?

4.2.3 Data Analysis

Paired t-tests and Wilcoxon signed-rank tests were applied to assess pre/post differences. Descriptive statistics were conducted to summarize background characteristics of the respondents as well as post-intervention perceptions of the tool and likely economic and environmental impact from adopting the tool.

4.3. Results

4.3.1 Descriptive Statistics

Participants had an average age of 48.3 years and 12.7 years of relevant experience. The sample was gender-balanced and professionally diverse, with participants from both Denmark (60.5%) and Greece (39.5%). More than 70 % were either working as agricultural scientist at a university (40 %) or as an agricultural advisor at a private company (35 %). (see table 20).

Table 20: Descriptive Statistics, age, gender, background.

	Mean	**SD**
age	48.325	10.70918
experience	12.675	11.83083
N	40	
Gender	**Freq.**	**Percent**
Female	17	42.50
Male	22	55.00
Other /Prefer not to tell	1	2.50
Total	40	100.00

Professional background	Freq.	Percent
Agricultural scientist at a university	16	40.00
Agricultural advisor at a private company	14	35.00
Policymaker focused on environmental re	6	15.00
Other	4	10.00
Total	40	100.00

When asked, how familiar are you with decision support tools for precision farming technologies? About 15 percent answered that they are not familiar with decision support tools for precision farming technologies (Table 21). On the contrary, about 42,5 percent of the respondents were either moderately familiar or very familiar with these decision support tool.

Table 21: How familiar are you with decision support tools for precision farming technologies?

Familiarity	Freq.	Percent
Not at all familiar	6	15.00
Slightly familiar	12	30.00
Neutral	5	12.50
Moderately familiar	8	20.00
Very familiar	9	22.50
Total	40	100.00

4.3.2 The distribution of sample respondent for the three outcome variables

Attitude Change

Pre-demonstration survey response shows that of the sampled respondents about 40% selected "Moderately" and 37.5% selected "Significantly," with only a small fraction (5%) selecting "Slightly" highlighting that the majority of participants already held a positive view regarding the potential of DSTs to enhance robotic spraying. Post-demonstration survey response results highlighted that the attitude distribution shifted slightly, specifically the "Moderately" attitude level was relatively high (41.5%).

Figure 10 provides the frequency distribution of stakeholders attitudes toward DSTs for robotic weeding/spraying. As indicated in the figure there is a tendency that the intervention and demonstration session only had a little impact on the potential of using DSTs to enhance robotic spraying.

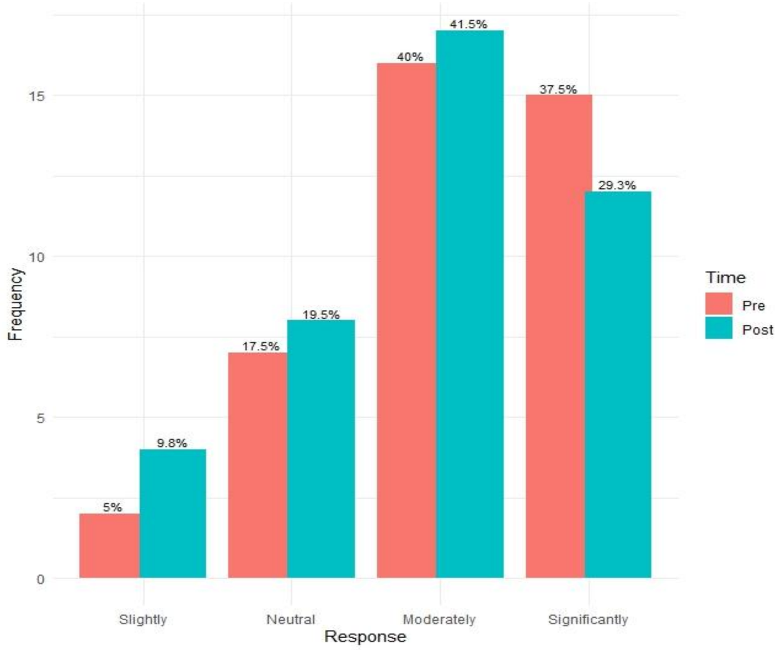

Figure 10: Attitudes toward DSTs for robotic weeding/spraying

Intention change

Figure 11 provides the frequency distribution of stakeholders intentions to use the webtool for decision-making in advisory, consultancy, and training

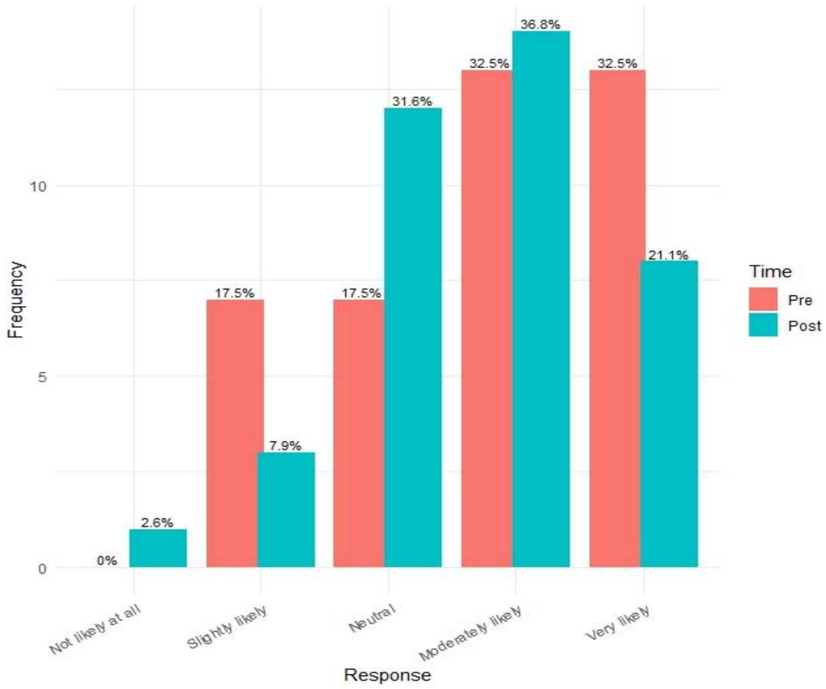

Figure 11: Intentions to use the webtool for decision-making in advisory, consultancy, and training

Figure 11 above also indicates that the intervention and demonstration session only had a little impact on stakeholders' intentions to use the webtool for decision-making in advisory, consultancy, and training activities. Here the frequency decreased from "very likely to use the tool" (32.5 percent) to 21,1 percent after the intervention and demonstration of the tool.

Comfortability change

Figure 12 below shows advisors comfortability with sharing farm-related data via an online decision support tool.

In general, many stakeholders seems to be comfortability with sharing farm-related data via an online decision support tool. Here we see a change of stakeholders that are moderately comfortability with sharing farm-related data from 30 percent before demonstration to nearly 49 percent after the demonstration.

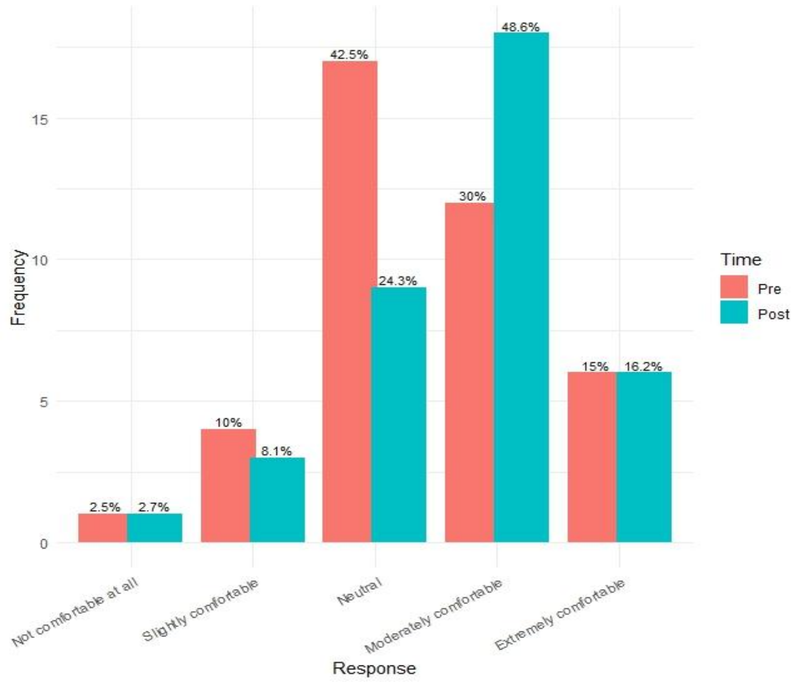

Figure 12: *Comfortability with sharing farm-related data via an online decision support tool to enhance its functional*

At end of appendix 4 is provided the mean score differences for the three outcome variables (pre and post) which indicate a similar pattern as described above.

4.3.3 Testing the effect of the treatment based paired T-tests based on score values

Paired t-tests as indicated below in three tables it was found that there were no statistically significant differences between pre and post scores across the three main outcome variables:

- Attitude towards web DSTs: t= 1.12
- Intention to Use web DSTs: t = 1.67
- Comfortability about sharing Data: t= -1.66

Table 22-24 summarise and provide the mean and standard errors, pre and post questions about 1) to what extent stakeholders believe that economic and environmental assessment decision support Tools (DSTs) can enhance the adoption of robotic spraying? 2) How likely are stakeholders to integrate economic and environmental impact assessment DSTs into their professional activities? and 3) How comfortable are stakeholders with sharing farm-related data via an online decision support tool?

Attitudes: To what extent do you believe that economic and environmental assessment decision support tools (DSTs) can enhance the adoption of robotic spraying?

Table 22: Attitude mean score for pre and post questions

Variable	Obs	Mean	Std. err.	Std. dev.	[95% conf. interval]
pre_ Attitudes	38	4.078947	.1430295	.8816931	3.789142 4.368753
post_ Attitudes	38	3.894737	.1590757	.9806086	3.572419 4.217055
diff	38	.1842105	.1637716	1.009556	-.1476223 .5160433

mean(diff) = mean (pre_belief- post_belief) Degrees of freedom = 37 t = 1.1248

Intentions to use: How likely are you to integrate economic and environmental impact assessment DSTs into your professional activities (e.g., consultancy, training, advising farmers)?

Table 23: Intention means score for pre and post questions

Variable	Obs	Mean	Std. dev.	[95% conf.	interval]
pre_ Intentions to use	35	3.914286	1.039554	3.557186	4.271385
post_ Intentions to use	35	3.685714	1.022437	3.334495	4.036934
diff	35	.2285714	.8075276	-.048824	.5059669

mean(diff) = mean (pre_intent- post_intent) t = 1.6746

Comfortability: How comfortable are you with sharing farm-related data via an online decision support tool to enhance its functionality?

Table 24: Comfortability means score for pre and post questions

Variable	Obs	Mean	Std. dev.	[95% conf.	interval]
pre_ Comfortability	35	3.514286	.9813385	3.177184	3.851387
post_ Comfortability	35	3.8	1.023259	3.448498	4.151502
diff	35	-.2857143	1.016668	-.6349519	.0635233

mean(diff) = mean (pre_comfort - post_comfort) t = -1.6626

However, alternative Wilcoxon signed-rank tests in the below table shows that:

- A significant increase in comfortability with data sharing ($z = -2.16$, $p = 0.03$)

- A marginal trend toward increased intention to use DSTs ($z = 1.77$, $p = 0.08$)
- No significant change in beliefs in DST effectiveness ($z = 0.90$, $p = 0.37$)

Table 25 provides z and p-values for the outcome variables.

As indicated in table 25 above attitude towards DSTs enhancing robotic spraying and Intention to use DSTs professionally did not show statistically significant shifts, although intention shows a marginal trend ($p \approx 0.077$).

However, the comfortability of sharing data among users significantly increased after the demonstration and training intervention ($p < 0.05$)

Table 25: Wilcoxon Signed-Rank Tests (Pre vs Post)

Outcome Variable	z	p-value
Attitude towards DSTs enhancing robotic spraying	0.899	0.369
Intention to use DSTs professionally	1.770	0.077
Comfortability sharing data via DST	-2.157	0.031

Post questions

Below in table 26-28 is provided the frequency and percentage distribution of three post demonstration questions about the relevance of using a decision support tool among stakeholders, their likelihood to recommend it to others and whether they find the DST Webtool demonstration useful.

Table 26-28 shows the frequency in regard to a) Relevance of DSTs, b) Likelihood to recommend DSTs and c) Usefulness of the Webtool demonstration tool.

How relevant do you now think the economic and environmental impact of PA technologies DSTs are for stakeholders involved in farmer advisory, training, or consultancy?

Table 26: Relevance of DSTs are for stakeholders

Relevance of DSTs for stakeholders	Frequency	Percent
Neutral	6	16.22
Moderately relevant	13	35.14
Very relevant	18	48.65
Total	37	100.00

Relevance of DSTs for stakeholders: 84% rated as moderately or very relevant

How likely are you to recommend the economic and environmental impact of PA technologies DSTs (such as Webtool) to farmers and other stakeholders?

Table 27: Likelihood to recommend DSTs

Likelihood to recommend DSTs	Frequency	Percent
Not likely at all	1	2.70
Neutral	6	16.22
Moderately likely	15	40.54
Very likely	15	40.54
Total	37	100.00

Likelihood to recommend DSTs: 81.1% moderately or very likely

How do you perceive the usefulness of today's Webtool demonstrated?

Table 28:Usefulness of the Webtool demo

Post: Usefulness of the Webtool demo	Frequency	Percent
Slightly useful	2	5.56
Neutral	5	13.89
Moderately useful	12	33.33
Very useful	17	47.22
Total	36	100.00

Usefulness of Webtool: 80.5% rated as moderately or very useful

4.4. Concluding summary of LAB7 and perspective

The objective of this study was to assess whether a demonstration (as proxy of training) of a decision support tool (DST) influences stakeholders attitude DST and intension to use it.

Findings from this study indicate that there were no statistically significant differences between pre and post scores questions and interventions across the three main outcome variables, namely in regard to the attitude about DSTs enhancing robotic spraying, intention to use DSTs professionally and interest to share farm-related data via an online decision support tool. Attitude about the decision support tool and intention to use it did not show any statistically significant shifts after introducing the DST-webtool, although intention to use it indicate a marginal trend. However, there was some indication of interest to share farm-related data via an online decision support tool to enhance its functionality. The interest to share these data significantly increased after the training and demonstration intervention ($p < 0.05$).

One reason for the modest differences in intention and attitude about the tool could be explained by the type of stakeholders participating in the two experiments. Many of them came from research institutions and were not direct potential users or likely end users of the DST tool, which may explain the low intension to change attitude after the presentation. The results may have changed with a broader group of direct end users like farm advisors and farmers.

However, there was a positive impact on the usefulness of the DST webtool. There seems to be a majority of respondents who found the tool useful after the demonstration. A majority of the respondents also found that the economic and environmental impact of PA technologies DSTs are important for stakeholders involved in farmer advisory, training, or consultancy. And a majority of the respondents are also likely to recommend an assessment of the economic and environmental impact of PA technologies like the webtool to farmers and other stakeholders. In total, 82 % of the respondents would either moderately or very likely recommend the tool to others. In addition, 81 % found the tool moderately or very useful.

In summary, this experiment presented a pre and post demonstration experiment to assess the impact of training and demonstration sessions with a DS web-tool and its impact on attitude and intension to use it for decision making. Although the experiment gave some valuable insights about stakeholders behavior, it is difficult to provide final conclusions as the study is based on a relatively low number of respondents. Moreover, the sample was not only targeted to advisors but also other stakeholders, with a relatively large group of non-advisors participating at the workshops.

This targeted experiment, with a demonstration of a decision support webtool, supplements the first BEATLES studies about decision making factors and adoption of CSA technologies and practices among farmers and other stakeholder groups (see Erekalo et. al. 2024, Pedersen et.al. 2024, Gemtou at. al 2024, Erekalo et. al. 2025). Overall, these studies indicate that there is a general interest among stakeholders in all parts of the supply chain, including farmers and consumers to support climate smarts initiatives in the agricultural sector.

However, further studies with a more targeted group of stakeholders from the advisory sectors are recommended to further understand the impact of using decision support tools to enhance climate smart technology adoption in the European agricultural sector.

5. Concluding summary of Deliverable 2.2

Lab 4 experiment was conducted with Danish farmers to test the effect of two economic instruments—regulatory tax and market demand-based incentives—on CSA land allocation decisions. The market-based incentive, a premium price on CSA products, had slightly stronger effects. However, uncertainty about these policy options appeared to act as a lock-in barrier, as it negatively correlated with CSA land allocation. Additional insights were drawn from post-experiment reflections on decision-making motives and trade-offs in implementing CSA. Farmers who focused on both climate benefits and profitability during their land allocation decision-making allocated more land to CSA, highlighting the importance of framing CSA as a 'win-win' strategy that offers both economic and environmental benefits. Providing training, demonstrations, or compensation may be more effective than emphasizing climate benefits alone. Tailored economic incentives, such as premium price contracts for CSA-produced goods, could also encourage behavior change among profit-motivated farmers.

Lab 5 experiment was conducted with future farmers (farmer students) to test the effect of social norm information framing—specifically, a role model message targeting young farmers—on CSA adoption, measured through land allocation decisions between conventional and CSA practices. While the difference in CSA land allocation between treatment and control groups was not statistically significant, the actual amount of land allocated to CSA was relatively higher among those exposed to the role model message. Moreover, within-subject comparisons showed that future farmers exposed to the social norm message significantly increased their CSA land allocation. Based on self-reported motives, respondents who prioritized climate benefits—either exclusively or over profit—

allocated more land to CSA in both rounds than those who prioritized profit. Overall, social norm interventions showed small average effects, but they suggest potential for encouraging climate-smart farming practices and technology adoption.

Lab 7 experiment was conducted with 38 stakeholders to test whether a demonstration of a web tool (as a proxy for training) influenced attitudes toward a decision support tool (DST), intention to use it, and willingness to share farm-related data online. Based on pre- and post-test scores, the interventions did not yield statistically significant changes across the three outcome variables. However, there was some indication of increased interest in sharing farm-related data to enhance DST functionality. Most respondents recognized the importance of assessing the economic and environmental impacts of precision agriculture technologies and expressed a willingness to recommend such tools to farmers and other stakeholders. While the experiment provided valuable insights into stakeholder behavior, final conclusions are limited due to the relatively small and diverse sample, which included a large number of non-advisors alongside advisors.

6. References

Altobelli, F., Monteleone, A., Cimino, O., Dalla Marta, A., Orlandini, S., Trestini, S., Toulios, L., Nejedlik, P., Vucetic, V., Cicia, G., Panico, T., Cavallo, C., D'Urso, G., Del Giudice, T., & Giampietri, E. (2019). Farmers' willingness to pay for an environmental certification scheme: Promising evidence for water saving. *Outlook on Agriculture*, *48*(2), 136–142. https://doi.org/10.1177/0030727019841059

Banerjee, P., Pal, R., Wossink, A., & Asher, J. (2021). Heterogeneity in Farmers' Social Preferences and the Design of Green Payment Schemes. *Environmental and Resource Economics*, *78*(2), 201–226. https://doi.org/10.1007/s10640-020-00529-7

Cialdini, R. B., & Jacobson, R. P. (2021). Influences of social norms on climate change-related behaviors. *Current Opinion in Behavioral Sciences*, *42*, 1–8. https://doi.org/10.1016/j.cobeha.2021.01.005

Constantino, S. M., Sparkman, G., Kraft-Todd, G. T., Bicchieri, C., Centola, D., Shell-Duncan, B., Vogt, S., & Weber, E. U. (2022). Scaling Up Change: A Critical Review and Practical Guide to Harnessing Social Norms for Climate Action. *Psychological Science in the Public Interest*, *23*(2), 50–97. https://doi.org/10.1177/15291006221105279

Costa, M. P., Reckling, M., Chadwick, D., Rees, R. M., Saget, S., Williams, M., & Styles, D. (2021). Legume-Modified Rotations Deliver Nutrition With Lower Environmental Impact. *Frontiers in Sustainable Food Systems*, *5*, 656005. https://doi.org/10.3389/fsufs.2021.656005

Cusworth, G., Garnett, T., & Lorimer, J. (2021). Legume dreams: The contested futures of sustainable plant-based food systems in Europe. *Global Environmental Change*, *69*, 102321. https://doi.org/10.1016/j.gloenvcha.2021.102321

D'Alberto, R., Targetti, S., Schaller, L., Bartolini, F., Eichhorn, T., Haltia, E., Harmanny, K., Le Gloux, F., Nikolov, D., Runge, T., Vergamini, D., & Viaggi, D. (2024). A European perspective on acceptability of innovative agri-environment-climate contract solutions. *Land Use Policy*, *141*, 107120. https://doi.org/10.1016/j.landusepol.2024.107120

Danish Agriculture & Food Council. (2023). *Facts & figures: Denmark – a food and farming country*. https://agricultureandfood.dk/media/m1qfuuju/lf-facts-and-figures-2023.pdf

Drescher, M., Hannay, J., Feick, R. D., & Caldwell, W. (2024). Social psychological factors drive farmers' adoption of environmental best management practices. *Journal of Environmental Management*, *350*, 119491. https://doi.org/10.1016/j.jenvman.2023.119491

Erekalo, K. T., Pedersen, S. M., Christensen, T., Denver, S., Gemtou, M., Fountas, S., & Isakhanyan, G. (2024). Review on the contribution of farming practices and technologies towards climate-smart agricultural outcomes in a European context. *Smart Agricultural Technology*, 100413. https://doi.org/10.1016/j.atech.2024.100413

Expert Group for a Green Tax Reform. (2024). *Green tax reform: Final report.* https://skm.dk/media/tngh1b4r/green-tax-reform-final-report.pdf

Foolen-Torgerson, K., Lagerkvist, C. J., Sok, J., Dicke, M., & Oude Lansink, A. (2023). Cultivating choices: How social context shapes farmers' considerations in crop and soil health promoter selection. *NJAS: Impact in Agricultural and Life Sciences*, *95*(1), 2256694. https://doi.org/10.1080/27685241.2023.2256694

Gemtou, M., Kakkavou, K., Anastasiou, E., Fountas, S., Pedersen, S. M., Isakhanyan, G., Erekalo, K. T., & Pazos-Vidal, S. (2024). Farmers' Transition to Climate-Smart Agriculture: A Systematic Review of the Decision-Making Factors Affecting Adoption. *Sustainability*, *16*(7), 2828. https://doi.org/10.3390/su16072828

Greiner, R., Patterson, L., & Miller, O. (2009). Motivations, risk perceptions and adoption of conservation practices by farmers. *Agricultural Systems*, *99*(2–3), 86–104. https://doi.org/10.1016/j.agsy.2008.10.003

Heyl, K., Ekardt, F., Roos, P., & Garske, B. (2023). Achieving the nutrient reduction objective of the Farm to Fork Strategy. An assessment of CAP subsidies for precision fertilization and sustainable agricultural practices in Germany. *Frontiers in Sustainable Food Systems*, *7*, 1088640. https://doi.org/10.3389/fsufs.2023.1088640

Hüttel, S., Leuchten, M.-T., & Leyer, M. (2022). The Importance of Social Norm on Adopting Sustainable Digital Fertilisation Methods. *Organization & Environment*, *35*(1), 79–102. https://doi.org/10.1177/1086026620929074

Kocira, A., Staniak, M., Tomaszewska, M., Kornas, R., Cymerman, J., Panasiewicz, K., & Lipińska, H. (2020). Legume Cover Crops as One of the Elements of Strategic Weed Management and Soil Quality Improvement. A Review. *Agriculture*, *10*(9), 394. https://doi.org/10.3390/agriculture10090394

Long, T. B., Blok, V., & Coninx, I. (2016). Barriers to the adoption and diffusion of technological innovations for climate-smart agriculture in Europe: Evidence from the Netherlands, France, Switzerland and Italy. *Journal of Cleaner Production*, *112*, 9–21. https://doi.org/10.1016/j.jclepro.2015.06.044

MFAFD. (2023). *Danish Action Plan for Plant-based Foods*. Ministry of Food, Agriculture and Fisheries of Denmark. https://en.fvm.dk/Media/638484294982868221/Danish-Action-Plan-for-Plant-based-Foods.pdf

Notz, I., Topp, C. F. E., Schuler, J., Alves, S., Gallardo, L. A., Dauber, J., Haase, T., Hargreaves, P. R., Hennessy, M., Iantcheva, A., Jeanneret, P., Kay, S., Recknagel, J., Rittler, L., Vasiljević, M., Watson, C. A., & Reckling, M. (2023). Transition to legume-supported farming in Europe through redesigning cropping systems. *Agronomy for Sustainable Development*, *43*(1), 12. https://doi.org/10.1007/s13593-022-00861-w

Papadopoulos, G., Arduini, S., Uyar, H., Psiroukis, V., Kasimati, A., & Fountas, S. (2024). Economic and environmental benefits of digital agricultural technologies in crop production: A review. *Smart Agricultural Technology*, *8*, 100441. https://doi.org/10.1016/j.atech.2024.100441

Pedersen, S. M., Erekalo, K. T., Christensen, T., Denver, S., Gemtou, M., Fountas, S., Isakhanyan, G., Rosemarin, A., Ekane, N., Puggaard, L., Nertinger, M., Brinks, H., Puško, D., & Adrián, J. B. (2024). Drivers and barriers to climate-smart agricultural practices and technologies adoption: Insights from stakeholders of five European food supply chains. *Smart Agricultural Technology*, *8*, 100478. https://doi.org/10.1016/j.atech.2024.100478

Plaza-Bonilla, D., Nolot, J.-M., Raffaillac, D., & Justes, E. (2015). Cover crops mitigate nitrate leaching in cropping systems including grain legumes: Field evidence and model simulations. *Agriculture, Ecosystems & Environment*, *212*, 1–12. https://doi.org/10.1016/j.agee.2015.06.014

Price, J. C., & Leviston, Z. (2014). Predicting pro-environmental agricultural practices: The social, psychological and contextual influences on land management. *Journal of Rural Studies*, *34*, 65–78. https://doi.org/10.1016/j.jrurstud.2013.10.001

Riar, A., Goldmann, E., Bautze, D., Rüegg, J., Bhullar, G. S., Adamtey, N., Schneider, M., Huber, B., & Armengot, L. (2024). Farm gate profitability of organic and conventional farming systems in the tropics. *International Journal of Agricultural Sustainability*, *22*(1), 2318933. https://doi.org/10.1080/14735903.2024.2318933
Scherer, L., & Verburg, P. H. (2017). Mapping and linking supply- and demand-side measures in climate-smart agriculture. A review. *Agronomy for Sustainable Development*, *37*(6), 66. https://doi.org/10.1007/s13593-017-0475-1
SEGES. (2025). *Budget calculations for various cereal crops and soil types in 2025. SEGES Farm-Online System.* [Dataset]. https://farmtalonline.dlbr.dk/
Stagnari, F., Maggio, A., Galieni, A., & Pisante, M. (2017). Multiple benefits of legumes for agriculture sustainability: An overview. *Chemical and Biological Technologies in Agriculture*, *4*(1), 2. https://doi.org/10.1186/s40538-016-0085-1
Statistics Denmark. (2024). *Accounting Statistics for Agriculture 2023* [Audio recording]. https://www.dst.dk/da/Statistik/nyheder-analyser-publ/Publikationer/VisPub?cid=52306
Wang, Y., Möhring, N., & Finger, R. (2023). When my neighbors matter: Spillover effects in the adoption of large-scale pesticide-free wheat production. *Agricultural Economics*, *54*(2), 256–273. https://doi.org/10.1111/agec.12766

Appendix

Appendix 1: Lab 4 descriptive results

1. Descriptive statistics results on socioeconomic variables

Age summary statistics by experimental group

Group	Mean Age	Std. Dev.	Min	Max	N
Control	53.56	12.71	33	76	81
Premium Price on CSA	54.82	12.29	33	75	89
Tax on Conventional	57.01	10.83	36	73	81
Total	55.12	12.02	33	76	251

Farming experience by experimental group

Farming Experience	Control	Tax on Conventional	Premium Price on CSA	N
Less than 10 years	6 (46.15%)	1 (7.69%)	6 (46.15%)	13
11 to 20 years	20 (39.22%)	16 (31.37%)	15 (29.41%)	51
More than 20 years	55 (29.41%)	64 (34.22%)	68 (36.36%)	187
Total	81 (32.27%)	81 (32.27%)	89 (35.46%)	251

Farm size by experimental group

Farm Size	Control	Tax on Conventional	Premium Price on CSA	N
51 to 100 ha	38 (38.38%)	30 (30.30%)	31 (31.31%)	99
101 to 200 ha	14 (24.14%)	23 (39.66%)	21 (36.21%)	58
201 to 500 ha	26 (35.14%)	22 (29.73%)	26 (35.14%)	74
More than 500 ha	3 (15.00%)	6 (30.00%)	11 (55.00%)	20
Total	81 (32.27%)	81 (32.27%)	89 35.46%)	

2.Post experiment questions descriptive statistics results

Environmental commitment by group

Group	Sustainability is a core value	I take proactive steps beyond regulation	I balance sustainability with other priorities	I follow required regulations only	I do only what's necessary to comply	Total
Control	2 (2.47%)	10 (12.35%)	33 (40.74%)	22 (27.16%)	14 (17.28%)	81
Tax on Conventional	6 (7.41%)	39 (48.15%)	18 (22.22%)	18 (22.22%)	0 (0.00%)	81
Premium Price on CSA	6 (6.74%)	47 (52.81%)	25 (28.09%)	11 (12.36%)	0 (0.00%)	89
Total	14 (5.58%)	96 (38.25%)	76 (30.28%)	51 (20.32%)	14 (5.58%)	251

Summary of perceptions on uncertainty and proposed tax by experimental group

Category	Control	Tax on conventional	Premium price on CSA
Uncertainty about government policy (Not at all, slightly, moderately, very much, completely)	10% slightly, 56% very much	10% slightly, 54% very much	20% slightly, 43% very much
Uncertainty about market stability (Not at all, slightly, moderately, very much, completely)	25% moderately, 57% very much	30% moderately, 53% very much	40% moderately, 37% very much
Perception of agricultural emission tax **(**Support, neutral, oppose to some extent, strongly oppose)	79% oppose to some extent	78% oppose to some extent	77% oppose to some extent
Trust in government policies **(**1 = No trust at all, 5 = complete trust)	59% A little trust, 32% neutral	51% A little trust, 38% neutral	56% A little trust, 32% neutral
Awareness of CSA **(**No, minimal, moderate and high awareness)	56% minimal awareness	63% minimal awareness	58% minimal awareness

Appendix 2: Questionnaire for LAB4

Experimental instruction and survey questions

Opening Section:

Thank you for your interest in participating in this study. It will take approximately 20 minutes.

The study is carried out by researchers at the University of Copenhagen.

This study focuses on the implementation of agricultural farming practices under different scenarios. Your participation helps us understand how farmers make decisions farming practices land allocation.

Please note there are no "right" or "wrong" answers, what matters is your honest opinion and preferences.

To express our gratitude, you will receive a voucher of 100 DKK from Aspecto A/S. You will also receive an additional payment of up to 1600 DKK based on 5% chance of winning.

Consent Section

Your participation is voluntary, and your responses are completely anonymous, and no one, including the researchers, will be able to trace your answers back. You can withdraw at any time by closing the browser window, and your responses will not be saved.

If you have any questions about the study, please contact us at: ----------------.

Please confirm:
[ ] I have read and understood the above information and would like to participate.
[ ] I do not grant my consent and will terminate my participation.

If consent is declined:
Thank you for your time. Your decision not to participate means your responses will not be saved or used. Please click exit the survey." to exit.

If consent is granted:
Thank you for giving your consent, now we will introduce our study for you in the following sections.

Background Information Survey

Before we begin the experiment, we would like to ask you a few questions to gather some background information. Your responses will help us better understand your context and perspectives. *Please note that your answers will remain anonymous and will only be used for research purposes.*

1. **What is your age?** [Enter age]
2. **What is your gender?**
   ☐ Male
   ☐ Female
   ☐ Other
3. **How long have you been working in farming?**
   ☐ Less than 10 years
   ☐ 11 to 20 years
   ☐ More than 20 years
4. **What is your farm size?**
   ☐ Less than 50 ha
   ☐ 51 to 100 ha
   ☐ 101 to 200 ha
   ☐ 201 to 500 ha
   ☐ More than 500 ha
5. **What is the main production system of your farm?**
   ☐ Arable crops
   ☐ Livestock
   ☐ Mixed farming
6. **Which region do you live in?**
   ☐ Region Hovedstaden
   ☐ Region Sjælland
   ☐ Region Syddanmark
   ☐ Region Midtjylland
   ☐ Region Nordjylland

Common instruction and farming practices scenario description for the experiment

Welcome to the experiment section of this study

In this experiment, you will decide how to allocate 100 hectares of agricultural land between two farming practices: conventional agriculture and climate-smart agriculture. Your participation is invaluable in helping us understand how farmers make decisions regarding land allocation. For the purposes of this experiment, you can only choose between these two options.

Conventional agriculture practices involve, among other things, reliance on chemical fertilizers in crop production to increase crop yield. In Denmark, the use of chemical fertilizers is regulated to reduce nitrogen leaching into aquatic ecosystems and coastal waters. However, these fertilizers remain a significant source of agricultural emissions, including nitrous oxide, nitrogen leaching, and CO_2 during production and application, contributing to climate change

Climate-smart agriculture practices include sustainable practices that maintain productivity while improving soil fertility, reducing reliance on chemical fertilizers, and lowering greenhouse gas emissions. The practice involves incorporating legume-based crops (e.g., faba beans) into crop rotations, which naturally fix nitrogen in the soil and serve as a climate-friendly source of protein for food and feed. Climate-smart agriculture practices also involve using organic fertilizers (e.g., animal manure and/or slurry (liquid manure), compost, and green manure: E.g. legumes like peas harvested and spread on the field) as alternatives to chemical fertilizers. Additionally, precision technologies are also used to optimize the application of nutrients and pesticides.

Trade-offs between conventional agriculture and climate-smart agriculture
Conventional agriculture offers higher short-term profits but relies on chemical fertilizers, which can affect soil health and contribute to emissions over time. While this approach provides immediate financial stability, long-term productivity may be affected by soil depletion and environmental constraints.
Climate-smart agriculture, by contrast, focuses on improving soil fertility and reducing reliance on chemical inputs. While these methods may initially require adaptation and result in lower short-term profits, they can enhance soil resilience and maintain productivity over time.
Farmers should weigh the benefit of immediate profits against the potential for long-term sustainability and productivity when choosing how to allocate land.

Two Rounds of Land Allocation

In this experiment, you will participate in two rounds of decision-making, each representing a growing season. Your task is to decide how to distribute 100 hectares of land between two farming practices: conventional agriculture and climate-smart agriculture (CSA). Consider what you would do in a real-life situation.

- For conventional practice, you earn 8000 profit points per hectare.
- For climate-smart practice, you earn 6800 profit points per hectare. This 6800 profit points includes 300 points per hectare for land allocated to climate-smart agriculture, reflecting existing government policies that support sustainable agriculture and acknowledge efforts to reduce agriculture's environmental footprint.

We provide real economic incentives in the experiment
In this experiment, you have the opportunity to earn real monetary rewards based on your decisions. The rewards consist of:

Lottery Participation:
- By participating, you are automatically entered into a lottery with a 5% chance of winning (12 winners out of 240 participants).
- The maximum reward you can win in the lottery is 1600 DKK.

The exact payoff is calculated:

- Pay Amount = Total profit points ÷ 500, that means for every 10000 total profit points, you will receive 20 DKK as a real payment if you are one of the lottery winners.
- Where total profit points are calculated as:
  (8000 × hectares allocated to conventional practices) + (6800 × hectares allocated to climate-smart practices).

Your payout depends on your decisions made in one of the randomly selected rounds (either Round 1 or Round 2).

Note: Your participation fee of DKK 100 will be transferred to you by Aspecto A/S together with your calculated payoff if you are one of the lucky winners of the lottery

Example of Calculating Profit Based on Land Allocation Decision

If you allocate **40 hectares** of land to climate-smart agricultural practices and **60 hectares** to conventional agricultural practices, your profit is calculated as follows:

1. Profit from Conventional Practices: =60 hectares×8000 DKK/ha=480000DKK
2. Profit from Climate-Smart Practices: =40 hectares×6800 DKK/ha=272000 DKK
3. Total Profit Points: =480000 + 272000=752000
4. Reward related to this choice: (752000÷ 500) = 1504DKK

   That means, if you allocate 60 hectares to conventional practices and 40 hectares to climate-smart practices, your total profit points will be 752,000. This corresponds to a lottery reward of 1,504 DKK if you win.

A short quiz
Which of the following statements is correct based on this experiment?"

- A) Conventional farming offers higher short-term profit, while climate-smart practices focus on long-term sustainability.
- B) Climate-smart farming provides both the highest short-term profit and the greatest sustainability benefits.
- C) There is no difference between conventional and climate-smart farming in terms of profit or environmental impact.

Answer: A (Note that answers will not be displayed to respondents)

Round 1: Baseline scenario description

Welcome to Round 1 of the experiment, representing Growing Season 1.

In this round, you will decide how to allocate 100 hectares of farmland into the two farming options: conventional and climate-smart, based on your personal goals and preferences and profit points generated by each option given below:

Profit Calculation in Round 1:
• For Conventional practice, you earn 8000 DKK in profit points per hectare
• For Climate-smart practices, you earn 6800 DKK in profit points per hectare.

Your total profit for the 100 hectares is calculated as:

- Total profit points = (8,000 × hectares allocated to conventional practices) + (6800 × hectares allocated to climate-smart practices)

The payment amount that you will receive if you win the lottery is calculated as:
Reward related to a given choice = Total profit points ÷ 500

A short quiz

Based on the profit points provided in the scenario, which farming practice allocation is best to maximize short-term profitability?

A) Climate-smart practices, because it is more sustainable.
B) Conventional practice, because it provides higher short-term profit points per hectare.
C) Both equal, as their profitability is the same.

Answer**: B**

7. Now please allocate the land to conventional and climate-smart agricultural practice? Note that the sum of land divided between conventional, and climate-smart is 100 hectares.

Number of hectares I want to cultivate conventionally = -----
Number of hectares I want to cultivate climate-smart =------

Randomly allocate respondents in the following three groups for round 2

1. ***Group 1=*** *Control Group (Neutral framing)*
2. ***Group 2 =*** *Treatment 1 (Tax on conventional practice).*
3. ***Group 3=*** *Treatment 2 (Consumer demand feedback loop).*

Round 2:
Group 1 Control group: Scenario Description

Welcome to Round 2 of the experiment, representing **Growing Season 2.**

Denmark has a temperate climate with plenty of rain, a flat landscape, and fertile soils. About 60% of Denmark's total area is cultivated. The average farm size is 83 ha but more than 20% of the farms exceed 100 ha of land.

In this round, you will again decide how to allocate 100 hectares based on your personal goals and preferences.

Profit Calculation in Round 2
• For conventional practice, you earn **8000 DKK** in profit points per hectare
• For Climate-smart practices, you earn **6800 DKK** in profit points per hectare.

Your total profit for the 100 hectares is calculated as:
Total profit points= (8,000 × hectares allocated to conventional practices) + (6,800 × hectares allocated to climate-smart practices)

The payoff amount that you will receive if you win the lottery is calculated as:

Payoff related to a given choice = Total profit points ÷ 500

8. How much land do you allocate to conventional practices and to climate-smart practices? Note that the sum of land divided between conventional and climate-smart is 100 hectares **(Randomize the below two questions)**

Land allocated to conventional practice = ____ hectares
Land allocated to climate smart practice = ____ hectares

Group 2. Tax

Welcome to Round 2 of the experiment, representing **Growing Season 2**.

To promote sustainable agricultural practices and reduce environmental impacts, the government has introduced an agricultural emissions (like nitrogen leaching, nitrous oxide, and CO_2 emissions) tax on conventional farming based on expert recommendations. This tax is part of a broader strategy to encourage sustainable practices through environmental cost adjustment on conventional farming. This tax is applied due to conventional farming's significant reliance on chemical fertilizers, which contribute to nitrogen leaching into aquatic ecosystems and CO_2 emissions during production and use. Suppose the tax is set at 700 DKK per hectare. Note that the government may revise the tax rate in the future, which could mean an increase, decrease, or removal, depending on policy evaluations and feedback

In this round, you will again decide how to allocate 100 hectares based on your personal goals and preferences.

Profit Calculation in Round 2

- For conventional practice you earn 7300 DKK profit points per hectare (including 700DKK tax)
- For climate smart practice you earn 6800 DKK profit points **per** hectare (including 300DKK environmental bonus)

Your profit points from 100 hectares land allocation between the two practices are calculated as:
*Total profit points= (7300 × conventional practice land allocated**)** **+** (6800 × climate smart practice land allocated**)***

The payoff amount that you will receive if you win the lottery is calculated as:
Payoff related to a given choice **= Total profit points ÷ 500**

A short quiz
Which of the following statements is **true** about your second growing season under the agricultural emission tax scheme?
A) Conventional practice is taxed at 700 dkk profit points from the profit points per hectare, which reduces its profit.
B) Allocating more land to conventional practice will increase your total profit points.
C) The tax makes climate smart practice less profitable than conventional practice overall.

Answer: A

8, Decision Task: allocate your land (Randomize the below two questions)
Land allocated to **conventional** = ____ hectares
Land allocated to **climate smart**= _____ hectares

Group 3

Treatment 2: Feedback loop based on the premium price

Welcome to Round 2 of the experiment, representing **Growing Season 2**.

Growing consumer awareness of sustainable agriculture has increased demand for climate-friendly food products. Suppose that you have the opportunity to enter into a contract to deliver climate-friendly products produced by implementing climate smart agricultural practice. Imagine that these products will receive a special label called "climate-friendly produced food", making them eligible to be sold at a premium price. This premium reflects the market's willingness to pay more for sustainably produced goods. As a result, farmers allocating climate-smart practices can get a premium price of 700 DKK per hectare through contracts with food companies offering certified climate-friendly labels. Note that the consumer willingness to pay for climate-friendly products may increase or decrease in the future, depending on market trends.

In this round, you will again decide how to allocate 100 hectares based on your personal goals and preferences.

Profit Calculation in Round 2

- For conventional practice conventional you earn 8000 DKK profit points per hectare
- For climate smart practice you earn 7500 DKK profit points per hectare (including 700 DKK premium price)

Your profit points from 100 hectares land allocation between two practices are calculated as:

Total profit points = (8000 × conventional *practice land allocated)* **+** *(7500* **×** *climate smart practice land allocated)*

The payoff amount that you will receive if you win the lottery is calculated as:
Payoff related to a given choice = Total profit points ÷ 500

A short quiz

Which of the following statements is **true** about climate smart practice under the consumer demand premium scheme?

A) The premium price makes climate smart practice equally profitable as conventional practice.

B) climate smart practice receives an additional 700dkk profit points per hectare, making it more competitive than in the first round.

C) The profitability of climate smart practice does not change with the premium price.

Answer: B

8, Decision Task: allocate your land (Randomize the below two questions)

Land allocated to conventional = ____ hectares
Land allocated to climate smart = _____ hectares

Post experimental questions

Thank you for completing the experiment. We now have a few questions related to land allocation decisions and your attitudes toward farming practices.

9. How realistic did you find farming scenarios in this study?

☐ Completely realistic ☐ Somewhat realistic ☐ Somewhat unrealistic
☐ Not realistic at all

10. To what extent do you agree with the following statements about your land allocation decision in this experiment?(randomize sub questions)

Scale:☐ Strongly disagree ☐ Disagree☐ Neutral☐ Agree☐ Strongly agree
☐ I focused solely on minimizing climate impact when allocating the 100 hectares.
☐ Climate benefits and profit were equally important factors in my decision.
☐ The climate benefits of climate-smart agriculture were not significant enough to outweigh the lower profit compared to conventional agriculture.
☐ I focused solely on maximizing profit when allocating the 100 hectares.

11. How did you perceive the agricultural emission tax on conventional farming in round 2? (Group 2)

☐ The tax made conventional farming less attractive and encouraged me to allocate more land to climate-smart practices.
☐ The tax somewhat influenced my decision to allocate land to climate-smart practices.
☐ The tax did not affect my land allocation decisions.

11. How did you perceive the premium price for climate-smart agricultural products in round 2? (Group 3)

☐ The premium price made climate-friendly food products more attractive and encouraged me to allocate more land to climate-smart practices.
☐ The premium price somewhat influenced my decision to allocate land to climate-smart practices.
☐ The premium price did not affect my land allocation decisions.

12. To what extent did the availability of the environmental bonus for sustainable agriculture influence your decision to allocate land to climate-smart agriculture?

☐ No influence ☐Slight influence ☐Moderate influence ☐Considerable influence ☐Significant influence ☐ I don't know / I don't remember

13. To what extent did you seriously consider the opportunity to win up to 1600 DKK with a 5% chance of winning when making your land allocation decisions based on profit points?

☐ Not considered at all
☐ Slightly considered
☐ Moderately considered
☐ Considerably considered
☐ Strongly considered

14. To what extent did your Round 1 decisions influence your Round 2 land allocation of climate-smart practices?

☐ Not at all, I made my Round 2 decisions independently
☐ Slightly influenced by Round 1 decisions
☐ Moderately influenced by Round 1 decisions
☐ Considerably influenced by Round 1 decisions
☐ Strongly influenced by Round 1 decisions

15. Which statement best describes your commitment to environmental sustainability in your farming practices? (randomize the response)

☐ Sustainability is a core value in my farming, and I actively lead in adopting sustainable practices.
☐ I take proactive steps to go beyond what regulations require.
☐ I balance sustainability with other farming priorities.
☐ I follow the required regulations but do not take additional steps.
☐ I do only what is necessary to comply with regulations.

16. Do you have experience with implementing the following climate-smart agricultural practices activities?

Climate-smart agricultural practices	**Yes**	**No**
Diversified crop production including legume crops like faba beans, peas or alfalfa (for consumption or feed)	☐	☐
Animal manure and/or slurry (liquid manure)	☐	☐
Green manure: E.g. legumes like peas harvested and spread on the field.	☐	☐
Cover cropping or catch crops	☐	☐
Variable rate of fertilizer application	☐	☐
Organic farming	☐	☐

Regenerative farming	☐	☐

Perceptions and Attitudes Toward Climate-Smart Agricultural Practices

17. To what extent do you agree with the following statements about your decision-making in general? **Use the scale provided**. 1= *Strongly Disagree, 2 =Disagree, 3 =Neutral, 4 = Agree 5 =Strongly Agree*

1. Many farmers in my community are implementing climate-smart agricultural practices.
2. People whose opinions I value think that I should implement climate-smart agricultural practices.
3. There is a general expectation among farmers to adopt climate-smart agricultural practices.
4. I generally avoid incurring immediate financial costs, even if there could be long-term profitability.
5. I avoid adopting practices that might increase costs in the short term, even if they could bring long-term benefits.
6. I hesitate to adopt new farming methods due to concerns about financial risks.
7. Reducing climate impact is my personal responsibility as a farmer.
8. I feel morally obligated to produce food in a more climate-friendly way.
9. Regardless of what others do, my personal values make me feel I should implement climate-smart practices rather than conventional methods.

18. To what extent did the following types of uncertainty influence your land allocation decisions among alternatives? Please rate the impact of each uncertainty type on your decision-making by: ☐ Not at all ☐ Slightly ☐ Moderately ☐ Very much ☐ Completely

a. Uncertainty about government policy changes (e.g., potential shifts in subsidies or taxes)
b. Uncertainty about market stability (e.g., fluctuating demand for climate-friendly products)

19.The Danish government has recently planned to implement agricultural emissions taxes aimed at reducing emissions from agriculture, effective from 2030. How do you perceive this initiative? *Choice one*

A) I strongly support the initiative.
B) I support to some extent the initiative
C) I am neutral toward the initiative.
D) I oppose to some extent the initiative
E) I strongly oppose the initiative

20. How much trust do you have in government agricultural policies to support farmers in a transition to more sustainable farming practices? *(1 = No trust at all, 5 = Complete trust)*

✓ ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

21.How likely are you to adopt Climate-Smart Agricultural Practices on your farm in the next five years? *Please indicate your likelihood on a scale of **1 to 5**, where: **1** = Very Unlikely **5**= Very Likely*

22. If you have the 5% chance of winning 1,600 DKK vs. 10% chance of winning 800 DKK, indicate how likely you are to choose each option:

☐ Definitely Choose 1,600 DKK
☐ Probably Choose 1,600 DKK
☐ Neutral
☐ Probably Choose 800 DKK
☐ Definitely Choose 800 DKK

23. How willing are you to take risks in decision-making, in general? Rate your response willingness on a scale from 0 to 10 where 0 indicates Not willing at all while 10 indicates very strongly willing to take

☐ Not willing at all ☐ Slightly willing ☐ Neutral ☐ Moderately willing ☐ Very willing

24. Before participating in this experiment, how aware were you of climate-smart agriculture practices (CSA)?

☐ I had never heard of CSA.
☐ I had heard of CSA but did not know what it involves.
☐ I was somewhat aware of CSA and its general concepts
☐ I was fully aware of CSA and its applications in farming

25. Please rate the following statements using the given 7 scale:

Strongly Disagree – Disagree – Neutral – Agree – Strongly Agree

a. I made decisions that I believed would reflect positively on me, even if they did not align with my actual preferences.
b. I felt free to make decisions based on my own preferences, without any influence from the experiment.

Thank you for your participation. By contributing your insights, you are playing a key role in shaping research that aims to support environmentally friendly and economically sustainable farming methods. Your decisions and perspectives are instrumental in advancing research on sustainable farming practices that are aimed at promoting environmentally friendly and economically viable agriculture. We sincerely appreciate your time and effort**.**

If you win the lottery, you will receive a payout based on your decisions from a randomly selected round. The amount of money you earn will be sent by Aspecto A/S.

Finally, do you have any remarks concerning this questionnaire?

☐Yes, I do ☐ No, I don't

You can give your remark(s) in the text box below: ____________________

Appendix 3: Questionnaire LAB5

Experimental instruction and survey questions

Overview of experimental groups

LAB5 *Experiment 1 (Denmark, Spain)*

Round 1 *Baseline* *(all respondents)*

Round 2

- *Group 1 Control (neutral framing information)* *(half of the respondents)*
- *Group 2 Social norm* *(half of the respondents)*

Opening Section:

Thank you for your interest in participating in this study. It will take approximately 20 minutes.

The study is carried out by researchers at the University of Copenhagen. It is part of a larger project (the BEATLES project) that is financed by the European Commission (EU).

This study focuses on the implementation of agricultural farming practices.

Please note there are no "right" or "wrong" answers, what matters is your honest opinion and preferences.

Your participation is voluntary, and your responses are completely anonymous, and no one, including the researchers, will be able to trace your answers back. You can withdraw at any time by closing the browser window, and your responses will not be saved.

Consent Section

Please confirm:
[ ] I have read and understood the above information and would like to participate.
[ ] I do not grant my consent and will terminate my participation.

If consent is declined:
Thank you for your time. Your decision not to participate means your responses will not be saved or used. Please click exit the survey." to exit.

If consent is granted:
Thank you for giving your consent, now we will introduce our study for you in the following sections.

Background Information Survey

17. What is your age? [Enter age]
18. What is your gender?
☐ Female

☐ Male
☐ Other

3. How would you describe your farm experience? Please tick off all relevant boxes

☐ I grew up on a farm

☐ I grew up on a hobby farm (a few pigs, cows, chicken etc.)

☐ I have often visited a farm

☐ I have worked or work on a farm

☐ I have my own farm

☐ I have never or seldom visited a farm

4. **How would you describe the farming system on the farms that you have experiences with? Please tick off all relevant boxes ONLY GIVEN TO THOSE WHO HAVE NOT ANSWERED 'I have never or seldom visited a farm' IN Q3.**

Farming System	**Organic**	**Non-organic**	**Both**
Livestock production	☐	☐	☐
Arable production	☐	☐	☐
Mixed production (e.g., livestock and arable)	☐	☐	☐
Horticulture (vegetables and fruits)	☐	☐	☐
Agroforestry or permaculture	☐	☐	☐
Other (please specify): _________	☐	☐	☐

5. In which region did you grow up? TO UC's: NEEDS COUNTRY ADJUSTMENT (5 Danish regions)

☐ Region Hovedstaden

☐ Region Sjælland

☐ Region Syddanmark

☐ Region Midtjylland

☐ Region Nordjylland

6. What kind of education are you currently enrolled in? To UC's: The categories should hopefully allow us to separate educations targeted towards being a farmer and broader educations where you can become farmer, advisor, teacher etc.) Please, check whether country adjustment needed.

☐ Education (to become a farmer) at agricultural school or college

☐ Education in agronomy or other agriculture-related education at a university (e.g., bachelor's, master's, or equivalent)

☐ Other (please specify): ________________

7. What kind of job would you like to have? Please tick off all relevant boxes

☐ Farmer

☐ Advisor

☐ Other (e.g. teacher, working in the farming industry, feed company, research)

8. Have you heard about climate- smart agriculture?

- I have never heard about climate smart agriculture
- I have heard about climate-smart agriculture but I don't know much
- I have heard about climate-smart agriculture and I know quite a lot about it

Instruction and description of farming practices for the experiment

Welcome to the experiment section of this study

In this experiment, you are a farm manager. You must decide how to allocate 100 hectares of agricultural land between two farming practices: conventional agriculture and climate-smart agriculture. In the experiment, you can only choose between these two farming practices. Your participation in the experiment is highly valuable in helping us understand how future farmers make decisions regarding land allocation.

Conventional agriculture practices involve, among other things, reliance on the use of chemical fertilizers in crop production to improve yield. The use of chemical fertilizers is regulated to reduce nitrogen leaching into aquatic ecosystems and coastal waters. In addition, the use of chemical fertilizer is regulated because the actual production of chemical fertilizers and the use of chemical fertilizer in crop production contribute to CO_2 emissions – and thereby contribute to climate change.

Climate-smart agriculture practices aim to increase productivity sustainably while at the same time reducing greenhouse gas emissions and increasing resilience to climate changes. Farmers can produce crops, vegetables and fruit with lower climate impact by investments in precision technologies that can reduce the use of chemical fertilizers, pesticides and irrigation water. Farmers can also use legume-based crops and organic fertilizers as viable, environmentally friendly alternatives to chemical fertilizer. The climate-smart practice reduces nitrogen leaching and reduces CO_2 emissions but can also lead to lower profits at least in the first few years compared to conventional agriculture.

Two rounds of land allocation

In the experiment, you will participate in **two rounds of decision-making**. Each round represents a growing season. Suppose that you as a farm manager are responsible for making land allocation decision for 100 hectares of land. Think about how your goals and preferences are in your real life. Suppose that:

- For conventional practice you earn **1100 Euro profit** per hectare
- For climate smart practice you earn **900 Euro profit** per hectare

Your **profit points** for 100 hectares are calculated as:

= **1100** Euro × (number of hectares allocated to conventional practices) + **900** Euro × (number of hectares allocated to climate-smart practices)

Example of profit calculation: Suppose you allocated 60 hectares of land to conventional agricultural practices and 40 hectares of land to climate-smart agricultural practices. Then your profit is calculated as follows:

- Profit from conventional agricultural practices = 60 hectares × 1100 = 66000 Euro
- Profit from climate-smart agricultural practices = 40 hectares × 900 = 54000 Euro

Round 1: Baseline scenario description

Welcome to the first round of the experiment. This is growing season 1.

Please, consider a typical rain fed arable crop rotation. You will decide how to allocate 100 hectares of farmland between two farming practices: conventional agriculture (profit of 1100 Euro per hectare) and climate-smart agriculture (profit of 900 euro per hectare). Your land allocation decision shall be based on your personal goals and preferences.

To support climate-smart practices and recognize efforts to reduce agriculture's environmental footprint, the government provides an environmental bonus per hectare for land allocated to climate-smart agriculture. This environmental bonus is included in the profit of 900 Euro per hectare for climate smart agriculture.

Your **profit points** for 100 hectares are calculated as:

= **1100** Euro × (number of hectares allocated to conventional practices) + **900** Euro × (number of hectares allocated to climate-smart practices)

9**. Decision task:**

Please allocate number of hectares below for the two alternatives. It should add up to 100 ha

Number of hectares I want to cultivate conventionally = -----
Number of hectares I want to cultivate climate-smart =------

Round 2
Group 1 Control group

Welcome to the second round of the experiment. This is growing season 2.

Agriculture is a cornerstone of rural communities worldwide, providing food, raw materials, and livelihoods. Across various regions in Europe there is a wide mix of small and large farms, with varying climates, landscapes, and soil fertility.

Please, consider a typical rain fed arable crop rotation. You will decide how to allocate 100 hectares of farmland between two farming practices: conventional agriculture (profit of 1100 Euro per hectare) and climate-smart agriculture (profit of 900 euro per hectare). Your land allocation decision shall be based on your personal goals and preferences.

To support climate-smart practices and recognize efforts to reduce agriculture's environmental footprint, the government provides an environmental bonus per hectare for land allocated to climate-smart agriculture. This environmental bonus is included in the profit of 900 Euro per hectare for climate smart agriculture.

Your **profit points** for 100 hectares are calculated as:

= **1100** Euro × (number of hectares allocated to conventional practices) + **900** Euro × (number of hectares allocated to climate-smart practices)

10. Decision task

Please allocate number of hectares below for the two alternatives, it should add up to 100 ha

Number of hectares I want to cultivate conventionally = -----
Number of hectares I want to cultivate climate-smart =------

Round 2
Group 2 Treatment group (Social norm)

Welcome to the second round of the experiment. This is growing season 2.

Many young people across Europe are concerned about climate changes. Young farmers who allocate part of their land for climate-smart agriculture contribute to protecting the environment and reducing climate change. These young farmers are role models in their communities, setting a strong example for sustainable farming. By choosing climate-smart agriculture practices, you would contribute to this collective effort to protect the environment and secure a sustainable farming in the future. (Group 2 intervention, experiment 1)

Please, consider a typical rain fed arable crop rotation. You will decide how to allocate 100 hectares of farmland between two farming practices: conventional agriculture (profit of 1100 Euro per hectare) and climate-smart agriculture (profit of 900 euro per hectare). Your land allocation decision shall be based on your personal goals and preferences.

To support climate-smart practices and recognize efforts to reduce agriculture's environmental footprint, the government provides an environmental bonus per hectare for land allocated to climate-smart agriculture. This environmental bonus is included in the profit of 900 Euro per hectare for climate smart agriculture.

Your **profit points** for 100 hectares are calculated as:

= **1100** Euro × (number of hectares allocated to conventional practices) + **900** Euro × (number of hectares allocated to climate-smart practices)

11. Decision task

Please allocate number of hectares below for the two alternatives, it should add up to 100 ha

Number of hectares I want to cultivate conventionally = -----
Number of hectares I want to cultivate climate-smart =------

Post experimental questions

Thank you for completing the experiment. We now have a few questions related to land allocation decisions and your attitudes toward farming practices.

12. How realistic did you find the farming scenarios in this study?

☐ Completely realistic ☐ Somewhat realistic ☐ Somewhat unrealistic ☐ Completely unrealistic

12. Please pick the option below that best describes your land allocation decision?

☐ I focused exclusively on considerations of climate impact when deciding how to allocate my land.

☐ Considerations of climate impact were more important, than the profit loss from choosing climate-smart practices impact when deciding how to allocate my land.

☐ The climate benefit and profit loss were equally important in my decision.

☐ Considerations about the profit loss were more important than the climate impact of climate-smart practices when deciding how to allocate my land.

☐ I focused exclusively on maximizing profit when deciding how to allocate my land.

13. (only experiment 1 group 2)

Please indicate the extent to which you agree or disagree with the following statement:

The information about young farmers engaging in climate-smart agriculture being 'role models' encouraged me to allocate more land to climate-smart practices.
1= *Strongly Disagree, 2 =Disagree, 3 =Neutral, 4 = Agree 5 =Strongly Agree*

Perceptions and Attitudes Toward Climate-Smart Agricultural Practices

15. **Please indicate the extent to which you agree or disagree with each of the following statements**.

a. Many farmers in my community are implementing climate-smart agricultural practices.
b. People whose opinions I value think that I should implement climate-smart agricultural practices
c. Adopting climate-smart agricultural practices might increase farming costs, at least in the short term.
d. Reducing climate impact is a key responsibility of every farmer.
e. I feel that I have a moral obligation to produce in a more climate-friendly way.
f. Regardless of what others do, my values and principles make me feel I should adopt climate-smart agricultural practices instead of conventional ones
1= *Strongly Disagree, 2 =Disagree, 3 =Neutral, 4 = Agree 5 =Strongly Agree*

16. Please indicate the extent to which you agree or disagree with the following statements:

- **I trust that government agricultural policies will support farmers in a transition to more climate-smart farming practices.**
- **Young farmers in my network are concerned about climate changes.**
- **When I start my farming business, I will implement climate-smart agricultural practices.**
- **This questionnaire has increased my awareness of climate-smart agriculture.**

1= *Strongly Disagree, 2 =Disagree, 3 =Neutral, 4 = Agree 5 =Strongly Agree*

17. **Which statement best describes your commitment to environmental sustainability in your farming practices?**

☐ I aim to be a front-runner in adopting sustainable practices.
☐ I like to do a little more than required by legislation.
☐ I comply with the legislation.
☐ I think it is impossible to comply with all the environmental rules.

18. Finally, do you have any remarks concerning this questionnaire? …………….

Thank you very much for answering the questionnaire!

Appendix 4: Questionnaire LAB7

Pre training questionnaire

Study Context

This study is part of the BEATLES (Behavioural Change Towards Climate-Smart Agriculture) project, an EU-funded initiative aimed at accelerating behavioral shifts towards climate-smart farming technologies. BEATLES focuses on identifying barriers and drivers of sustainable farming adoption by engaging farmers, advisors, policymakers, agribusinesses, and researchers in co-creating innovative solutions.

One of the interventions to be tested in BEATLES is the demonstration of Economic Decision Support Tools (DSTs), which help farmers make data-driven decisions about adopting precision farming technologies, including robotic weeding and spraying. DSTs also assist stakeholders in enhancing advisory services by improving decision-making efficiency, reducing uncertainty, and supporting policy-driven agricultural transformations.
Objective of this Study
The purpose of this study is to assess whether training on a decision support tool influences stakeholders':

Attitudes toward precision farming technologies, particularly robotic weeding/spraying.

Intentions to use the webtool for decision-making in advisory, consultancy, and training.

Perceptions of the tool's usability and value in enhancing the efficiency of advisory services and supporting climate-smart agriculture.

Each participant will enter a personal number at the beginning of the survey and use the same number for the post-training questions to allow us to link pre- and post-demonstration responses while maintaining complete anonymity.

I hereby consent to the usage of my answers for research purposes and dissemination of results
Note: If you choose "No" option, the questionnaire ends

(1) Yes, I give my consent
(2) No, do not give my consent

About you

Age

______

Gender
(1) Female
(2) Male
(3) Other / Prefer not to tell

Professional background

(1) Agricultural scientist at a university
(2) Agricultural advisor at a private company
(3) Policymaker focused on environmental regulation
(4) Other ______

Years of relevant experience

______

Personal number (to allow us to link the answers before and after the demonstration, at the same time maintaining complete anonymity)

______

Pre-demonstration baseline assessment

How familiar are you with decision support tools for precision farming technologies?
(1) Not at all familiar
(2) Slightly familiar
(3) Neutral
(4) Moderately familiar
(5) Very familiar

To what extent do you believe that economic and environmental assessment decision support tools (DSTs) can enhance the adoption of robotic spraying?
(1) Not at all
(2) Slightly
(3) Neutral
(4) Moderately
(5) Significantly

How likely are you to integrate economic and environmental impact assessment DSTs into your professional activities (e.g., consultancy, training, advising farmers)?
(1) Not likely at all
(2) Slightly likely
(3) Neutral
(4) Moderately likely

(5) Very likely

How comfortable are you with sharing farm-related data via an online decision support tool to enhance its functionality?
(1) Not comfortable at all
(2) Slightly comfortable
(3) Neutral
(4) Moderately comfortable
(5) Extremely comfortable

Please Pause Here Before Proceeding
Thank you for completing the pre-demonstration questionnaire.

The Webtool demonstration will now be presented by our colleagues and will take approximately 20 minutes. After the demonstration, please continue with the post-demonstration survey to complete the study.

Post training questionnaire

Please Insert your number again

Personal number (to allow us to link the answers before and after the demonstration, at the same time maintaining complete anonymity)

______

Post-demonstration survey (impact questions)

To what extent do you now believe that the economic and environmental assessment DSTs can enhance the adoption of robotic spraying?
(9) Not at all
(10) Slightly
(11) Neutral
(12) Moderately
(13) Significantly

How likely are you to integrate DSTs (such as the Webtool) into your professional activities (e.g., consultancy, training, advising farmers)?
(1) Not likely at all
(2) Slightly likely

(3) Neutral
(4) Moderately likely
(5) Very likely

How relevant do you now think the economic and environmental impact of PA technologies DSTs are for stakeholders involved in farmer advisory, training, or consultancy?
(5) Not relevant at all
(6) Slightly relevant
(7) Neutral
(8) Moderately relevant
(9) Very relevant

How comfortable are you with sharing farm-related data via an online decision support tool to enhance its functionality?
(1) Not comfortable at all
(2) Slightly comfortable
(3) Neutral
(4) Moderately comfortable
(5) Extremely comfortable

How likely are you to recommend the economic and environmental impact of PA technologies DSTs (such as Webtool) to farmers and other stakeholders?
(1) Not likely at all
(2) Slightly likely
(3) Neutral
(4) Moderately likely
(5) Very likely

How do you perceive the usefulness of today's Webtool demonstrated?

(1) Not useful at all
(2) Slightly useful
(3) Neutral
(4) Moderately useful
(5) Very useful

Appendix 5: Results from Lab 7

Mean score difference for the three outcome variables pre and post

Figure A1 provides the mean score differences for the three outcome variables (pre and post).

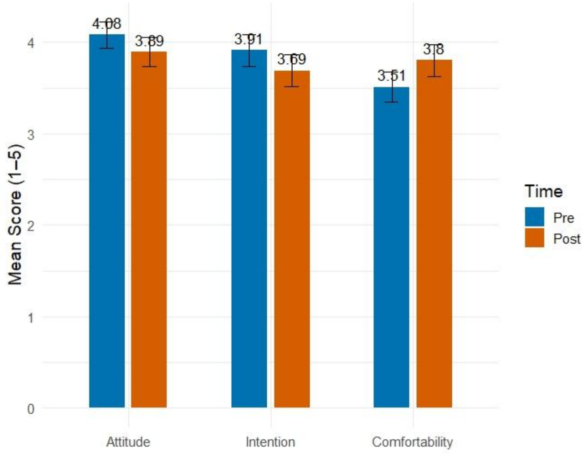

Figure A1 Mean score difference between pre and post