PUEY UNGPHAKORN INSTITUTE
FOR ECONOMIC RESEARCH

Nudging sustainable farming: Experimental evidence on the role of budget constraints and agricultural subsidy formats

by

Nopparuj Chindasombatcharoen and Phumsith Mahasuweerachai

March 2026
Discussion Paper
No. 247

Nudging sustainable farming: Experimental evidence on the role of budget constraints and agricultural subsidy formats

Nopparuj Chindasombatcharoen
Thailand Development Research Institute

Phumsith Mahasuweerachai
Khon Kaen University

Abstract
Reducing environmental damage from agricultural systems is a critical priority for governments. Particularly, rice farmers in developing nations frequently resort to the environmentally harmful practice of post-harvest residue burning. Promotion of practices to mitigate burning is met with differing degrees of success. Through experimental research with farmers in Thailand, this study examines the impact of temporary cost and income subsidies on the reduction of burning by farmers with differing financial attributes. Financial characteristics were modelled by imposing budget constraints on participants through varying initial endowments. The findings indicated that temporary subsidies were effective in not only the short-term during provision but also in the long-term after subsidies ended. Additionally, several psychological impacts contributing to disparities in adoption rates were identified, including the perceived need for obtaining more income among budget-constrained individuals and the noteworthy impact of loss aversion on long-term adoption decisions. The study's insights offer valuable contributions to understanding smallholder farmers' behaviours in accepting temporary subsidies for sustainable agriculture and provides policymakers with practical strategies to alleviate the harmful consequences of conventional farming practices.

Keywords: sustainable agriculture; crop residue burning; field experiment; financial incentives; smallholder farmers; budget constraints

1. Introduction

The agriculture sector exhibits significant environmental damages caused by its processes. The extensive reliance on unsustainable agricultural practices, such as excessive use of chemical fertilisers and improper waste management, poses detrimental consequences to the environment, human health, and socio-economic systems (Singh et al., 2021). One of the most damaging practices is Crop Residue Burning (CRB) - the burning of leftover stalks and straw after harvest. Though convenient for clearing fields, CRB has wide-reaching costs. It contributes about 3.5% of global greenhouse gas emissions, releasing pollutants such as nitrogen dioxide, nitrous oxide, sulphur dioxide, carbon monoxide, carbon dioxide, and methane (Ritchie et al., 2020; Liu et al., 2019). Pollution from CRB can drift hundreds of kilometers. Satellite data show its effects can reach urban areas as far as 600 km away (Guo, 2021). Health impacts are also severe. In China and Thailand, exposure to PM2.5 from straw burning has been linked to declines in cognitive functioning and increase chance of respiratory diseases (Lai et al., 2022; Mahasuweerachai et al., 2023). Burning also harms soils by depleting nutrients, disrupting pH and moisture levels, and reducing organic matter and microbial activity, which ultimately lowers yields (UNESCAP, 2020).

The problem is especially pronounced in parts of Asia where agriculture is intensive, and burning remains the easiest way to clear fields (Singh et al., 2021). In Thailand, the issue has drawn increasing public concern because of its contribution to rising PM2.5 levels across both rural and urban areas. Figure 1 shows biomass burned from rice production over time, illustrating how CRB persists at significant levels despite policy efforts to reduce it (FAOSTAT, 2023). These trends underline how difficult it is to shift farmers away from burning, even as the environmental and social costs mount.

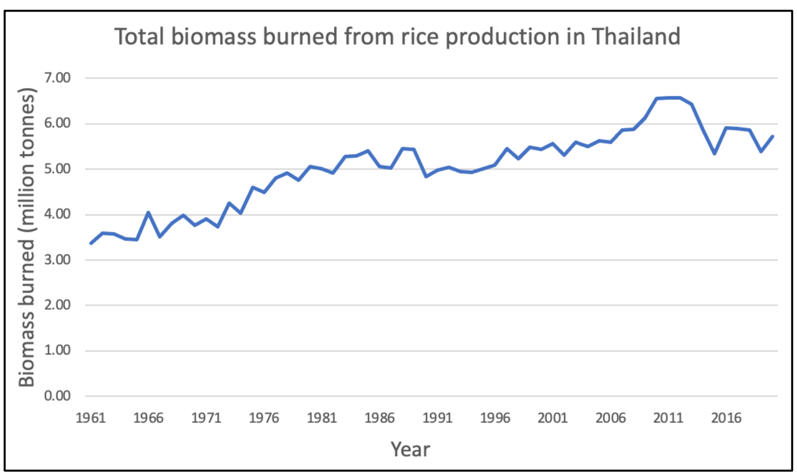

Figure 1 Statistics of total biomass burned from rice production in Thailand (FAOSTAT, 2023)

A sustainable alternative, Sustainable Residue Management (SRM), makes use of crop residues rather than destroying them - for example, by turning them into livestock feed or ploughing them back into the soil to improve fertility (Magnan et al., 2012; Bechini et al., 2015). SRM helps reduce pollution and greenhouse gas emissions while also offering economic benefits through better yields and lower fertiliser costs (Singh et al., 2021). Yet despite these advantages, many farmers stick with CRB because SRM is more labour-intensive and costly to implement (Bechini et al., 2015).

Encouraging the adoption of SRM requires strategies that tackle both technical and financial barriers. Keck and Hung (2019) highlight four possible policy approaches, which are banning burning outright, subsidising mechanisation, rewarding farmers who avoid burning, and adjusting fertiliser subsidies to make alternatives more attractive. Financial incentives have proven particularly promising, with field studies showing that payments for reducing CRB can significantly lower burning rates (Kelsey Jack et al., 2023). Studies have found that agri-environmental schemes for burning reduction are significantly more efficient that the command-and-control approach (Morello, 2023). However, not all subsidies work the same way. Evidence suggests that the form a subsidy takes can shape farmers' behaviour, not just its size, because different formats trigger different psychological and behavioural responses (Moser and Musshoff, 2016).

Cost subsidies, which reduce expenses upfront (e.g., lowering the price of machinery or services for SRM), may feel like removing a barrier, making adoption seem more affordable and practical. In contrast, income subsidies, which provide payments after farmers adopt SRM, may act more like a reward, emphasising the achievement of a goal rather than lowering the hurdle to act. These differences can influence risk perceptions, mental accounting, and how farmers plan for the future. The structure of incentives - whether framed as gains or cost reductions, immediate or delayed, performance-based or unconditional - affects not only initial uptake but also long-term motivation and persistence (Gneezy et al., 2011). For example, upfront support might encourage one-time trials of new practices, whereas performance-based rewards could foster a sense of accomplishment but may also deter risk-averse farmers who fear they might not qualify for the payout. Moreover, behavioural research suggests that people value gains and losses differently. Receiving a reward may be experienced as a bonus, while reduced costs may be integrated into normal operations, leading to distinct long-term effects. These mechanisms raise the possibility that equivalent financial amounts could lead to very different adoption patterns over time.

This distinction becomes even more important in contexts of tight budget constraints. Many farmers in the Global South lack the financial flexibility to absorb risks or delays in payments. In Thailand, for example, roughly 40% of farmers earn below the poverty line of 32,000 THB per year (United Nations, 2020). For these farmers, cost subsidies might be more immediately attractive because they ease liquidity pressures, while income subsidies might be perceived as less accessible or more uncertain. Understanding how these dynamics play out is critical for designing policies that work on the ground.

This study addresses these gaps by comparing short- and long-term effects of cost subsidies and income subsidies, with a focus on how budget constraints influence farmers' choices. Using a lab-in-the-field (LITF) experiment with small-scale rice farmers in the North-eastern Thailand, we explore how these financial interventions affect decisions to adopt SRM as an alternative to burning.

By examining how subsidy formats and financial constraints interact, this research deepens our understanding of how to design effective policies for sustainable agriculture. It also adds to the growing use of behavioural experiments in real-world contexts, bringing psychological and economic insights together. As governments move to redirect agricultural subsidies toward environmentally friendly practices (Gautam et al., 2022), these findings offer timely guidance for creating programs that support environmental sustainability, social equity, and long-term economic viability.

The rest of this paper is structured as follows. Section 2 presents the literature review. Section 3 describes the research designs, which cover details of lab-in-the-field experiment and sampling procedure. Section 4 presents the results of the study. Discussion and conclusion are highlighted in sections 5 and 6, respectively.

2. Literature Review

2.1 Effectiveness of Incentives

Incentive-based programs are widely used to encourage sustainable agricultural practices, yet their success depends greatly on how they are designed and implemented. A review of nearly 18,000 studies finds that programs offering short-term economic benefits tend to achieve higher adoption rates than those emphasizing environmental goals alone (Piñeiro et al., 2020). Farmers are more willing to adopt practices when incentives offset income losses and additional costs, whereas uptake is rare when these costs are not covered. However, sustaining adoption over the long term depends less on continuous subsidies and more on the intrinsic or environmental benefits generated by the practice (Piñeiro et al., 2020).

Farmers, particularly in the global south, often encounter psychological barriers that hinder innovation adoption, indicating that government support must be designed to address these challenges (Chindasombatcharoen et al., 2024). The effectiveness of incentives hinges on their framing, timing, and interaction with intrinsic motivation (Gneezy et al., 2011). Motivation crowding theory suggests that extrinsic rewards can crowd out intrinsic motivation when perceived as controlling, making farmers less likely to continue once payments end (Frey & Jegen, 2001). Self-determination theory further explains that incentives that reduce autonomy or shift attention toward compliance can weaken commitment (Deci & Ryan, 1985). Anticipation of future subsidies or anchoring to subsidized prices can also discourage paying unsubsidized prices (Omotilewa et al., 2019). A review of conservation incentives finds crowding out effects to be common (Rode et al., 2015).

On the other hand, incentives can crowd in motivation when they are seen as enabling rather than controlling (Frey & Jegen, 2001; Gneezy et al., 2011). Supportive incentives can signal that a behavior is socially valued or provide resources to overcome temporary barriers, strengthening intrinsic motivation (Xu et al., 2022). For example, temporary subsidies in Ghana increased long-term adoption of minimum tillage (Ambler et al., 2020), while one-time subsidies for improved grain storage bags in Uganda created lasting commercial demand (Omotilewa et al., 2019). These studies suggest that the persistence of adoption depends not only on the size of the incentive but also on how it is perceived and the conditions under which it is offered.

2.2 Formats of Incentives

This study focuses on two main formats, which are cost and income subsidies. Cost subsidies directly reduce the expenses of adopting sustainable practices, easing financial barriers. For example, to curb crop residue burning, China subsidized machinery purchases and operating costs (Chen et al., 2019). In contrast, income subsidies provide conditional payments to farmers, adding to their income when they adopt sustainable practices. Payments for ecosystem services represent a widely used form of income subsidy (Wu and Yu, 2017). An example seen in Thailand is the measure used to reduce unsustainable harvesting of sugarcanes, where financial rewards for sustainable harvests were provided as incentives for farmers (Mahasuweerachai and Suksawat, 2022).

The timing of incentives also matters. A randomized controlled trial in Zambia found that upfront payments were more effective in reducing crop residue burning than payments provided after practice completion (Kelsey Jack et al., 2023). Upfront payments not only build trust in the program but also alleviate liquidity constraints, enabling farmers to cover the higher costs of sustainable residue management (SRM). However, cost subsidies can suffer from subsidy leakage, where benefits extend to all farmers regardless of need. Income subsidies, while requiring more complex administration, allow for better targeting and may be more cost-effective in achieving policy goals (Chunyan et al., 2013). These distinctions suggest that the effectiveness of each format depends on farmers' financial situations, with budget constraints shaping which type of support leads to greater adoption and persistence of sustainable practices.

2.3 Budget Constraints

Budget constraints - defined here as limited financial resources that restrict agricultural decision-making - play a crucial role in technology adoption. Poverty-induced financial stress has been shown to impair cognitive functioning and reduce the quality of decision-making (Mani et al., 2013). While little research directly examines how budget constraints influence uptake of subsidies for sustainable practices, related studies provide useful insights. Allowing delayed payments for weather insurance significantly increased adoption among farmers in Ethiopia (Belissa et al., 2019). Other work shows that financial constraints affect technology adoption, post-harvest decisions, and investment in perennial energy crops (Bocquého and Jacquet, 2010; Gabriel and Hundie, 2006; Moser and Barrett, 2006).

Despite existing insights, little is known about how budget constraints shape the effects of subsidies for sustainable practices. This is particularly relevant in developing countries, where adopting SRM often requires substantial upfront investment (Kumar et al., 2020). Cost subsidies remove liquidity pressures by covering initial expenses, enabling adoption without extra cash on hand, while income subsidies provide funds only after adoption, which may limit their usefulness under tight finances. We expect cost subsidies to be more effective than income subsidies when farmers face budget constraints, and income subsidies to work better when constraints are absent - especially if SRM offers private benefits that help sustain use after support ends. However, cost subsidies may fail to ensure long-term adoption if their withdrawal shifts farmers' reference point from the subsidized to the full cost. As *Prospect Theory* suggests, such loss aversion can outweigh perceived private benefits, leading farmers to revert to earlier practices (Kahneman & Tversky, 1979). This study examines how cost and income subsidies, interacting with budget constraints, affect both initial adoption and persistence once subsidies are removed.

3. Research Design

3.1 Lab-in-the-Field (LITF) Experiment

The use of experimental methodologies is increasingly prevalent in economics research (Bretschger and Pittel, 2020). This study utilises the lab-in-the-field (LITF) experimental method, which represents a hybrid model within the broader range of approaches employed in the social sciences. The LITF methodology integrates the controlled conditions of laboratory experiments with the authenticity of field settings, effectively balancing the analysis of decision-making processes with the contextual relevance of real-world environments (Harrison and List, 2004; Roe and Just, 2009).

In a LITF experiment, structured decision-making tasks or simulation games are conducted with a nonstandard subject pool in a setting directly relevant to the research problem. This design allows for the systematic manipulation of treatment variables while capturing behavioral responses in decision environments that closely mirror real-world conditions (Harrison and List, 2004;

Gneezy and Imas, 2017). In the present context, the experiment is designed to vary the format of subsidies, cost and income subsidies. It also incorporates differences in participants' liquidity positions, allowing for the observation of how budget constraints influence adoption decisions. It further allows for testing whether the withdrawal of subsidies shifts reference points from subsidized to full costs, potentially triggering loss aversion effects that reduce persistence. By embedding these scenarios in a controlled yet contextually authentic environment, the LITF experiment provides robust evidence on the mechanisms through which subsidy type and budget constraints shape both immediate adoption and long-term sustainability of practice use.

3.2 Experiment Design

With the objective of understanding participants' decisions when provided with varying formats of financial incentives, the design of the LITF experiment is as follows. Participants are divided into 6 groups (2 control, 4 treatment groups) based on the forms of incentives and the financial characteristics they receive, with 100 participants per group (explained later in this section). Their task involves choosing between the residue management methods of CRB and SRM based on the payoff table, considering their remaining endowments and risk tolerance within the given situational context. This process is repeated 10 times, reflecting 10 crop cycles, to investigate how their decisions evolve over time. The selection of either method results in different costs, returns, and risks, as outlined in Table 1, which is presented to farmers during the selection stage of each round. Selecting SRM incurs a higher short-term cost, but the same income compared to CRB, resulting in a short-term loss. However, participants consecutively choosing SRM for more than 3 cycles will experience a reduction in cost and an increase in income, ultimately leading to the same profit as CRB.

Furthermore, participants selecting SRM face an additional risk related to operational difficulty, which further increases the associated costs. The randomisation of this risk is achieved by randomly selecting coloured balls from boxes, each corresponding to a specific level of risk as indicated in brackets in Table 1. These risks are randomised in every cycle, and all participants within the same experimental group will share the same risk outcomes. The design of payoffs and associated risks is intended to closely emulate the actual environment for CRB and SRM. According to the literature, transitioning from CRB to SRM is found to result in an 11%-23% increase in yield over three years, depending on the historical prevalence of CRB. However, this switch also leads to an increase in costs (Westerberg, 2017).

Table 1. Payoff table of two farming methods (risk percentage shown in brackets)

Method	Cycle	Operating cost (THB)		Income (THB)	
		Normal case	Bad case	Normal case	Bad case
CRB	All cycles	75	-	85	64 (25%)
SRM	First 3 cycles	90	100 (40%)	85	64 (25%)
	Cycle 4 onwards	85	-	95	72 (25%)

For example, participants who selected CRB in a round when not faced with income risk will make a payment of 75THB and receive 85THB income, which totals to 10THB profit for that cycle. On the other hand, participants who selected SRM for the first time in the same round (no weather risk) but faced with operating risk will make a payment of 100THB and receive 85THB, totalling to 15THB loss for that cycle.

To enhance the realism of the experiment, a short-term debt mechanism is introduced. If participants lack sufficient in-game money to cover the operating costs of their chosen method, they are compelled to take a short-term loan from the bank. This loan amount must be equal to the additional funds needed to pay the operating cost. The principal must be repaid at the end of the same cycle, deducted directly from their income. Additionally, participants incur a 100% interest charge, payable at the conclusion of the 10-round experiment. This debt mechanism simulates the real-world scenario of relying on loan sharks when facing financial distress due to excessive risk-taking. Overall, the participants' in-game profit function is:

$$Total\ profit_i = \sum_{t=1}^{10} (Income_{i,t} - Cost_{i,t} - \text{ST}\ debt\ interest_{i,t}) \quad (1)$$

Upon conclusion of the experiment, all participants receive compensation for joining the research study, consisting of an 80THB travel allowance plus a sum equivalent to twice their remaining in-game money. This remuneration structure enhances farmers' engagement and incentivises them to choose options that closely mirror their real-world farming decisions. In total, depending on the risk randomisation and the operational choices made, farmers received a remuneration ranging between 80THB to 300THB (around 2.2-8.5 USD).

In addition to the standard payoffs faced by the control group, additional interventions are administered to subsets of participants, as shown in Table 2. The experiment follows a between-subject design, wherein participants are allocated to one set of intervention conditions, and the analysis of responses are made across the different intervention groups. Treatment groups are administered at the village level, meaning that participants in each experiment group in each village receives the same interventions.

Table 2. Experimental groups

	Control (BC)	**Control (NC)**	**Treatment 1 Cost (BC)**	**Treatment 2 Cost (NC)**	**Treatment 3 Income (BC)**	**Treatment 4 Income (NC)**
Subsidy format	N/A	N/A	Cost subsidy	Cost subsidy	Income subsidy	Income subsidy
Budget constraint	Yes	No	Yes	No	Yes	No
Participants	100	100	100	100	100	100

First, all treatment groups receive either form of subsidies: cost or income. These subsidies are temporary, applicable only to those who opt for SRM in cycles 1-3. Notably, participants retain the freedom to choose between SRM and CRB in any cycle, irrespective of the interventions. The cost subsidies are framed as a 20THB reduction in the operating cost of SRM, while income subsidies are framed as a 20THB increase in the income generated from SRM. Beyond the financial interventions, a subset of participants encounters an additional budget constraint, receiving a smaller initial endowment at the experiment's outset. Participants in the non-budget constraint (NC) group receive 200THB of in-game money, while those in the budget constraint (BC) group start with 85THB. This setup aims to investigate real-world conditions where farmers grapple with cash management issues and taking additional risks beyond conventional practices can jeopardise their livelihoods.

For the control group, no subsidies are provided, and the payoffs in Table 1 directly applies to this group. Furthermore, the control group also experiences a budget constraint, starting the experiment with 85THB. In the best-case scenario, without facing any risks, selecting SRM would lead to a 5THB loss in each of the first 3 cycles, while the subsequent cycles yield a 10THB profit (under no risk). Choosing CRB would lead to a 10THB profit (under no risk) from the outset and is therefore the profit-maximising choice.

For treatment groups 1 and 2, participants receive the cost subsidy which reduces the costs of SRM in the first 3 rounds to 70THB (80THB under risk). This improves the profitability of SRM in the first 3 rounds to be 15THB (5THB under risk), while the subsequent rounds have indifferent profitability between SRM and CRB (both 10THB). Therefore, regardless of the budget conditions, the decisions of farmers in these two groups depend on their perspectives on operational risks of SRM. If farmers have a low tolerance for risk, they will choose the less risky option of CRB. However, a risk neutral (and risk seeking) person would select SRM due to the higher expected value.

Finally, participants in treatment groups 3 and 4 receive income subsidies, increasing the income of SRM in rounds 1-3 to 105THB (84THB under risk). While the effect on profitability is identical to cost subsidies mentioned in the above paragraph, treatment group 3 who faces budget constraints have a cost barrier that is not alleviated by the income subsidy. They are forced to issue a short-term borrowing of at least 5THB since the first round if they choose SRM, depending on the operational risk faced. Overall, treatment 3 faces a higher level of risk of adopting SRM due to the short-term debt, and it is expected that only the risk-seeking individuals will select SRM. Treatment 4, on the other hand, have identical expectations to treatments 1 and 2 from the rational choice perspective due to the absence of financial constraints.

3.3 Experiment and Sampling Procedures

The experiment was conducted with rice farmers from the north-eastern region of Thailand.[1] This region was chosen due to its highest prevalence of burning, totalling 57.91% of total rice biomass burned in Thailand (Kumar et al., 2020). Shown in Table 3, subdistricts with high rice production areas were selected from two provinces of the North-eastern region, Khon Kaen and Maha Sarakham. A total of 60 agricultural villages were recommended by the district administrative offices based on the request for villages that have a high degree of crop residue burning. The research team then contacted the village heads approximately 1-2 weeks in advance and requested for 10 farmers to join the experiment at the village centre where the research team travelled to on the experiment day.

Table 3. Locations of experiment participants

Province	**Number of districts**	**Number of sub-districts**	**Number of villages**	**Number of farmers**
Khon Kaen	6	15	35	350
Maha Sarakham	4	9	25	250
Total	10	24	60	600

[1] Prior to the conducting the actual experiment with farmers, initial designs and video instructions were created and underwent 12 rounds of pre-testing, held with researchers from a research institute (2 rounds), university students (4 rounds), and farmers (6 rounds).

At the experiment site, farmers were given instructions via a video clip to ensure all farmers received the same information. After the video instructions, participants had the opportunity to ask clarifying questions, and a trial run of the experiment is held to ensure the instructions were understood. Farmers are then provided with in-game money and the experiment then commences. Each round of the experiment is split into three stages:

- *Decision stage*

  This stage represents the post-harvest stage where farmers manage the crop residues that remain after harvesting. Participants choose between two methods of operations: CRB and SRM. The choice impacts the in-game money to be paid and received within the experiment, as well as the risks to be faced.
- *Operating cost payment stage*

  This stage represents the payment of all operating costs of growing their crops. In this stage, the operational risks are randomised, and participants make a payment corresponding to their choice from stage 1 using the in-game money provided.
- *Income receipt stage*

  The final stage represents the harvesting and sales of their crops. In this stage, the risks of income receipt are randomised, and farmers are paid for their harvests.

The three stages of the experiment repeat for 10 rounds where participants make a total of 10 decisions. Upon completion of the experiment, surveys were gathered from participants. The survey data served as control variables in the subsequent regression analysis. Then, participants were remunerated proportional to their profits from their decisions in the experiment. The demographic statistics for the entire sample and its breakdown by treatment group are presented in Table 4.

Overall, the group averages are closely aligned with the whole-sample mean, reflecting a generally balanced randomization process. Nonetheless, certain deviations are observed. Specifically, variations in perceptions regarding burning within villages present challenges that have proven difficult to fully mitigate. However, these have been accounted for in the regression model analysis in this paper. Minor differences also exist, such as slightly higher average age and farming experience in the Control (NC) group, and the greater household agricultural income and assets in the Income Subsidy (NC) group. Although the groups exhibit some differences, these variations are generally minor, indicating that baseline characteristics remain largely comparable across treatments.

Table 4 Sample participant demographic statistics

Variable		**Whole sample**	**Control**		**Cost Subsidy**		**Income Subsidy**	
			BC	***NC***	***BC***	***NC***	***BC***	***NC***
Age (years)	Mean: Std. Dev:	58.1 10.0	58.1 10.5	61.4 8.9	58.5 11.0	56.1 9.2	56.5 10.0	58.2 9.1
Farm experience (years)	Mean: Std. Dev:	34.4 15.8	33.8 15.2	40.1 14.4	35.6 16.7	30.1 15.0	32.5 15.4	34.6 16.5
Farmland (rai)	Mean: Std. Dev:	14.1 10.7	12.5 8.0	14.7 10.2	13.5 9.3	17.4 15.3	13.2 10.3	13.2 9.0
Household agricultural income (THB)	Mean: Std. Dev:	48,951 68,109	48,345 54,940	57,546 75,870	37,610 37,654	50,851 54,470	42,734 42,008	56,621 112,376
Percent HH income from agriculture	Mean: Std. Dev:	58.5% 34.7%	61.7% 35.1%	71.9% 30.5%	52.5% 32.5%	54.2% 34.7%	53.9% 35.7%	57.0% 35.7%
Household asset (THB)	Mean: Std. Dev:	1,983,753 2,493,452	2,004,400 2,454,942	1,320,700 1,632,681	1,853,600 3,152,067	2,316,200 2,203,695	2,137,400 2,854,717	2,270,219 2,242,202
Household debt (THB)	Mean: Std. Dev:	270,784 432,595	323,210 628,001	229,950 326,406	282,360 473,230	223,450 315,420	264,240 283,093	301,494 459,869
Gender	Male: Female:	19% 81%	20% 80%	13% 87%	33% 67%	19% 81%	13% 87%	17% 83%
Perception of burning in village	Don't burn: Burn:	47% 53%	35% 65%	30% 70%	64% 36%	50% 50%	47% 53%	54% 46%
Number of farmers		600	100	100	100	100	100	100

4. Results

4.1 Descriptive statistics of farmers' decisions

The decisions of 600 farmers, encompassing a total of 6,000 observations over the course of 10 decision rounds, were collected and synthesised, as depicted in Figure 2 and Figure 3. These figures present data categorised by each experimental group. As expected, SRM adoption is significantly lower in the control group than most other treatment groups, reflecting the comparatively less profitable nature of the practice. However, the outcomes across different treatment groups exhibit variability. Notably, income subsidies provided to the group with budget constraints appears to have the least influence on decision-making. Furthermore, Figure 3 provides insight into the differentiation between choices made during the subsidy provision period and those made after the subsidies concluded. Various treatment groups exhibit varying degrees of behavioural change between these two distinct periods.

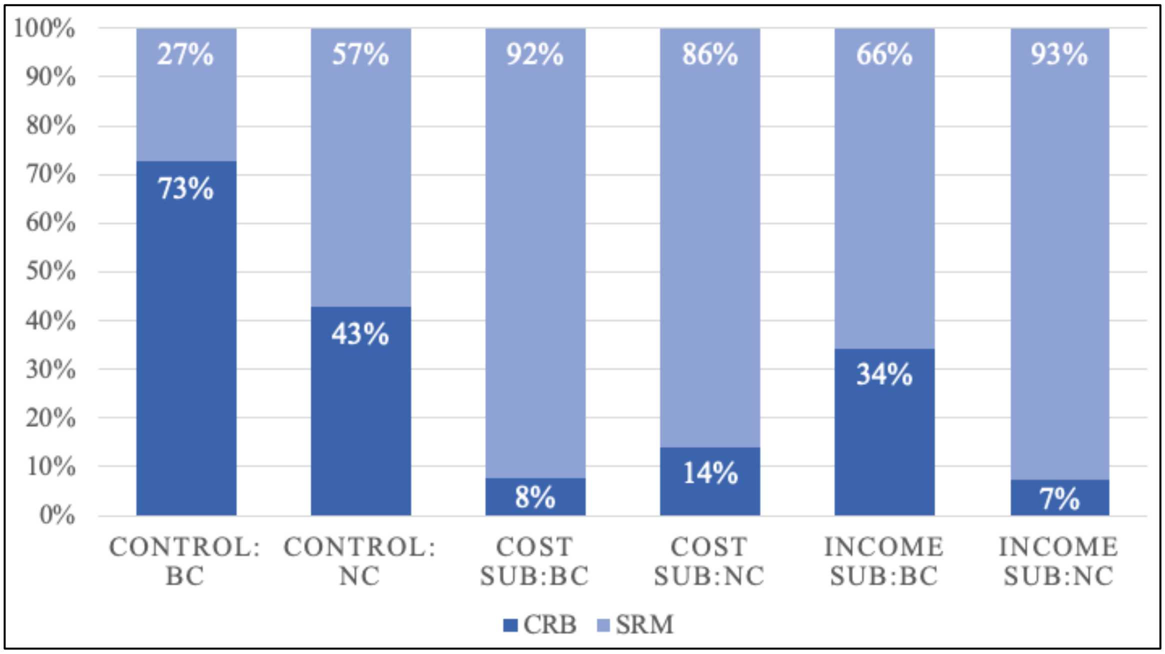

Figure 2 Percentage of participants' choices

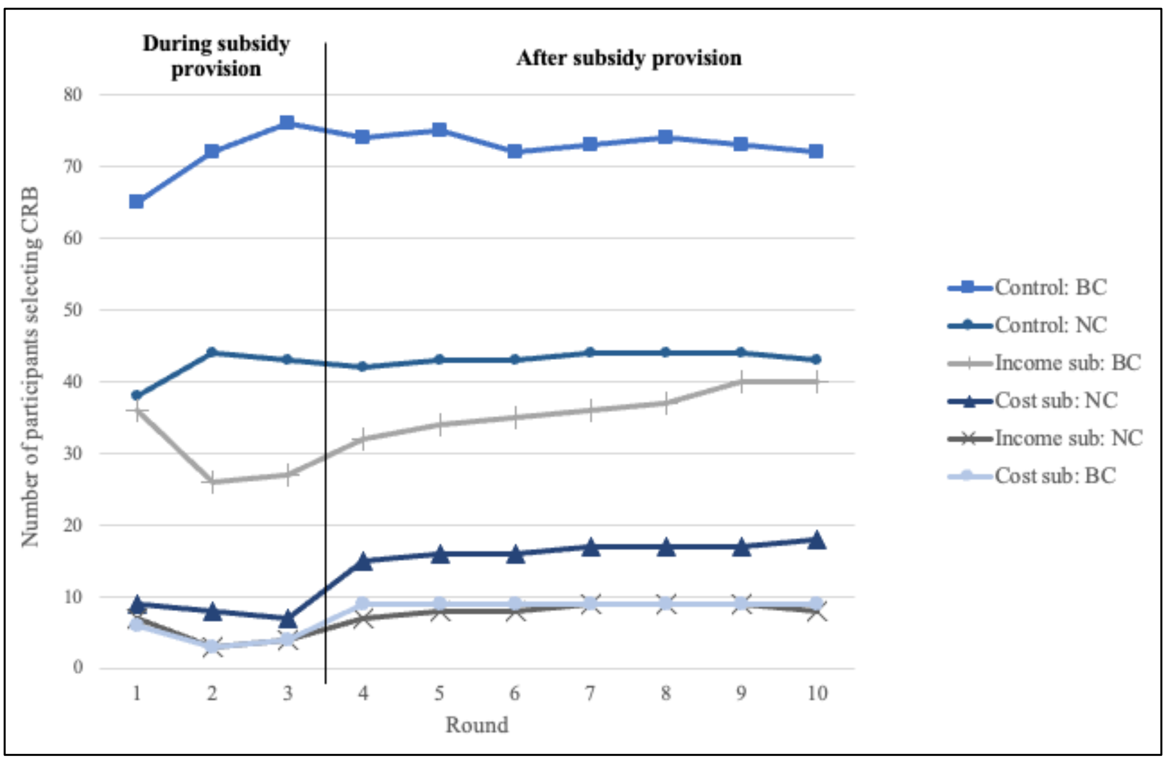

Figure 3 Number of participants selecting CRB by round

4.2 Empirical model

Panel data analysis was conducted given the dataset's structure encompassing selections from each of the 600 farmers across the 10 rounds of the experiment. To account for individual variations, a random effects model was adopted. Specifically, random probit regression models, the results outlined in Table 5, were employed to assess the effects of treatments and control factors.[2] The regression model can be represented by the following regression equation:

$$D_{it} = \alpha + \boldsymbol{\beta}.\boldsymbol{TD_i} + \boldsymbol{\gamma}\boldsymbol{X_i} + \varepsilon_i + u_{it}$$

where D_{it} is a binary variable equal to 1 if farmer i in round t selected CRB and 0 if SRM was chosen. $\boldsymbol{TD_i}$ denotes treatment group indicators, $\boldsymbol{X_i}$ represents the set of control variables listed in Table 5. The control group with budget constraint (Control BC) was used as a reference.

Model 1 presents the effect of the treatments without inclusion of the control variables, while Model 2 presents effect of treatment with inclusion of control variables. All four treatment groups were statistically significant in reducing the choice of CRB in both Models 1 and 2. The results prove that temporary cost and income subsidies are effective in discouraging CRB for the majority of individuals, statistically significant at the 1% level.

In Model 3, the analysis was refined to include only participants who believe that others in their village have engaged in burning practices within the past three years. Although control variables were already incorporated, the notable differences in actual behaviours across treatment groups (as outlined in Table 4) may still affect the results. Since crop residue burning (CRB) is generally viewed as socially undesirable, farmers might hesitate to choose CRB in the experimental setting if it is not commonly practiced in their village. This could introduce bias into the findings by influencing participants' responses based on perceived social norms. The results of Model 3 point to the same conclusions as Model 2, showing a limited impact of participants' selections based on their actual farming practices.

To gain a deeper understanding, the farmers' decisions were segmented into the short-run, during the provision of subsidies (t = 1, 2, 3), and the long-run, after the subsidies had ended (t = 4, 5, …, 10). These segments are represented by Models 4 and 5, respectively. The results showed differences between the two time periods, aligning with the observations described in Figure 3 with regards to the reversion of decisions after subsidies ended.

[2] Results from a random logit model were also analysed and pointed towards the same conclusions.

Table 5 Probit regression results

Dependent variable = CRB (1 if participant selected 'Burn', 0 if participant selected 'SRM')					
Model	**1** *Treatment only*	**2** *Full model*	**3** *Burn only*	**4** *Short-run*	**5** *Long-run*
Treatment:					
Control (NC)	-2.199***	-3.301***	-4.604***	-3.168***	-1.928***
	(0.18)	(0.43)	(0.51)	(0.67)	(0.30)
Cost subsidy (BC)	-6.030***	-9.158***	-10.034***	-8.331***	-5.577***
	(0.29)	(0.49)	(0.79)	(0.98)	(0.44)
Income subsidy (BC)	-2.848***	-5.920***	-5.196***	-4.456***	-2.277***
	(0.19)	(0.44)	(0.55)	(0.59)	(0.31)
Cost subsidy (NC)	-5.240***	-8.199***	-8.774***	-7.676***	-4.683***
	(0.31)	(0.41)	(0.58)	(0.72)	(0.53)
Income subsidy (NC)	-5.957***	-8.895***	-8.867***	-7.981***	-5.460***
	(0.28)	(0.47)	(0.72)	(0.87)	(0.46)
Faced cost risk at round t-1		-0.794***	-0.729***	-0.078	-1.479***
		(0.17)	(0.22)	(0.23)	(0.42)
Faced income risk at round t-1		-0.034	-0.299*	-0.134	-0.111
		(0.11)	(0.15)	(0.21)	(0.15)
Perception of CRB practice in village		0.558		0.949	0.252
		(0.29)		(0.48)	(0.23)
Irrigated area		0.656	0.577	0.592	0.979**
		(0.38)	(0.43)	(0.55)	(0.33)
Rice Variety GK105		-0.514	-1.173**	-0.875	-0.508*
		(0.29)	(0.37)	(0.47)	(0.23)
Rice Variety GK6		-0.153	0.104	0.198	-0.222
		(0.44)	(0.47)	(0.63)	(0.32)
Rice Variety GK15		-0.293	0.948	-0.938	0.41
		(0.84)	(0.95)	(1.07)	(0.55)
Khon Kaen		-0.341	-0.281	-0.516	-0.364
		(0.27)	(0.35)	(0.41)	(0.22)
Age		0.015	-0.021	0.025	0.026*
		(0.02)	(0.02)	(0.03)	(0.01)
Male		-0.222	0.705	-0.351	-0.17
		(0.35)	(0.43)	(0.55)	(0.28)
Education:					
Secondary		0.115	0.315	-0.038	0.215
		(0.33)	(0.43)	(0.47)	(0.28)
University		-2.496*	0.406	-2.516	-0.489
		(1.04)	(1.47)	(2.49)	(0.72)

Vocational		1.526**	2.743***	1.615*	1.661***
		(0.54)	(0.75)	(0.81)	(0.50)
Farm size (rice only)		0.008	0.032	0.021	-0.004
		(0.01)	(0.02)	(0.02)	(0.01)
Log of household agricultural income		0.013	0.287	0.011	-0.04
		(0.11)	(0.16)	(0.16)	(0.07)
Percentage of household income from agriculture		-0.371	-0.275	-0.292	-0.062
		(0.45)	(0.62)	(0.64)	(0.36)
Log of household asset		0.154	0.071	0.281	0.082
		(0.12)	(0.21)	(0.16)	(0.08)
Log of household debt		0.012	-0.038	0.036	0.012
		(0.03)	(0.03)	(0.04)	(0.02)
Risk aversion coefficient		0.148**	0.098	0.169*	0.104**
		(0.05)	(0.06)	(0.08)	(0.04)
Number of processes managed by owner		-0.285*	-0.923***	-0.36	-0.249*
		(0.13)	(0.18)	(0.20)	(0.11)
Intercept	1.576***	-0.017	2.041	-3.376	-0.428
	(0.13)	(2.29)	(3.40)	(3.29)	(1.52)
Log likelihood	-924.24	-924.02	-551.20	-458.26	-516.64
Observations	6000	6000	3200	1800	4200

*** p-val < 0.01, ** p-val < 0.05, *p-val < 0.1, standard errors in parentheses

To elaborate on the reversion of decisions after subsidies ended, Models 6 and 7, presented in Table 6, shows the difference-in-difference regression for the treatment groups, with separation between rounds 1-3 and round 4 onwards, using the cost subsidy treatment groups as the baseline. Namely, Model 6 focuses on the income and cost subsidies with budget constraint treatment groups, while Model 7 captures the reversion decision of the income and cost subsidies with no budget constraint treatment groups. The regression equation to estimate Model 6 and 7 is as follows:

$$D_{it} = \alpha + \beta_1 INC_i + \beta_2 ROUND4_{it} + \beta_3 (INC_i * ROUND4_{it}) + \boldsymbol{\gamma X_i} + \varepsilon_i + u_{it}$$

where *INC* represents dummy variables for treatment groups. *ROUND4* represents a dummy variable for Round 4 onwards (after removal of subsidies), and *INC*ROUND4* is the interaction term to test the difference between two treatment groups after the subsidies ended.

These models test the significance of the differences between cost and income subsidy groups in switching back to selecting CRB after subsidy ends. The coefficient associated with the dummy variable "*ROUND4*" reveal that participants in the cost subsidy treatment group exhibit a higher tendency to choose CRB compared to the rounds during subsidy provision (rounds 1-3). In contrast, the figure is statistically significantly lower for the income subsidy group, indicated by the significance of the interaction term "*INC*ROUND4*". This implies that there is a lower likelihood of switching to CRB after the subsidy ends for the income subsidy group than for the cost subsidy group. Further details will be elaborated in the Discussion section.

Table 6 Difference-in-Difference Probit regression results

Dependent variable = CRB (1 if participant selected 'Burn', 0 if participant selected 'SRM')		
Model	**6** *Difference-in-Difference (BC)*	**7** *Difference-in-Difference (NC)*
Income subsidy (BC)	9.231*** (1.15)	
Income subsidy (NC)		0.663 (0.82)
Round 4 ++	3.621*** (0.78)	2.888*** (0.46)
Income sub (BC) * Round 4 ++	-2.448*** (0.81)	
Income sub (NC) * Round 4 ++		-1.534** (0.60)
Intercept	-39.347*** (6.09)	-13.673** (6.99)
Control variables added	Yes	Yes
Log likelihood	-242.31	-181.20
Observations	2000	2000

*** p-val < 0.01, ** p-val < 0.05, *p-val < 0.1, standard errors in parentheses

5. Discussion

Overall, the results of this study indicate that temporary subsidies can be effective in certain scenarios to promote long-term adoption of sustainable practices, even when these practices do not necessarily yield higher profits in the long run. In this section, we discuss the key takeaways from the experimental findings.

First, the results confirm that temporary financial incentives can substantially increase the adoption of sustainable practices in the short term. However, the experiment also demonstrates that farmers with different budget characteristics respond differently to subsidy formats. Among budget-constrained individuals, cost subsidies significantly reduced the likelihood of selecting CRB (*Wald-test p-value* = 0.000), highlighting that high upfront costs remain a critical barrier. Income subsidies had a weaker effect for this group because they did not directly address this liquidity constraint. In contrast, for non-constrained individuals, the difference between cost and income subsidies was not statistically significant (*Wald-test p-value* = 0.1331). This finding suggests that identifying farmers' budget conditions before implementing interventions is essential to maximize subsidy effectiveness. This aligns with Kelsey Jack et al. (2023), who found that post-activity payments (analogous to income subsidies) were less effective than upfront payments (analogous to cost subsidies), likely due to underlying financial constraints.

Second, focusing on the cost subsidy treatments, budget-constrained individuals were significantly more likely to accept the subsidy and adopt SRM than their non-constrained counterparts (*Wald-test p-value* = 0.0447). This outcome contradicts a purely economic expectation that those with tighter budgets would avoid SRM due to financial risk. However, from a behavioral perspective, the subsidy may have been more psychologically salient to budget-constrained participants, making them more willing to take on potential process-related risks. This aligns with Payne et al. (2017), who argue that inequality can create a perceived need that increases risk-taking to meet that need.

To further understand behavior over time, we compared the short-run effects (Model 4; Rounds 1–3, during subsidy provision) with the long-run effects (Model 5; Rounds 4–10, after subsidies ended). Across all treatment groups, the long-run effects were smaller, indicating that some farmers initially adopted SRM primarily to access subsidies, then reverted to CRB after incentives were removed. This pattern is consistent with the notion that part of the adoption was subsidy-driven rather than preference-driven. Nevertheless, a notable proportion of farmers continued SRM use after subsidies ended, supporting Omotilewa et al. (2019)'s finding that one-time subsidies can sometimes "crowd in" demand for agricultural technologies. This outcome contrasts with Rode et al. (2015), indicating that crowding-out effects were more common. The contrasting evidence from our experiment is due to the fact that SRM was associated with eventual yield gains and CRB was socially undesirable, making continued selection of SRM more appealing once short-term risks were buffered. Under the payoff structure in this study, temporary subsidies facilitated a two-stage adoption pathway, where incentives reduced short-term risk and loss exposure, enabling adoption until the longer-term agronomic benefits became apparent (Sommerville et al., 2010).

We also examined the post-subsidy period in more detail. The rate of switching back to CRB was higher in the cost subsidy groups than in the income subsidy groups for both budget-constrained and non-budget-constrained farmers. One plausible explanation lies in loss aversion (Kahneman & Tversky, 1979). At the end of the subsidy period, cost subsidy participants experienced a sharp increase in production costs (from 70 THB to 85 THB) paired with only a modest income increase (from 85 THB to 95 THB). From a loss aversion perspective, the perceived disutility from this 15 THB cost increase would loom larger than the utility of the 10 THB income gain, making CRB more attractive again. In contrast, the income subsidy group faced a more gradual change. Their costs fell slightly (from 90 THB to 85 THB) while income decreased (from 105 THB to 95 THB). Because their post-subsidy shift did not involve as salient a cost "loss," the psychological trigger for switching back was weaker. This framing is consistent with prior behavioral economics evidence showing that individuals are more sensitive to increases in out-of-pocket expenses than to equivalent reductions in income streams. By altering the post-subsidy reference point more dramatically, cost subsidies may inadvertently increase the salience of cost losses, amplifying the tendency to revert to the less costly practice. While numerous studies have explored the influence of loss aversion on farmers' behaviour (Balew et al., 2023; Jin et al., 2020), this research has highlighted a significant instance of loss aversion within the adoption and promotion of sustainable agricultural practices.

6. Conclusion

This study examined how farmers respond to policy interventions designed to promote sustainable residue management (SRM) practices, focusing on the behavioural and financial factors that condition adoption decisions. Through a lab-in-the-field experimental design, the research provides evidence that adoption is shaped not only by the economic value of subsidies but also by how these subsidies interact with budget constraints and psychological biases. The findings suggest that successful policy design must account for both financial realities and behavioural tendencies if it is to generate durable changes in agricultural practices, complementing prior studies on overcoming psychological barriers (Chindasombatcharoen et al., 2024).

A key contribution of the study is the identification of budget constraints as a critical determinant of farmer behaviour. By explicitly modelling budget limitations, the research demonstrates that constrained farmers respond differently to equivalent subsidies compared with unconstrained counterparts. Scarcity amplifies the perceived value of external support, making subsidies more effective in overcoming adoption barriers when liquidity is tight. These insights extend behavioural economics by showing how financial scarcity interacts with decision-making under uncertainty, and they caution against policy designs that neglect the heterogeneity of farmers' financial capacities.

The study also highlights the central role of loss aversion in shaping long-term adoption. Results indicate that while both cost and income subsidies initially increased SRM uptake, the rate of persistence differed once subsidies were removed. Cost subsidies, by reducing immediate expenses, created a stronger sense of loss when withdrawn, resulting in higher reversion to crop residue burning (CRB). Income subsidies, in contrast, framed support as additional gain and therefore generated greater durability of SRM adoption. This asymmetry, despite the equivalence of economic value, provides direct evidence that cognitive biases mediate the effects of incentives. The findings thus underscore the importance of integrating psychological insights into agricultural policy design, as financial calculations alone cannot fully explain behavioural outcomes.

The practical implications are considerable. The evidence confirms that temporary subsidies can be a viable policy tool for encouraging the adoption of SRM, particularly when the social costs of CRB—such as health impacts of air pollution and environmental degradation—are accounted for. Subsidies should be seen not simply as short-term transfers but as investments that generate long-term public savings by mitigating environmental and health costs. Importantly, the study shows that the form of subsidy matters. Cost subsidies and income subsidies cannot be considered interchangeable; rather, their relative effectiveness depends on farmers' financial conditions. Cost subsidies are more effective in alleviating liquidity constraints, while income subsidies may provide stronger incentives where adoption is feasible but returns are uncertain. These distinctions are crucial for designing policies that align with the needs of heterogeneous farming populations.

Despite these contributions, the research acknowledges several limitations. The experimental design, while rigorous, cannot fully replicate the complexities of farming. In particular, the absence of a timing element (where in reality, farmers incur costs months before returns are realized) reduces the ability to capture risks associated with delayed income. Similarly, the experiment excluded the physical effort required to implement SRM, which in practice involves significant adjustments compared with CRB. These simplifications may have influenced decision-making. Behavioural responses may also have been shaped by the Hawthorne effect, with participants potentially modifying their choices because they were aware of being observed. While the design sought to mitigate these issues, they remain important caveats when interpreting the results.

These limitations point to avenues for future research. Randomized controlled trials (RCTs) conducted under real farming conditions could strengthen external validity by incorporating actual timing of costs and returns, as well as labour requirements. Further work is also needed to investigate the depth of loss aversion in agricultural decision-making, testing whether interventions framed in terms of avoiding losses outperform those framed in terms of gains. In addition, hybrid subsidy designs merit exploration. Combining upfront cost support with income-based rewards could address both liquidity constraints and the need for sustained incentives. Such designs may better balance short-term feasibility with long-term persistence of sustainable practices. Broader comparative studies across different agricultural systems would also help identify which behavioural patterns are generalisable and which are context-specific.

Taken together, the findings provide important theoretical and practical insights into the promotion of sustainable agricultural practices. They show that farmer adoption cannot be understood purely in terms of economic rationality but is shaped by the interaction of financial scarcity, psychological biases, and policy framing. Temporary subsidies emerge as a promising tool for facilitating transitions away from environmentally harmful practices, but their effectiveness depends on careful design. The evidence underscores that equivalent incentives can yield divergent outcomes depending on how they are structured and perceived. For policymakers, the implication is clear: interventions must be tailored to farmer realities, accounting for both financial constraints and behavioural tendencies.

By advancing understanding of how subsidies influence adoption decisions, this study contributes to more effective and evidence-based policy design. It demonstrates that integrating behavioural insights into economic models enriches both theory and practice, and it highlights the need for continued experimentation and validation in real-world contexts. Ultimately, the results suggest that well-crafted subsidies, informed by both financial and psychological considerations, can play a critical role in steering agricultural systems toward sustainability, resilience, and contribution to climate mitigation.

References

Adair, J.G., 1984. The Hawthorne effect: A reconsideration of the methodological artifact. Journal of Applied Psychology 69, 334–345. https://doi.org/10.1037/0021-9010.69.2.334

Ambler, K., de Brauw, A., Murphy, M., 2020. Increasing the adoption of conservation agriculture: A framed field experiment in Northern Ghana. International Food Policy Research Institute, Washington, DC. https://doi.org/10.2499/p15738coll2.133739

Balew, S., Bulte, E., Abro, Z., Kassie, M., 2023. Incentivizing and nudging farmers to spread information: Experimental evidence from Ethiopia. American Journal of Agricultural Economics 105, 994–1010. https://doi.org/10.1111/ajae.12346

Banerjee, S., Conte, M.N., 2018. Information Access, Conservation Practice Choice, and Rent Seeking in Conservation Procurement Auctions: Evidence from a Laboratory Experiment. American Journal of Agricultural Economics 100, 1407–1426. https://doi.org/10.1093/ajae/aay064

Bechini, L., Costamagna, C., Zavattaro, L., Grignani, C., Bijttebier, J., Ruysschaert, G., 2015. Barriers and drivers towards the incorporation of crop residue in the soil. Analysis of Italian farmers' opinion with the theory of planned behaviour. Italian Journal of Agronomy 10, 178–184. https://doi.org/10.4081/ija.2015.663

Belissa, T., Bulte, E., Cecchi, F., Gangopadhyay, S., Lensink, R., 2019. Liquidity constraints, informal institutions, and the adoption of weather insurance: A randomized controlled Trial in Ethiopia. Journal of Development Economics 140, 269–278. https://doi.org/10.1016/j.jdeveco.2019.06.006

Bellemare, M.F., Lee, Y.N., Just, D.R., 2020. Producer Attitudes Toward Output Price Risk: Experimental Evidence from the Lab and from the Field. American Journal of Agricultural Economics 102, 806–825. https://doi.org/10.1002/ajae.12004

Bhuvaneshwari, S., Hettiarachchi, H., Meegoda, J.N., 2019. Crop Residue Burning in India: Policy Challenges and Potential Solutions. International Journal of Environmental Research and Public Health 16, 832. https://doi.org/10.3390/ijerph16050832

Bocquého, G., Jacquet, F., 2010. The adoption of switchgrass and miscanthus by farmers: Impact of liquidity constraints and risk preferences. Energy Policy, Greater China Energy: Special Section with regular papers 38, 2598–2607. https://doi.org/10.1016/j.enpol.2010.01.005

Bretschger, L., & Pittel, K., 2020. Twenty Key Challenges in Environmental and Resource Economics. *Environmental and Resource Economics*, *77*(4), 725–750. https://doi.org/10.1007/s10640-020-00516-y

Capano, G., Howlett, M., 2020. The Knowns and Unknowns of Policy Instrument Analysis: Policy Tools and the Current Research Agenda on Policy Mixes. SAGE Open 10, 2158244019900568. https://doi.org/10.1177/2158244019900568

Chen, J., Gong, Y., Wang, S., Guan, B., Balkovic, J., Kraxner, F., 2019. To burn or retain crop residues on croplands? An integrated analysis of crop residue management in China. Science of The Total Environment 662, 141–150. https://doi.org/10.1016/j.scitotenv.2019.01.150

Chindasombatcharoen, N., Tsolakis, N., Kumar, M., O'Sullivan, E., 2024. Navigating psychological barriers in agricultural innovation adoption: A multi-stakeholder perspective. Journal of Cleaner Production 475, 143695. https://doi.org/10.1016/j.jclepro.2024.143695

Chunyan, H., Funing, Z., Jun, H., 2013. Income vs price subsidy: policy options to help the urban poor facing food price surge. China Agricultural Economic Review 5, 89–99. https://doi.org/10.1108/17561371311294775

Deci, E.L., Ryan, R.M., 1985. Intrinsic Motivation and Self-Determination in Human Behavior. Springer.

Drechsler, M., 2021. Impacts of human behaviour in agri-environmental policies: How adequate is homo oeconomicus in the design of market-based conservation instruments? Ecological Economics 184, 107002. https://doi.org/10.1016/j.ecolecon.2021.107002

Eberhard, R., Coggan, A., Jarvis, D., Hamman, E., Taylor, B., Baresi, U., Vella, K., Dean, A.J., Deane, F., Helmstedt, K., Mayfield, H., 2021. Understanding the effectiveness of policy instruments to encourage adoption of farming practices to improve water quality for the Great Barrier Reef. Marine Pollution Bulletin 172, 112793. https://doi.org/10.1016/j.marpolbul.2021.112793

Engel, S., Pagiola, S., Wunder, S., 2008. Designing payments for environmental services in theory and practice: An overview of the issues. Ecological Economics, Payments for Environmental Services in Developing and Developed Countries 65, 663–674. https://doi.org/10.1016/j.ecolecon.2008.03.011

FAOSTAT, 2023. FAOSTAT Statistical Database. https://www.fao.org/faostat/en/#data/GCE

Foguesatto, C.R., Borges, J.A.R., Machado, J.A.D., 2020. A review and some reflections on farmers' adoption of sustainable agricultural practices worldwide. Science of The Total Environment 729, 138831. https://doi.org/10.1016/j.scitotenv.2020.138831

Frey, B.S., Jegen, R., 2001. Motivation Crowding Theory. Journal of Economic Surveys 15, 589–611. https://doi.org/10.1111/1467-6419.00150

Gabriel, A.H., Hundie, B., 2006. Farmers' Post-Harvest Grain Management Choices under Liquidity Constraints and Impending Risks: Implications for Achieving Food Security Objectives in Ethiopia. Presented at the International Association of Agricultural Economists (IAAE), International Association of Agricultural Economists.

Gautam, M., Laborde, D., Mamun, A., Martin, W., Pineiro, V., Vos, R., 2022. Repurposing Agricultural Policies and Support: Options to Transform Agriculture and Food Systems to Better Serve the Health of People, Economies, and the Planet. World Bank, Washington, DC.

Gneezy, U., Meier, S., & Rey-Biel, P., 2011. When and why incentives (don't) work to modify behavior. *Journal of Economic Perspectives*, 25(4), 191–210. https://doi.org/10.1257/jep.25.4.191

Gneezy, U., & Imas, A. 2017. Lab in the Field: Measuring Preferences in the Wild. In *Handbook of Economic Field Experiments* (Vol. 1, pp. 439–464). North-Holland. https://doi.org/10.1016/bs.hefe.2016.08.003

Guo, S., 2021. How Does Straw Burning Affect Urban Air Quality in China? American Journal of Agricultural Economics 103, 1122–1140. https://doi.org/10.1111/ajae.12132

Harrison, G.W., List, J.A., 2004. Field Experiments. Journal of Economic Literature 42, 1009–1055. https://doi.org/10.1257/0022051043004577

Howard, G., Zhang, W., Valcu-Lisman, A., Gassman, P.W., 2023. Evaluating the tradeoff between cost effectiveness and participation in agricultural conservation programs. American Journal of Agricultural Economics n/a. https://doi.org/10.1111/ajae.12397

Jin, J., Xuhong, T., Wan, X., He, R., Kuang, F., Ning, J., 2020. Farmers' risk aversion, loss aversion and climate change adaptation strategies in Wushen Banner, China. Journal of Environmental Planning and Management 63, 2593–2606. https://doi.org/10.1080/09640568.2020.1742098

Kahneman, D., Tversky, A., 1979. Prospect Theory: An Analysis of Decision under Risk. Econometrica 47, 263–291. https://doi.org/10.2307/1914185

Keck, M., Hung, D.T., 2019. Burn or bury? A comparative cost–benefit analysis of crop residue management practices among smallholder rice farmers in northern Vietnam. Sustain Sci 14, 375–389. https://doi.org/10.1007/s11625-018-0592-z

Kelsey Jack, B., Jayachandran, S., Kala, N., Pande, R., 2023. Money (Not) to Burn: Payments for Ecosystem Services to Reduce Crop Residue Burning. MIT CEEPR Working Paper 2023-05.

Kumar, I., Bandaru, V., Yampracha, S., Sun, L., Fungtammasan, B., 2020. Limiting rice and sugarcane residue burning in Thailand: Current status, challenges and strategies. Journal of Environmental Management 276, 111228. https://doi.org/10.1016/j.jenvman.2020.111228

Lai, W., Li, S., Li, Y., Tian, X., 2022. Air Pollution and Cognitive Functions: Evidence from Straw Burning in China. American Journal of Agricultural Economics 104, 190–208. https://doi.org/10.1111/ajae.12225

Liu, X., Zhang, Y.-L., Peng, Y., Xu, L., Zhu, C., Cao, F., Zhai, X., Haque, M.M., Yang, C., Chang, Y., Huang, T., Xu, Z., Bao, M., Zhang, W., Fan, M., Lee, X., 2019. Chemical and optical properties of carbonaceous aerosols in Nanjing, eastern China: regionally transported biomass burning contribution. Atmospheric Chemistry and Physics 19, 11213–11233. https://doi.org/10.5194/acp-19-11213-2019

Magnan, N., Larson, D.M., Taylor, J.E., 2012. Stuck on Stubble? The Non-market Value of Agricultural Byproducts for Diversified Farmers in Morocco*. American Journal of Agricultural Economics 94, 1055–1069. https://doi.org/10.1093/ajae/aas057

Mahasuweerachai, P., Suksawat, J., 2022. Incentives for mechanized cane harvesting in Thailand: A choice experiment. Journal of Asian Economics 78, 101434. https://doi.org/10.1016/j.asieco.2021.101434

Mahasuweerachai, P., Suksawat, J., Saeng-avat, V., Chailanka, P., Toonsiri, P., Suksavate, W., Walalite, T., Pagdee, A., Chamchoi, N., & Buddhawongsa, P., 2023. Measuring what matters in sustainable rice production. Research Report prepared by Faculty of Economics, Khon Kaen University. https://teebweb.org/our-work/agrifood/country-implementation/eupi2019/thailand/

Mani, A., Mullainathan, S., Shafir, E., Zhao, J., 2013. Poverty Impedes Cognitive Function. Science 341, 976–980. https://doi.org/10.1126/science.1238041

Morello, T., 2023. An Agri-environmental Scheme for Reducing Inputs Subjected to Accidental Spillage: An Application to Agricultural Burnings by Smallholders. *Environmental and Resource Economics*, *84*(2), 383–408. https://doi.org/10.1007/s10640-022-00720-y

Moser, C.M., Barrett, C.B., 2006. The complex dynamics of smallholder technology adoption: the case of SRI in Madagascar. Agricultural Economics 35, 373–388. https://doi.org/10.1111/j.1574-0862.2006.00169.x

Moser, S., Musshoff, O., 2016. Ex-ante Evaluation of Policy Measures: Effects of Reward and Punishment for Fertiliser Reduction in Palm Oil Production. Journal of Agricultural Economics 67, 84–104. https://doi.org/10.1111/1477-9552.12114

Omotilewa, O.J., Ricker-Gilbert, J., Ainembabazi, J.H., 2019. Subsidies for Agricultural Technology Adoption: Evidence from a Randomized Experiment with Improved Grain Storage Bags in Uganda. Am J Agric Econ 101, 753–772. https://doi.org/10.1093/ajae/aay108

Payne, B.K., Brown-Iannuzzi, J.L., Hannay, J.W., 2017. Economic inequality increases risk taking. Proceedings of the National Academy of Sciences 114, 4643–4648. https://doi.org/10.1073/pnas.1616453114

Piñeiro, V., Arias, J., Dürr, J., Elverdin, P., Ibáñez, A.M., Kinengyere, A., Opazo, C.M., Owoo, N., Page, J.R., Prager, S.D., Torero, M., 2020. A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. Nat Sustain 3, 809–820. https://doi.org/10.1038/s41893-020-00617-y

Ritchie, H., Roser, M., Rosado, P., 2020. CO_2 and Greenhouse Gas Emissions. Our World in Data.

Rode, J., Gómez-Baggethun, E., Krause, T., 2015. Motivation crowding by economic incentives in conservation policy: A review of the empirical evidence. Ecological Economics 117, 270–282. https://doi.org/10.1016/j.ecolecon.2014.11.019

Roe, B.E., Just, D.R., 2009. Internal and External Validity in Economics Research: Tradeoffs between Experiments, Field Experiments, Natural Experiments, and Field Data. American Journal of Agricultural Economics 91, 1266–1271. https://doi.org/10.1111/j.1467-8276.2009.01295.x

Singh, G., Gupta, M.K., Chaurasiya, S., Sharma, V.S., Pimenov, D.Y., 2021. Rice straw burning: a review on its global prevalence and the sustainable alternatives for its effective mitigation. Environ Sci Pollut Res 28, 32125–32155. https://doi.org/10.1007/s11356-021-14163-3

Sommerville, M., Milner-Gulland, E. j., Rahajaharison, M., Jones, J.P. g., 2010. Impact of a Community-Based Payment for Environmental Services Intervention on Forest Use in Menabe, Madagascar. Conservation Biology 24, 1488–1498. https://doi.org/10.1111/j.1523-1739.2010.01526.x

Streletskaya, N.A., Bell, S.D., Kecinski, M., Li, T., Banerjee, S., Palm-Forster, L.H., Pannell, D., 2020. Agricultural Adoption and Behavioral Economics: Bridging the Gap. Applied Economic Perspectives and Policy 42, 54–66. https://doi.org/10.1002/aepp.13006

Thaler, R.H., 1999. Mental accounting matters. Journal of Behavioral Decision Making 12, 183–206. https://doi.org/10.1002/(SICI)1099-0771(199909)12:3<183::AID-BDM318>3.0.CO;2-F

Tong, E.M.W., Reddish, P., Oh, V.Y.S., Ng, W., Sasaki, E., Chin, E.D.A., Diener, E., 2022. Income robustly predicts self-regard emotions. Emotion 22, 1670–1685. https://doi.org/10.1037/emo0000933

UNESCAP, 2020. Reducing straw residue burning and air pollution through sustainable agricultural mechanization. Committee on Environment and Development, Sixth Session 6.

United Nations, 2020. Thai Agricultural Sector: From Problems to Solutions | United Nations in Thailand [WWW Document]. URL https://thailand.un.org/en/103307-thai-agricultural-sector-problems-solutions, https://thailand.un.org/en/103307-thai-agricultural-sector-problems-solutions (accessed 5.1.23).

Westerberg, V., 2017. Cost Benefit Analysis of Agricultural Burning Practices in the Dedoplistskaro Municipality, Georgia. GIZ.

Wu, J., Yu, J., 2017. Efficiency-Equity Tradeoffs in Targeting Payments for Ecosystem Services. American Journal of Agricultural Economics 99, 894–913. https://doi.org/10.1093/ajae/aaw095

Xu, C., Qin, B., Rawlings, D., 2022. Motivational crowding effects of monetary and nonmonetary incentives: Evidence from a common pool resources experiment in China. Ecological Economics 202, 107597. https://doi.org/10.1016/j.ecolecon.2022.107597