Climate change beliefs and subsidy for adaptation: Evidence from cocoa farmers in Ghana

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- This study uses a lab-in-the-field experiment with cocoa farmers in Ghana to compare the effects of two subsidies for shade tree planting. It also examines the role of information campaigns combined with the two subsidies in shaping individual beliefs. Shade management, planting more forest trees for shade over cocoa trees, affects production and environmental outcomes.
- The study compares the *Input* subsidy for forest shade trees and the *Output* subsidy for cocoa beans from shaded farms in a lab game. Both subsidies increase forest tree planting and income sizably. The *Output* subsidy increases 7.6 trees per acre, compared with 8.4 under the *Input* subsidy, which is driven by farmers' prior beliefs of climate risk and optimal shade level.
- Interacting two subsidies with an information intervention on climate risks and shade benefits, the lab game results show information is more effective under the *Output* subsidy by shifting beliefs about optimal shade. Farmers' requests and pick-up of forest tree seedlings during the Green Ghana Program corroborate the lab game findings.
- This study highlights the critical role of farmers' heterogeneous beliefs in the effectiveness of subsidy policies. Agro-environmental policies should consider individual belief heterogeneity and better use of the deployed targeted information campaigns, especially in localised enforcement periods.

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Introduction

Climate change increases the tension between environmental protection and poverty reduction in sub-Saharan Africa. Around one-third of the world's droughts occur in this region, exacerbating income shocks, especially for the 54% of the labour force in agriculture, which is heavily reliant on rain-fed irrigation. Farmers face reduced and more volatile yields due to prolonged droughts, extreme heat, and other climate-related events in recent years.

Various agro-environmental policies are being developed to ease the tension in low- and middle-income countries with high poverty and climate change concerns. Environmental conservation programs and sustainable certification programs are two popular policy tools to incentivise adaptation and mitigation. Conservation programs are direct cash transfers to participants who conduct specific pro-environment activities, like payment-for-ecosystem-services (PES) for tree planting. Sustainable certification programs, such as Rainforest Alliance, offer price premiums for certified sustainable agricultural products to indirectly subsidise pro-environment activities. Certification programs are often seen in the coffee and cocoa sectors, with rising global demand for environmentally friendly products.

However, comparing these subsidies' impacts on individual welfare and environmental benefits remains unclear, especially considering heterogeneous individual beliefs. Specifically, variations in individuals' perceptions of climate risks and the integration of adaptation tools into production functions can lead to divergent responses to adaptation under incentivised subsidy policies.

This study compares the effectiveness of a standard PES subsidy and an output-based subsidy in incentivising smallholder farmers' adaptation. It also explores the role of individual beliefs using a lab-in-the-field experiment in Ghana's cocoa industry. As Ghana's most important cash crop, supporting over 40% of its population, cocoa is highly vulnerable to climate-change-related shocks such as prolonged droughts. This vulnerability underscores the need for adaptation by shade management - planting trees scattered around cocoa farms to provide shade. This context offers a setting to compare these two subsidies, as shade trees serve dual functions in stabilising yields (production impacts) and enhancing ecosystem services (environmental outcomes).

Overview of the research

This study compares two subsidies targeting shade management – the *Input* subsidy and *Output* subsidy - and investigates smallholder farmers' adaptation responses and welfare impacts using a lab-in-the-field experiment. To explore the role of beliefs in determining policy responses, the study layers an information

intervention on top of the subsidies, informing farmers about increasing climate change risks and shade tree benefits.

In the lab game, each respondent makes independent decisions about shade management and enrollment in subsidy programme(s) using their own real-world experience and knowledge of cocoa production. At the end of the lab session, respondents are rewarded based on their realised gains, including cocoa bean harvest, subsidies, and costs, from one randomly chosen game.

The experiment occurred in 30 communities in the Nkawkaw district of the eastern region and the Sefwi Bekwai district of the western north region in Ghana. A total of 1,905 cocoa farmers were randomly assigned into one of the five treatment groups:

- **Control**: No subsidy or information intervention.
- ***Input* Subsidy**: Farmers received a lump-sum payment for planting shade trees. The payment increases with the level of shade provided, ranging from 0 to 220 tokens (equivalent to 0.25 bags of beans, one bag = 64 kg).
- ***Output* Subsidy**: Farmers received price premiums for cocoa beans harvested from shaded farms. The premiums increase with shade level, varying from 0% (not qualified) to 12.5% (high) per bag, which links the incentive to output harvest.
- ***Input* Subsidy + Information**: Farmers received the *Input* subsidy and additional information about increasing climate change risks, including irregular rainfalls and drought, as well as the benefits of shade for climate resilience and ecosystem services.
- ***Output* Subsidy + Information:** Farmers received the *Output* subsidy and the same additional information.

The study assesses the treatment effects on (within-lab) shade tree planting, subsidy enrollment and farmer income. To validate these lab findings, the study also evaluates real-world outcomes, such as farmers' requests for forest tree seedlings in the Green Ghana Program collected during the post-game surveys in the lab and several months later in tree sapling distribution. Notably, tree sapling distribution occurs exclusively in the second district.

Findings

Heterogeneity in farmers' current practices and beliefs about shade management

There is significant variation in farmers' current shade adoption practices and their prior perceptions of optimal shade levels. Despite the Ghana Cocoa Board's uniform recommendation, actual practices vary widely among farmers, averaging nine shade trees per acre. Most farmers agree that shade trees mitigate climate-

related cocoa decline, yet considerable heterogeneity exists in their perceived optimal shade levels (the number of trees they believe maximises cocoa harvests). This measure is based on farmers' responses about expected harvests with varying shade tree counts from 0 to 25 per acre, with all other practices unchanged. The median perceived optimal shade level is 15 trees per acre.

Impact on forest shade tree planted (lab game decisions): *Input* vs. *Output* subsidies

Given farmers' initial prior beliefs, both subsidies increase shade adoption, but the increase under the *Output* subsidy is slightly lower (Figure 1). Farmers in the control group (without any subsidy) chose to plant 10 trees per acre in the game, consistent with their real-world practices. Farmers in the *Input* subsidy group increased tree planting by 8.4 trees per acre (an 82% rise). In comparison, farmers in the *Output* subsidy group increased planting by 7.6 trees per acre (a 75% rise), suggesting substantial environmental benefits.

Farmers' heterogeneous prior beliefs influence the 0.76 tree-per-acre difference between the two subsidies. Farmers anticipating more future droughts planted fewer trees under the *Output* subsidy. As the *Output* subsidy depends on cocoa bean harvests, those pessimistic about future rainfall expected lower subsidy rewards and thus adopted fewer shade trees. In the *Input* subsidy group, farmers who believed cocoa production peaks at lower shade levels showed a larger increase in tree planting, as the input-based subsidy directly compensates for potential yield loss from increased shade.

Role of information nudging

Information nudging enhances tree planting under both subsidies, with a more pronounced effect when paired with the *Output* subsidy, effectively closing the response gap between the two subsidy groups. Specifically, compared to the subsidy-only treatment groups, information nudging increases tree planting by 1.4 trees per acre with the *Input* subsidy and 2.4 trees per acre with the *Output* subsidy. Consequently, with information intervention, both subsidies result in an increase of 10 forest trees per acre compared to the control group, eliminating any difference between the two subsidy groups.

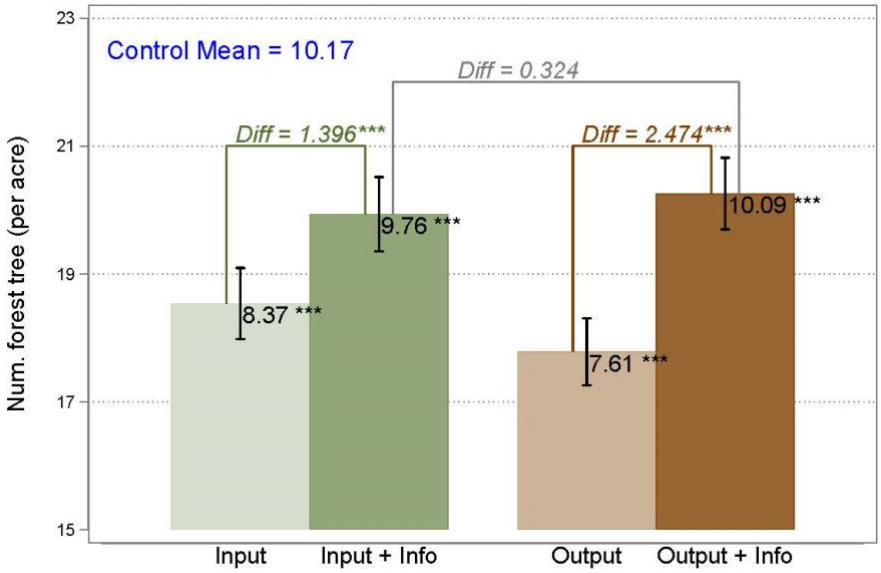
The greater impact of information intervention when combined with the *Output* subsidy is supported by evidence showing a more significant increase in farmers' perception of the optimal shade level under harsh weather conditions compared to the *Input* subsidy.

Impact on farmer income in the lab

Both subsidies lead to a 20% increase in total income in the lab game. Moreover, the *Output* subsidy on sustainable cocoa beans under certified shade leads to larger subsidy income gains under normal weather and smaller subsidy income

gains under harsh weather compared to the *Input* subsidy. Still, the impacts on total income are not statistically different. This pro-cyclical nature of the output-based subsidy does not translate into higher income volatility.

FIGURE 1: Impact on forest tree planting (lab game result)



Note: This figure presents the treatment effects on the number of forest trees farmers decided to plant on a one-acre cocoa plot in the lab game. Each column represents the magnitude of the treatment effect with respect to the mean in the control group: input-based treatments (*Input* subsidy; *Input* subsidy + Information) are in green, and output-based treatments (*Output* subsidy; *Output* subsidy + Information) in brown, with darker shades indicating information treatments. The bars are 95% confidence intervals. The text above the columns reports the group differences and the statistical significance of the group t-tests for each pair.

Validation by farmers' requests for Green Ghana Program

Incentivised subsidies for shade and information nudging in the lab game can translate into farmers' relevant responses in the real world. The study examines the lab-treatment impacts on farmers' requests for forest tree seedlings in the Green Ghana Program, an annual nationwide afforestation/reforestation programme launched in 2021 and held every June by the Ghanaian government to restore degraded landscapes. The programme operates as an input-based subsidy, offering free tree seedlings.

The study shows that participants in the input-based subsidy groups in the lab game requested more tree seedlings during the Green Ghana Program, but there was no evidence of an impact from information nudging under the input-based subsidy. However, while no impacts were observed among farmers in the *Output* subsidy group without nudging, information nudging coupled with the *Output* subsidy increased sapling requests by three trees. These findings are further supported by farmers' actual pick-up of tree seedlings during distribution three months later.

Policy implications

The study shows that both input- and output-based subsidies incentivising sustainable adaptation have promising potential in achieving dual objectives of environmental sustainability and poverty alleviation. However, the efficacy of the output-based subsidy relies heavily on individuals' capability to update their beliefs about climate risks and incorporate adaptation strategies into their production decisions.

These findings underscore the pivotal role of heterogeneous individual beliefs in shaping the effectiveness of different subsidy policies, with broader implications for formulating and implementing agro-environmental policies. Policy frameworks should meticulously consider the heterogeneity in individuals' beliefs alongside strategically deploying targeted information campaigns tailored to the needs of target populations. This is increasingly crucial in a global landscape marked by escalating climate risks, heightened uncertainty, and persistent information gaps, particularly affecting less educated farmers with limited access to reliable information.

Moreover, financial constraints, information barriers, and other challenges are often intertwined and vary across regions. Therefore, it is necessary to consider localised frictions and requirements when implementing global practices like payment-for-ecosystem-services or certification programs across regions. Tailoring information campaigns to align with local comprehension levels and institutional capacities is essential for effective policy uptake and impact.

Equity issues in programme enrollment and compensation distribution are growing concerns in local implementation or scaling up of compensation programs and other environmental policies. During the 2024 Green Ghana Program tree sapling distribution, respondents expressed concerns about unequal benefits favouring individuals with closer ties to community leaders or chiefs, while many others lacked access to information and programme benefits in previous years. Establishing robust monitoring systems is essential to enhancing local enforcement of sustainable programs, ensuring transparency and equitable distribution of benefits among the broader community.