FARMERS' WILLINGNESS TO CONTRIBUTE TO CIRCULAR ECONOMY: A FRAMED FIELD EXPERIMENT FROM KENYA

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Abstract

Tackling climate change requires scaling up circular economy practices. However, there is little guidance on how this can be done in resource-scarce settings such as sub-Saharan Africa (SSA), where most of the population relies on agriculture for livelihoods but faces challenges related to agricultural waste disposal. This study posits that an effective way of boosting circular economy practices is to promote conversion of biowaste to biochar and explores the acceptance of this idea among Kenyan smallholder tomato farmers. The study uses a randomized information-based intervention that conveys important facts about tomato biowaste and its conversion to biochar. Measured immediately after the intervention, the results show that farmers who received information about biochar are more likely to support relevant policies and the adoption of this practice, even if it is costly. Message framing plays an important role in shaping acceptance. Collective information more strongly increased policy support – a subsidy in particular, and public goods contributions, which capture intention to support collective biochar production. The individual framing significantly increased willingness to pay for own-farm biochar production. The implications of this study are twofold. First, it indicates a strong role of information and in particular collective message framing in eliciting support for public policies targeting the circular economy and climate change. Second, this study reveals that at present, there is interest in both collective and individual biochar production from tomato biowaste in Kenya. However, investments in collective facilities require transparency in assessing personal gains from collective effort. These findings are useful for policymakers when devising policy instruments and gauging the costs of public investment in the circular economy.

Keywords: circular economy, biochar, willingness to pay, message framing, smallholder farmers, agricultural biowaste

JEL Codes: Q15, Q53, Q54, Q56

1 Introduction

Agricultural waste is linked with environmental problems and emissions that contribute to global warming (Atinkut et al. 2020) and adverse health issues (Jack et al. 2025). However, agricultural waste can be converted to useful products, such as biochar, biofuel, feed, and various chemicals. This approach resonates strongly with circular economy principles, according to which giving new life and value to agricultural waste can contribute to improved economic, health, and environmental outcomes (Velasco-Muñoz et al. 2022). Biochar is an organic soil amendment that can be produced by pyrolysis of various plant materials (Martiny et al. 2024). Its production from agricultural waste is limited (FAO 2023), using mainly corn cobs and nut shells (Hansson et al. 2021). Although feasible, the use of residues from horticultural crops, such as tomatoes, in biochar production is only explored at the laboratory level (Stylianou et al. 2023). Tomato crops leave huge amounts of solid waste after harvesting, consisting of stems, leaves, and branches whose weight reaches 60% of the amount produced (Manríquez-Altamirano et al. 2020). Uncontrolled disposal and composting at home can even increase environmental risks, as various gases are released (Quirós et al. 2014). Irrespective of the feedstock type, biochar is mainly produced in a decentralized way on individual farms, which particularly holds in African countries (Hansson et al. 2021). In such contexts of insufficient resources, community-based (collective) biochar production systems deployed under coordinated management could be effective in increasing production (Purnama et al. 2025). However, existing studies rarely examine whether farmers prefer collective or individual approaches to biochar production (Purnama et al. 2025).

The existing literature lists a range of personal, institutional, and economic factors that shape farmers' decisions about biochar production (Fridahl et al. 2021; Campion et al. 2023; Soriano Ynfante et al. 2024; Hounnou et al. 2024). In particular, insufficient knowledge about biochar production and application is as relevant as production costs in shaping biochar adoption decisions (Soriano Ynfante et al. 2024). The adoption constraints of insufficient knowledge can be attenuated by providing additional information (Langer and Weber 2008), which can also be advantageous to generate support for public policies (Dewaelheyns et al. 2025). Additional information that conveys relevant facts affects farmers' perceived efficacy and outcome expectancy beliefs (Chatterjee et al. 2024) and can thereby increase willingness to adopt new practices (Jia and McNamara 2024; Fabregas et al. 2025).

Despite a growing body of evidence that information treatments can significantly affect agricultural decision-making (Fabregas et al. 2025), environmental behavior (Grelle et al. 2024), and acceptance of climate policies (Dechezleprêtre et al. 2025; Dewaelheyns et al. 2025), their effectiveness in the context of smallholder farming and biochar production from horticultural biowaste remains largely unexplored. There is little experimental evidence on circular economy adoption decisions (Peng et al. 2025) and policy preference among smallholder farmers (Losa 2025). Moreover, there is limited literature that aims to identify the preferred scale of biochar production from biowaste (Purnama et al. 2025), as most research analyzes technical performance (Schmidt et al. 2021; Campion et al. 2023; Ghosh et al. 2026) and adoption determinants (Hounnou et al. 2024; Soriano Ynfante et al. 2024) rather than organizational preferences.

To fill these gaps, this study explores the acceptance of biochar as a biowaste conversion technology and the preferred conversion scale among Kenyan farmers. A between-group randomized experiment is used to measure the effectiveness of collectively and individually framed information interventions on biochar policy preference and willingness to pay (WTP) for collective as opposed to individual solutions for biochar production. In addition, we explore the role of perceived efficacy and outcome expectancy beliefs in shaping revealed policy preferences and biochar valuations.

The study is related to recent literature that highlights the role of information in shaping farmers' intentions to adopt biochar (Hounnou et al. 2024; Soriano Ynfante et al. 2024; Perrone et al. 2025) and literature on the use of targeted information and message framing to elicit support for climate action (Dechezleprêtre et al. 2025), climate policy (Dewaelheyns et al. 2025), and biochar adoption (Wang et al. 2026). However, this study goes beyond measuring policy acceptance and intentions to measuring valuations of the adoption of biochar produced from tomato waste. This is done by eliciting public goods game (PGG) contributions and WTP measures that provide a valuation of collective and individual biochar technologies. Existing studies measuring farmers' WTP applied to agricultural waste management show associations (Huang et al. 2019; Atinkut et al. 2020; He et al. 2020), while this study uses randomized information treatments to identify causal impacts that differentiate the scale of biochar technology. This is highly relevant considering recent accounts of a lack of experimental evidence on biochar adoption (Gristina and Scalenghe 2026). In addition, by comparing individual and collective biochar production, this study reveals the preferred scale of biochar operations, which is important in light of the scarcity of literature investigating the scale of biochar technologies (Purnama et al. 2025).

The results of this study show that Kenyan tomato farmers who received more information (either collectively or individually framed) about the potential of converting tomato biowaste to biochar were more likely to express a desire for public policies that would regulate or support this practice. The results also show that information about collective gains from biowaste conversion can elicit stronger policy support than individually framed information, for subsidized conversion. Collective treatment was also effective in increasing collective conversion intentions, as revealed in the results of the PGG. Individual treatment had a stronger effect on WTP for individual biochar production. The collective intervention operates by increasing both collective and individual perceived efficacy and outcome expectancy, while the individual treatment activated personal outcome expectancy more than personal self-efficacy.

The findings of this study are relevant for public policy design, suggesting how communication can be framed to increase support for climate policy measures. They also indicate that at present there is interest in both collective and individual tomato biowaste conversion to biochar in Kenya. However, collective effort requires clear rules related to the distribution of the gains, emphasizing the importance of transparency and inclusiveness in collective action. These findings can be useful for developing optimal design of policy instruments for promoting circular economy and guiding decisions about the circular economy investments in resource-scarce environments.

The paper is organized as follows. Section 2 provides an overview of closely related literature and lists hypotheses. Section 3 describes the setting, the study design, and data. Section 4 presents the empirical model. The results and the discussion are in Sections 5 and 6, respectively. Section 7 concludes and highlights policy implications.

2 Conceptual framework

The adoption of circular economy technologies among smallholder farmers is shaped by a combination of personal, economic, institutional, and informational factors. The process is traditionally explained by calculating trade-offs between anticipated gains and costs, whereby households consider how the new technology can improve household income and the local ecological environment (He et al. 2020). However, the costs of technology and the effort needed to understand and use the new technology can slow down or deter adoption (Foster and Rosenzweig 2010). To reduce investment and transaction costs, some technologies benefit from scale and deployment at the community level (Olson 1965; Ostrom 1990). Collective arrangements in smallholder agricultural systems leverage collective infrastructure, social networks, and community institutions to foster new technology adoption (Wollni et al. 2010). For example, a treatment that motivated saving for collective maize storage resulted in greater benefits for participants than an individual savings treatment (Aggarwal et al. 2018). Purnama et al. (2025) tested the techno-economic feasibility of biochar production from oil palm fronds and waste cooking oil and found positive prospects for aggregating production in rural areas.

Knowledge deficiencies that constrain policy acceptance (Bergquist et al. 2022) and agricultural technology adoption (Foster and Rosenzweig 2010) can be attenuated by providing additional information (Fabregas et al. 2025). Information interventions are effective in increasing contributions to public goods (Faralla and Innocenti 2025), policy acceptance (Dewaelheyns et al. 2025), and circular economy efforts (Jäger-Roschko and Petersen 2022). Providing scientifically grounded information improves understanding, reduces perceived risks, and strengthens confidence in adopting circular economy practices (Soriano Ynfante et al. 2024). Additional information about production practices or technologies improves farmers' WTP for them (Britwum and Yiannaka 2019).

However, information framing plays an important role. Framing involves directing the audience's focus or emphasizing specific aspects of the shared contents to ensure that the audience interprets the message in the desired way (Chong and Druckman 2007). Information framed around profitability can be more efficient in increasing farmers' WTP than health (Jia and McNamara 2024) or environmentally framed information (Wang et al. 2026). By emphasizing shared responsibility and common benefits, collective framing can encourage cooperative behavior (Bicchieri 2005). A recent study found a higher willingness to accept strict climate adaptation policy instruments among those in the collectively framed infographic treatment than in the individually framed treatment (Dewaelheyns et al. 2025). Highlighting the role of individual actions is also important for motivating sustainable behavior (Grelle et al. 2024).

In social cognitive theory, personal beliefs, such as perceived efficacy and outcome expectancy, are key determinants of behavioral change (Bandura 1986) and climate policy acceptance (Bergquist et al. 2022). Collective efficacy is closely linked with personal self-efficacy, and each can amplify the other. For example, observing that a community member is effectively engaging in sustainable production can increase feelings of self-efficacy (Chatterjee et al. 2024). Also, perceiving one's own actions as an effective response to common challenges that go beyond personal capacity increases self-efficacy, which contributes to higher collective efficacy and stronger pro-environmental behavior (Chatterjee et al. 2024).

Information interventions operate by changing outcome expectancy beliefs and perceived efficacy. These intermediate behavioral responses are critical precursors for the actual adoption of circular economy practices, including willingness to contribute financially or through labor (Atinkut et al. 2020). Farmers must believe that biochar production is feasible and that it will generate tangible environmental and economic benefits. Communicating about collective benefits can influence key behavioral and attitudinal outcomes, strengthen perceptions of collective efficacy, and further mobilize acceptance of collective solutions and support for collective engagement (Chatterjee et al. 2024) and climate policies (Dewaelheyns et al. 2025). In contrast, prioritizing personal over collective outcomes often hinders engagement with environmental practices (Vugt et al. 2014). Clearly explaining the benefits of biochar enhances perceived efficacy, reduces psychological barriers, and increases the likelihood of support for adoption and related policies (Ariti et al. 2018). An intervention comprising text- and image-based information increased study participants' efficacy beliefs, which in turn influenced their behavioral intentions about the use of renewable technology (Hart and Feldman 2016). By affecting efficacy beliefs, an infographic-based intervention increased support for hard climate change policies in Belgium (Dewaelheyns et al. 2025).

In brief, collective action theory suggests that emphasizing shared benefits and responsibilities should increase support for collective solutions and public investments (Olson 1965; Ostrom 1990). Social cognitive theory predicts that information can influence behavior by strengthening efficacy beliefs and outcome expectancy (Bandura 1986), while framing theory argues that the way information is presented affects how individuals interpret and respond to it (Chong and Druckman 2007). Consequently, collectively framed information is expected to strengthen collective efficacy, collective outcome expectancy, support for public policies, and willingness to contribute to collective biochar production, whereas individually framed information is expected to strengthen personal efficacy, personal outcome expectancy, and willingness to invest in own-farm biochar production.

Therefore, the hypotheses of this study were as follows:

H1. Collectively framed information leads to a higher acceptance of biochar policy instruments and collective outcomes (PGG contribution, WTP for biochar, efficacy and outcome expectancy) compared to no information about biochar benefits.

H2. Individually framed information leads to higher acceptance of biochar policy instruments and individual outcomes (WTP for biochar, self-efficacy and outcome expectancy) compared to no information.

H3. Collectively framed information leads to a higher acceptance of biochar policy instruments and collective outcomes compared to individually framed information.

H4. Individually framed information leads to higher individual outcomes compared to collectively framed information.

To test H1 and H2, the mean support for policy instruments and outcomes in the control group was compared to the mean support of each group that received collectively or individually framed information. H3 and H4 were tested by comparing the mean support for policy instruments and outcomes between the two groups that received the information treatment. The main hypotheses differentiate between four different policy instruments: (a) a policy that would strictly prohibit disposal of biowaste along with other household trash (H1a-H4a); (b) a policy that would control and enforce biowaste conversion (H1b-H4b); (c) a policy that would introduce a fee based on farm size (H1c-H4c), and (d) a policy that would introduce a subsidy for converting all tomato waste to biochar (H1d-H4d). The hypotheses were also tested with respect to PGG (H1e-H4e), collective (H1f-H4f) and individual WTP (H1g-H4g), as well as the following mechanisms: collective efficacy (H1h-H4h), personal self-efficacy (H1i-H4i), collective outcome expectancy (H1j-H4j), and personal outcome expectancy (H1k-H4k). This results in 44 hypotheses in total. The main hypothesis is considered confirmed when all tests corresponding to the related sub-hypotheses show statistically significant differences. If at least one sub-hypothesis is confirmed, it is considered that the main hypothesis is partially supported.

3 Data and setting

Kenya was chosen as the study site given the large horticultural sector and ambitious climate and environmental policies. About a quarter of the Kenyan population faces food insecurity (Korir et al. 2020), while one-third of crop production is lost due to pests or damage during harvest and transportation (Ridolfi et al. 2018). Food waste disposal contributes 11% of total food system greenhouse gas emissions (Martius et al. 2023). The Fourth Medium Term Plan and Kenya Vision 2030, integrated with the Sustainable Development Goal (SDG) 6 and specifically target 6.3, call for the reduction of emissions from the agri-food sector (NTEP 2024; Kenya Vision 2030 2026) by, among others, climate-resilient waste management (Martius et al. 2023). Besides high crop loss rates during and after harvest (e.g., 30-40% of volume (Sibomana et al. 2016) and 16% of value (Gatere et al. 2022)), tomato crops also leave huge amounts of solid waste after harvesting suitable for biochar production (Stylianou et al. 2023). The use of charcoal and biochar, especially for cooking, is known in Kenya, but the main feedstock comes from trees and other forest products, which contributes to forest degradation (Veronesi et al. 2015) and does not efficiently convert agricultural biowaste.

Data are obtained from a between-subject randomized field experiment with a video-based information intervention and a participant survey. The intervention videos frame tomato waste management as an individual or a collective issue. An overview of the study design is shown in Figure 1. The sample was divided into separate randomly chosen groups of participants, including two treatment groups and one control group. The first treatment group watched a short video that presents the circular economy as collectively beneficial. The second treatment group watched a short video that presents the circular economy as individually beneficial. The control group watched a video with basic facts about biochar. In each village, the experiment was administered in two sessions. Each session contained 24 participants who were randomly divided into two treatment groups and one control group. The group allocation was determined by a number's lottery.

After watching the videos, the participants played the PGG and then were surveyed by the enumerators. This is compatible with research objectives to detect immediate effects of exposure to audiovisual material, as it is very likely that such material is broadcast infrequently in real life. Given that both treatment and control groups co-reside in the same villages, allowing some time to pass between the treatment and the second survey round would increase spillover bias from interaction of the treatment and the control groups. Finally, an advantage of the between-subject design is a lower sensitivity to experimenter demand bias, which tends to be more prominent in within-subject designs (Charness et al. 2012). Following consultation with experts, the experimental protocol and the survey instrument were pilot-tested on 28 and 29 October 2025 in Machakos and Kajiado counties using a sample of 48 tomato farmers in total (24 by county).

3.1 Sample size and selection criteria

The planned sample size was determined ex ante using a conventional power calculation for a three-arm comparison (Cohen 1988). Assuming a baseline preference for eco-friendly biowaste management of 59% drawn from prior evidence (obtained as a mean of 60.2% among female and 58.8% among male farmers in Ethiopia (Atinkut et al. 2020)), the mean difference of r = 0.15, 0.80 power at the standard 0.05 alpha error probability, the target sample size per experimental arm was 155 farmers, or 465 in total. The two-sample proportions test was implemented in Stata MP 18 using the command power, specifically power two-proportions 0.59, diff (0.15) power (0.8). To account for non-response, ineligibility, and post-survey exclusions, the recruitment target was inflated by 25%, resulting in 582 participants approached.

The fieldwork took place over two weeks in November and December 2025 in 24 villages located in the following eight counties in rural Kenya: Kajiado, Makueni, Machakos, Narok, Nakuru, Laikipia, Kirinyaga, and Kiambu. When selecting study sites, researchers considered regions with very high or moderate rates of tomato production, the operational feasibility of implementing the intervention, and the ease of participant recruitment. The participation criteria called for tomato farmers older than 18 years who are either the principal decision-maker or spend most of their time on tomato production. While several household members can take part in tomato production, only one participant per household could be included in the study. Although the selection criteria targeted tomato farmers, it was determined during and after the survey that some respondents produced only negligible amounts of tomato or did not produce it at all in the previous farming season. Five such cases were excluded from the analysis, and so were the participants who accepted WTP values that seemed too high compared to the reported tomato revenue. Thus, the final sample included 540 tomato farmers.

3.2 Video treatments

The videos contain a series of slides with scientific facts about biochar common to all three videos. The two treatment videos also contain information about a) tomato production and biowaste statistics, b) a call for action focusing on the outcome of applying biochar in tomato production, and c) benefits of using biochar in tomato production. This is aligned with a recent study on biochar adoption in Benin, which emphasizes that information disseminated to farmers should describe characteristics of the new technology and its long-term advantages (Hounnou et al. 2024). An overview of the information shared in the two treatment videos is shown in Figure 2. The shared information between all three videos includes biochar definition, production, and use (point 1 in Figure 2).

The central message was that converting tomato waste into biochar can make a positive difference, which is incorporated in the call to action. By referring to 'green growth,' the videos imply a positive link between farms and environmental and economic benefits. The facts about tomato production and biowaste are differentiated by scale. While the individual treatment contains figures for an average farm, the collective video presents facts for the whole country. Apart from the scale difference, the two treatments also differ in terms of language, highlighting societal ('we') or personal ('you') perspective. The individually framed video emphasized individual perspective, numbers and personal benefits, while the collectively framed video emphasized collective perspective, cumulative (national) figures, and broader benefits for society. Given this, the differences between the two treatments should be interpreted as the effect of a combined message package rather than as the isolated effect of pronouns used, scale, or numerical magnitude of the values alone (Chong and Druckman 2007).

All figures in the video were compiled by the research team with information derived from recent literature on general benefits of biochar (Mahmoud et al. 2021; FAO 2023), tomato waste amounts (Manríquez-Altamirano et al. 2020), conversion rates of biochar production from tomato biowaste (Llorach-Massana et al. 2017), and amounts of biochar needed to improve soil quality (Schmidt et al. 2021; Dai et al. 2020). The videos do not list all benefits but make a general statement that biochar could improve soil properties. This strategy was adopted to avoid priming participants or advertising biochar, and because some farmers may already know and use biochar, which was verified during data analysis.

The two treatment videos are about two minutes and thirty seconds long, while the control group video is one minute and thirty seconds long. The treatment videos were longer than the control video because they contained additional content on benefits and the call to action. Consequently, estimated treatment effects may partly reflect exposure duration as well as message content (Hauser et al. 2019). All videos were in the local language (Swahili). Videos were shown on researchers' laptops to eight participants in a group.

3.3 Public goods game

A PGG was implemented to obtain an incentivized measure of participants' contribution to biochar production. Participants were randomly assigned into groups of eight and asked how much of their initial endowment they would like to contribute to a public good, which in this game was defined as a collective biochar production facility fed by tomato biowaste. The game was played in one round to prevent confusing the framing effect with group dynamics such as retaliation (Schuch et al. 2025). Following a standard protocol, contributions of all players in a group were multiplied by a constant factor and the total multiplied contributions were evenly distributed among all players (Leibbrandt 2012). Each participant had an endowment of 10 points to distribute between the personal and group account. The assigned value for each point was 100 Kenya shillings (KSh). The game was played in one round. Participants were provided with a private space to make decisions about the number of points they wanted to transfer to the group account. The experimenters calculated the payouts, which were transferred to participants using the most popular local mobile phone money transfer service.

The multiplication factor for the common pool was 0.4 as similar in Fehr and Gächter (2000). This means that the contributions to the group fund were augmented by 40% and distributed equally among all players. With this value, contributions to the common pool reduce own gains but increase total gains for the group (Gneezy et al. 2016). While a rational response (Nash equilibrium) is zero contributions by everyone, the socially optimal response involves contributing the whole endowment. These theoretical predictions are routinely violated in empirical settings. Participants initially contribute about 30-50% of their endowment to the common pool (Weimann et al. 2019), driven by positive beliefs about contributions of others (Schuch et al. 2025).

3.4 Eliciting WTP for biochar

The study used the contingent valuation method to estimate farmers' WTP for conversion of tomato biowaste to biochar on their own farm or in a collective facility, where collective refers to joint biochar production at the community level. Participants were asked about their WTP for a randomly drawn monetary value in KSh and the labor contribution in days per year. The following options were available: 2,500; 5,000; 7,500; 10,000 and 12,500 or more KSh for biochar production in a collective biochar facility and 5,000; 10,000; 15,000; 20,000 and 25,000 or more KSh for biochar production on their own farm. In terms of labor contribution, the following options were available: 2, 4, 6, 8, and 10 or more labor days per year for biochar production in a collective biochar facility and 4, 8, 12, 16, and 20 or more labor days per year for biochar production on their own farm. The values were determined based on local information about labor costs, tomato profits, and the online price of biochar. Participants could respond with a "Yes" or a "No" to a particular randomly drawn value of their WTP for the conversion of tomato waste to biochar. From these responses, binary measures for labor and monetary WTP were constructed, as is common practice in the literature (Atinkut et al. 2020).

By showing only one value for the monetary and labor contributions, this study avoided the order effect bias (Loomis et al. 2000; Clark and Friesen 2008). Several approaches were implemented to deal with hypothetical and strategic biases (Loomis 2014). First, the WTP values were validated in consultation with experts and stakeholders. Second, the range of WTP elicitation values were refined based on the pilot survey. Third, ex post, both the monetary and labor WTP values were verified to be within the reasonable range with respect to the revenue from tomato farming and the actual labor use.

3.5 Survey questions and key variables

Several outcome variables were derived from the survey data including policy acceptance measures, as shown in Table 4. Participants were asked to express their acceptance of four potential tomato biowaste management policies that could be introduced by the Kenyan government on a Likert scale from 1 (opposing) to 5 (supporting the policy). The policy assessment index variable is the average value of the four policy acceptance questions. Perceived collective and personal efficacy and outcome expectancy beliefs drawing on Dewaelheyns et al. (2025) were evaluated on a Likert scale from 1 (do not agree at all) to 5 (fully agree).

The survey also collected information about sociodemographic characteristics, farming practices, and preferences. The variables used in the balance tests include age, education, household and land size, off-farm income, livelihood perceptions, farmer group membership, contract, credit, and personality traits (self-perceived risk aversion, time preferences, and trust). Variables used for background and description include tomato production, scale and causes of tomato damage and loss, biowaste management practices, and previous experience with biochar. The livelihood index was measured as the average score on a Likert scale from 1 (very inadequate) to 5 (very adequate) in the questions in which respondents were asked to rate their household’s ability to meet the needs related to food availability, health expenses, clothing, school fees, transport, housing, and festivities. The asset index counts ownership of several assets, including various vehicles, agricultural machinery and tools, electronics, furniture, and home appliances. Value chain participation measures the type of buyer and whether the farmer has a written contract with the main buyer before harvest. For validation, participants were asked to evaluate the content of the videos based on three statements shown in Table A1 in the Appendix and to express their climate change beliefs, perceptions and experience, and trust in how well they and different actors are dealing with the consequences of climate change.

Expert review, pilot testing, and post-pilot revision contributed to strengthening the questionnaire (Dillman et al. 2014). The experimental protocol and survey instruments were pilot-tested among tomato farmers, after which item wording, sequencing, and value ranges were refined. The five-point Likert scale was selected because it is cognitively manageable in field settings, reduces respondent burden, and provides sufficient variation for attitudinal measurement (Revilla et al. 2014). Expanding response categories beyond five or six does not automatically provide better measurement quality (Lietz 2010).

3.6 Ethical considerations

The intervention videos were informative in nature without misguiding, sensitive, offensive, or otherwise harmful elements. They can be considered as an infographic with a voiceover chosen to ensure that also illiterate respondents could participate and that the same information is delivered consistently to all participants, without accidental modifications of content when experimenters deliver information in person over the course of several experimental sessions.

All participants were verbally informed by the fieldwork supervisor about the purpose of the study and its expected relevance and contribution to society. It was explained that confidentiality of responses was ensured and that participation was voluntary. Informed oral consent was obtained before showing the videos, and written consent was obtained during the survey. Only the respondent and the research team know treatment allocation. The survey was administered in person, assuring privacy, such that other participants could not see or hear the respondent's answers.

4 Empirical analysis

Descriptive analysis was performed to report the characteristics of tomato farmers across study arms. To check whether covariates were balanced by the study arm, joint orthogonality was tested using multinomial logit with the treatment assignment variable regressed on key respondent characteristics. The likelihood ratio Chi-2 test was used to assess the sample balance. The estimations were based on the following regression:

$$Y_{it} = \alpha + \beta_1 T_1 + \beta_2 T_2 + \varepsilon$$

where Y_{it} denotes one of the following dependent variables: WTP for the collective and individual conversion of tomato biowaste to biochar, contribution in the PGG, beliefs about efficacy (personal or collective), and acceptance of circular economy and biowaste management policies. The key variable of interest is the randomization into study arms, that is, if a respondent has been assigned to watch the individual treatment video (T_1), the collective treatment video (T_2), or the control group (placebo) video. β_1 is the effect of watching the individual treatment video relative to the control group, while β_2 is the effect of watching the collective treatment video relative to the control group. ε is a random error term. An augmented specification includes a vector of control variables shown in Table 1.

For binary dependent variables, a logistic regression was implemented, and average marginal effects were reported. For continuous dependent variables, ordinary least squares (OLS) were used. All estimations include robust standard errors. Wald Chi-2 test was used to compare the size of coefficients of the collective and individual treatment variables. Given many outcomes, estimates require adjustment for multiple hypothesis testing, which is done using sharpened two-stage Q-values (Benjamini et al. 2006) as described in Anderson (2008). The interpretation of Q-values is the same as for p-values. The Q-values in the regression analysis adjust for 18 outcomes and two different treatments tested together in specifications with controls.

5 Results

Table 1 shows the main sociodemographic characteristics for the whole sample and by study arm. Each group comprises one third of the total sample. The number of female participants is notably smaller than the number of male participants. Around 80% of the respondents are married and almost all (96%) have attended at least some school. In addition to tomato farming, 40% of the participants also have non-farm income. The mean age among the respondents is 45 years, while the mean household has five members. The p-values from the Chi-2 test for joint orthogonality of covariates indicate that these key sociodemographic characteristics do not significantly explain the assignment to any of the trial arms, but some of the additionally considered variables do, including livelihoods, assets, type of buyer, risk and time preferences, and trust.

Table 2 shows an overview of tomato biowaste management practices for the whole sample and by the study arm, differentiating between tomato that has been damaged before or during harvest and tomato waste originating from stems, leaves, and branches of the tomato plant. Damaged tomatoes are mainly used as animal feed (81%), while some are composted (44%). Selling damaged tomatoes is not widespread, as it applies only to 18% of the sample. The waste from the tomato plant is also used as animal feed (64%) and compost (48%), but more than half of respondents leave it in the field (59%). Both treatment groups have a higher rate of waste conversion to compost and animal feed, but also biowaste burning. With an average of 1%, conversion of tomato waste to biochar is very rare in Kenya, and at 3%, its use is not widespread either.

Table 3 shows an overview of respondents' beliefs, as well as perceptions and experiences with climate change. Across all variables, the average score is above 4 (from a maximum of 5), indicating a very high likelihood that the respondents are not only perceiving, but also experiencing adverse effects of climate change. All three measures of climate beliefs have high mean scores. Consequently, the climate change belief index also has a high mean value (4.52). At 4.38, the climate change impact perceptions index has only a slightly lower mean. Both treatment groups have stronger beliefs about global warming, while the control group has stronger concerns about negative consequences of climate change. There are no significant differences between groups in terms of reduced tomato output and negative livelihood impacts of climate change. Respondents are, on average little convinced that various actors are adequately dealing with climate change. On average, respondents trust their own climate-related actions (3.43) more than the government's (2.70).

Table 4 shows the mean values of the outcome variables for the entire sample and by study arm. Variables measuring the extent of policy support for conversion of tomato waste to biochar show substantial variation. A policy that would introduce a subsidy for the conversion of tomato biowaste to biochar received the highest support score, while a policy that would require a fee from participants for conversion of biowaste to biochar received the lowest support score. Donation in the PGG has a mean value of 5.67 points (567 KSh), indicating that the respondents were comfortable contributing slightly more than half of their endowment to the collective biochar facility. As expected, the highest average value is observed in the collective treatment group.

In terms of monetary WTP, 86% of the amounts for collective and 77% of the amounts for individual biochar production were accepted. Acceptance of the proposed values for the labor contribution ranges from 94% for the individual to 98% for the collective biochar facility. Depending on the study group, the monetary WTP values range from 7,183 to 7,623 KSh for the collective biochar conversion (around 10% of the revenue from tomato farming) and from 13,144 to 14,485 KSh for the individual biochar conversion (around 17% of revenue). The labor WTP values range from 6.03 to 6.31 for collective (about 11% of total labor dedicated to tomato farming) and from 11.68 to 11.95 days per year for individual biochar production (about 22% of total labor). The respondents showed a high degree of agreement with the statements on efficacy and outcome expectancy, with mean values between 4.24 and 4.46. The mean value for personal self-efficacy is slightly higher than the average value for collective efficacy, whereas the opposite holds for outcome expectancy.

Table 5 shows that the mean support score for policies stipulating enforced biowaste conversion, financial contribution, and a conversion subsidy was significantly higher in both treatment groups compared to the control group in estimations without additional controls, as shown in columns (3), (5), and (7). The results with added controls are aligned. Comparing the two treatments, the results show that only in the case of the conversion subsidy did collective video treatment have a significantly higher effect compared to the individual video treatment (Wald Chi-2 p-value = 0 in column (8)). Collective treatment increased the subsidy support by 0.46 points (10% of the mean value of the score for the subsidy variable). The combined score for the four policies considered is also significantly higher in the collective than in the individual treatment group, both of which are significantly higher than the score in the control group, as shown in column (10).

As shown in column (2) in Table 6, the PGG donation in the collective treatment group was significantly higher than what the control and individual treatment groups were willing to contribute. The results indicate that the participants in the collective treatment group were willing to contribute 0.73 points (73 KSh) to the public good (defined as a collective biochar processing facility) more than the control group (Q-value = 0.009). In terms of WTP, the results indicate a 15 percentage point higher WTP for individual biochar production among the respondents in the individual treatment, which is significantly different from both the collective treatment and the control group (Wald Chi-2 p-value = 0.049), as shown in column (6).

Table 7 shows that collective treatment had a positive impact on collective efficacy, shown in column (2). Both treatments had a positive impact on personal self-efficacy, shown in column (4). The size of the coefficients in the two groups is not statistically different, as indicated by the high Wald Chi-2 p-values. Both treatments positively and significantly affected the outcome expectancy. In the case of collective outcome expectancy, the two videos performed equally (Wald Chi-2 p-value = 0.239 in column (6)). However, in the case of the personal outcome expectancy, the individual video had a stronger effect (Wald Chi-2 p-value = 0.028 in column (8)). The results indicate that the participants in the individual video treatment evaluated their personal outcome expectancy by 0.45 points higher than the participants in the control group, which is around 10% of the mean value of the personal outcome expectancy variable.

6 Discussion

This study shows that, compared to the control group, both video-based information treatments increased support for policies regulating the conversion of tomato biowaste to biochar. Collective treatment elicited broader support for a conversion subsidy and collective action, while individual treatment resulted in a higher WTP for individual biowaste conversion to biochar, operating through higher personal outcome expectancy. H1 is partially confirmed given the significant effect across some and not all policy support outcomes (sub-hypotheses H1b-H1d), PGG contributions (H1e), collective (H1h) and personal self-efficacy (H1i), as well as collective (H1j) and personal outcome expectancy (H1k). Likewise, H2 is partially confirmed, as significant effects were detected with respect to two policy support variables (H2b and H2c), individual monetary WTP (H2g), personal self-efficacy (H2i), and collective (H2j) and personal outcome expectancy (H2k). These results provide broad support for the expectation that information about biochar and benefits of its adoption increases farmers' openness to this circular economy practice. These results are consistent with earlier studies that highlight the relevance of additional information for biochar adoption among farmers (Hounnou et al. 2024; Soriano Ynfante et al. 2024). They are also consistent with the prediction from social cognitive theory that information reducing uncertainty about feasibility and returns strengthens both perceived efficacy and behavioral intentions (Bandura 1986).

Further, H3 and H4 are also partially confirmed, as a significant effect was detected for biochar conversion subsidy (H3d), PGG contributions (H3e), individual monetary WTP (H4g) and personal outcome expectancy (H4k). These results reveal meaningful heterogeneity in how collective and individual framing shape outcomes through distinct channels. Collective framing operates primarily through collective efficacy, social norms and the collective identity channel. Indeed, the social capital (trust) score is higher in the collective treatment than in the two other groups, as shown in Table 1. By emphasizing shared responsibility and cumulative national-scale impacts, collectively oriented information strengthens cooperative behavior and legitimizes policy-based responses, as evidenced by the significantly higher PGG donations and support for a conversion subsidy. This resonates with earlier studies on preferences for agricultural waste recycling subsidies (Danso et al. 2006; He et al. 2016). This pattern aligns with Dewaelheyns et al. (2025), who found the collective framing more effective for climate policy acceptance. Individual framing, by contrast, works through perceived personal efficacy and outcome expectancy, producing significantly higher monetary WTP for own-farm production. This pattern aligns with Grelle et al. (2024), who found a positive effect of individually framed interventions on sustainable behavior.

One puzzle is why the information treatments substantially shifted policy acceptance while achieving limited impact on WTP. The broad acceptance of the idea of contributing to biochar conversion and the limited impact on individual monetary WTP suggest that WTP related to common goods is not moved by information about collective gains from the circular economy, which could be a consequence of difficulties related to accurately assessing actual personal gains related to the collective effort. The PGG framework is clearer in that regard, which could explain the significant impact of collective treatment there. Competing explanations such as liquidity and labor availability constraints could also play a role (Magruder 2018). However, the results reveal a high acceptance rate of both monetary and labor WTP values. Although randomization of WTP values was orthogonal to randomization into treatment and control groups, most respondents in the individual treatment group were asked if they would accept the lowest monetary WTP value. As shown in Figure 3, 89% of respondents accepted the lowest and 64% the highest individual monetary WTP value. These values are 94% and 80% in the case of the collective monetary WTP, while the labor WTP values had acceptance rates of above 90% across groups (Table 4). Overall, the acceptance rates and values do not differ much between groups, suggesting that a restricted range of WTP values prevented detectable variation between group means.

The results also reveal a gap between stated willingness and actual behavior: whereas 77% of farmers accepted proposed monetary contributions for biochar conversion, only 3% currently use it, and only 1% currently produce it. While a lack of knowledge cannot be excluded, this gap could plausibly reflect the absence of structural conditions, technical support, and coordinating institutions, indicating an implementation rather than a motivation problem. Indeed, earlier studies highlight that it is important to teach farmers how to produce and use biochar, as the technology is not trivial and requires significant learning effort (Veronesi et al. 2015; Soriano Ynfante et al. 2024), which could be met with a systematic effort among policymakers and agricultural development agencies (Hounnou et al. 2024). The high climate change belief and impact perception scores provide contextual grounding for this finding. Farmers in this sample are not skeptical of environmental problems and are experiencing them; naturally, they want to take action against these problems. That collective framing increased acceptance even of cost-imposing policies under conditions where the current approach of the government towards mitigating climate change is not trusted strengthens the finding that framing operates through normative channels rather than through persuasion about government competence. This has direct implications for government, private, or NGO interventions aimed at introducing circular economy practices in rural areas: the issue is not persuasion; it is access and knowledge.

In terms of internal validity, the measures are in line with expectations from earlier literature. The PGG result where participants contribute about half of the endowment is consistent with one-round PGGs (e.g., Ledyard 1995) and with the initial contributions in repeated PGG designs (Fehr and Gächter 2000). The study recorded only slightly lower values of climate change concerns (4.51 in the climate change beliefs index) compared to a study in Belgium (4.63) (Dewaelheyns et al. 2025). The WTP measures from other studies for the specific product considered in this study do not exist, so the comparison is made with methodologically and conceptually related studies focused on different products. Compared to an agri-waste removal study in Ethiopia (Atinkut et al. 2020), individual WTP values in this study are substantially higher; e.g., compare the mean annual WTP of 11.75 days (73 KSh) in this study with 6.84 labor days (8.20 Birr or about 39 KSh in 2025) in Ethiopia. Furthermore, in countries such as China (He et al. 2016) and Ghana (Danso et al. 2006), households expect compensation for the removal or recycling of agricultural waste.

One limitation of the experimental design is that the collective and individual framing differed in terms of both the pronouns used and numerical magnitudes. Although such an approach may improve external validity by more closely approximating real-world communication strategies, the study estimates the combined effect of multiple framing elements rather than the independent effect of any specific component, a common challenge in framing experiments (Chong and Druckman 2007). Future studies are needed to disentangle the separate effects of linguistic framing, numerical scale, and anchoring mechanisms on attitudes toward circular economy technologies. While the study covers eight counties representing diverse agroecological and socioeconomic contexts, external validity is bounded by the focus on tomato farmers with specific biowaste characteristics and economic incentives, and by the between-subject design, which captures immediate post-treatment effects without observing whether attitudinal shifts persist or translate into behavior over time. Whether the framing advantage for collective messaging holds in settings with weaker community institutions or lower baseline social trust remains an open question.

Beyond the specific context of biochar production, the findings contribute to broader debates on climate communication and collective action. The results suggest that support for environmental policies can be strengthened when communication emphasizes shared societal benefits rather than only private gains (Dewaelheyns et al. 2025). This finding extends evidence from climate policy research to circular economy adoption in smallholder agricultural systems (Peng et al. 2025). From a practical perspective, governments, development agencies, and farmer organizations may achieve greater acceptance of the circular economy initiatives by combining technical information with messages that highlight collective environmental and economic benefits. These lessons are likely relevant beyond Kenya and may apply to other low- and middle-income countries seeking to scale circular economy technologies as part of climate adaptation and mitigation strategies.

7 Conclusion

This study examined the impact of information provision on smallholder farmers' acceptance of circular economy policies and practices. Framed around biochar production from tomato biowaste, the study employed collectively and individually framed randomized video interventions among tomato farmers in Kenya. The results show that providing information about biochar production generally increases policy support. However, collective narratives produced higher contributions in a PGG defined as investing in shared infrastructure for biochar production. Conversely, individual framing strengthens monetary WTP for individual biochar production, achieved through higher personal outcome expectancy. Resolving barriers concerning distributional fairness appears to be crucial for choosing collective solutions. This indicates that while information is key to policy support, the specific level of the policy framing (individual vs. collective) also has an impact on circular economy practice uptake. The findings of this study indicate that policies for public goods such as reducing climate impact and engaging in climate mitigation practices can realistically achieve broad support.

This study contributes to the literature on information-based interventions and the adoption of circular economy practices. It demonstrates that collective and individual message framing have distinct impacts on smallholder farmers' support and WTP for the conversion of biowaste into biochar. This extends social-cognitive theory (Bandura 1986) by showing that the pathway through which information operates is itself shaped by its presentation. Whereas collectively oriented messages more effectively strengthen legitimacy for shared and policy-based responses, individually oriented messages are more closely tied to personal outcome expectancy and own-farm willingness to act. This is highly relevant in smallholder contexts where green technologies often combine private returns with public-good characteristics.

Programs seeking to scale biowaste-to-biochar systems should not rely on generating awareness alone; communication strategies need to be paired with support, implementation, financing, and coordination mechanisms that address the constraints faced by smallholder farmers. Future research should explore these specific policy levers by isolating specific message components. Moreover, experimental evidence that tracks real-world efficacy and policy support over time can provide further evidence of the willingness to adopt different circular economy practices.

Parsing out actual policy compliance from indicated WTP or policy acceptance is a key challenge of future research on circular economy in SSA. Future research should consider employing trials that measure demand for biochar made from tomato biowaste in SSA. This could include field tests where biochar is made available to farmers, which allows future research to measure actual adoption of biochar and/or other circular economy practices.

Pairing this with measurements of the effects of biochar produced from tomato biowaste on crop productivity would provide further scientific evidence of biochar's use on smallholder farms.

Tables

Table 1 Sample characteristics

	(1) All	(2) Control	(3) Collective	(4) Individual	(5) All	(6) Control	(7) Collective	(8) Individual
Female	0.29	0.31	0.29	0.28	0.29	0.31	0.29	0.28
Married	0.81	0.81	0.83	0.81	0.81	0.81	0.83	0.81
Schooling	0.96	0.98	0.94	0.96	0.96	0.98	0.94	0.96
Off-farm income	0.40	0.42	0.35	0.44	0.40	0.42	0.35	0.44
Age	45.10	44.87	46.33	44.15	45.10	44.87	46.33	44.15
Household size	5.01	4.91	5.17	4.96	5.01	4.91	5.17	4.96
Land area					4.94	5.27	4.51	5.01
Livelihood assessment index					3.37	3.57	3.43	3.12
Asset index					4.95	4.63	5.05	5.18
Farmer organization member					0.47	0.48	0.57	0.37
Sells to brokers					0.71	0.76	0.71	0.66
Sells to collectors					0.38	0.31	0.45	0.39
Sells to other households					0.13	0.18	0.10	0.10
Risk taking					6.67	7.18	6.46	6.35
Time preference					7.48	7.27	7.77	7.41
Trust					3.52	3.47	3.63	3.48
Sample share						0.34	0.34	0.33
Wald Chi-2 p-value	0.528				0.000			

Table 2 Biowaste management practices

	(1) All	(2) Control	(3) Collective	(4) Individual	(5) Kruskal-Wallis p-value
Damaged tomato as feed	0.81	0.73	0.84	0.87	0.042
Damaged tomato as compost	0.44	0.20	0.66	0.46	0.000
Sells damaged tomato	0.18	0.10	0.24	0.22	0.040
Throws tomato waste together with other household waste	0.20	0.13	0.40	0.09	0.000
Burns tomato waste	0.31	0.24	0.42	0.28	0.009
Tomato waste as feed	0.64	0.58	0.61	0.73	0.021
Tomato waste as compost	0.48	0.23	0.66	0.55	0.000
Tomato waste as biogas	0.02	0.01	0.05	0.01	0.710
Dries tomato waste	0.23	0.19	0.33	0.18	0.029
Tomato waste left on the field	0.59	0.54	0.56	0.65	0.156
Makes biochar from tomato waste on own farm	0.01	0.00	0.03	0.01	0.883
Makes biochar from tomato waste at a collective facility	0.01	0.00	0.03	0.00	0.809
Using biochar	0.03	0.02	0.03	0.02	0.971

Table 3 Climate change beliefs, perceptions and experience climate

	(1) All	(2) Control	(3) Collective	(4) Individual	(5) Kruskal-Wallis p-value
Climate change beliefs index	4.52	4.43	4.46	4.66	0.000
Climate change is happening now	4.52	4.44	4.36	4.75	0.000
The main causes of global warming are human activities	4.43	4.35	4.40	4.52	0.018
Global warming will have negative consequences	4.61	4.51	4.62	4.70	0.028
Climate change impact perceptions index	4.38	4.47	4.27	4.38	0.000
The long-term changes in climate conditions ...					
... hurt tomato output	4.49	4.57	4.36	4.52	0.001
... hurt tomato quality	4.43	4.53	4.27	4.49	0.000
... reduce income from tomato farming	4.48	4.48	4.43	4.51	0.314
... make water for irrigation scarcer	4.36	4.46	4.25	4.36	0.005
... make water for domestic or other production uses scarcer	4.24	4.42	4.11	4.19	0.001
... decrease food security in my household	4.27	4.40	4.18	4.23	0.019
... negatively impact the livelihood of my household	4.37	4.42	4.29	4.39	0.102
Climate change actor trust index	3.04	3.07	2.98	3.06	0.144
Trust that ...					
... government deals well with the consequences of climate change	2.70	2.78	2.68	2.65	0.353
... private companies deal well with the consequences of climate change	2.77	2.83	2.71	2.76	0.434
... scientists deal well with the consequences of climate change	3.25	3.28	3.14	3.32	0.301
... other farmers deal well with the consequences of climate change	3.04	3.10	2.99	3.03	0.522
... you deal well with the consequences of climate change	3.43	3.36	3.39	3.55	0.110

Table 4 Mean values of outcome variables by study arm outcome

	(1) All	(2) Control	(3) Collective	(4) Individual	(5) Kruskal-Wallis p-value
Policy support					
Policy assessment index	3.90	3.63	4.13	3.96	0.000
Disposal prohibited	4.10	4.02	4.13	4.15	0.250
Conversion enforced	3.93	3.73	4.10	3.98	0.001
Financial contribution	3.15	2.56	3.61	3.31	0.000
Subsidy	4.42	4.22	4.68	4.38	0.000
PGG	5.67	5.48	6.13	5.43	0.005
Monetary contribution					
Collective WTP value accepted	0.86	0.87	0.87	0.86	0.969
Collective WTP value (KSh)	7,425	7,623	7,183	7,452	0.557
Individual WTP value accepted	0.77	0.71	0.79	0.83	0.135
Individual WTP value (KSh)	13,900	13,144	14,485	14,033	0.284
Labor contribution					
Collective WTP value accepted	0.98	0.98	0.99	0.98	0.985
Collective WTP (days)	6.17	6.31	6.15	6.03	0.670
Individual WTP value accepted	0.94	0.91	0.97	0.96	0.562
Individual WTP (days)	11.78	11.72	11.95	11.68	0.905
Efficacy					
Collective efficacy	4.24	4.17	4.34	4.22	0.025
Personal self-efficacy	4.46	4.34	4.50	4.53	0.007
Outcome expectancy					
Collective outcome expectancy	4.45	4.26	4.53	4.57	0.000
Personal outcome expectancy	4.33	4.13	4.38	4.50	0.000

Table 5 Regression results for policy acceptance

	Disposal prohibited		Conversion enforced		Financial contribution		Subsidy		Policy assessment index	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Collective	0.106	0.114	0.372***	0.404***	1.054***	1.055***	0.467***	0.462***	0.500***	0.509***
	(0.107)	(0.112)	(0.113)	(0.122)	(0.153)	(0.164)	(0.080)	(0.085)	(0.076)	(0.083)
		[0.269]		[0.003]		[0.001]		[0.001]		[0.001]
Individual	0.128	0.102	0.258**	0.306**	0.756***	0.819***	0.161**	0.148*	0.325***	0.344***
	(0.105)	(0.111)	(0.114)	(0.125)	(0.140)	(0.157)	(0.082)	(0.088)	(0.076)	(0.083)
		[0.290]		[0.021]		[0.001]		[0.124]		[0.001]
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Mean dep. var.	4.10	4.10	3.93	3.93	3.15	3.15	4.42	4.42	3.90	3.90
Wald Chi-2 p-value	0.840	0.914	0.311	0.361	0.053	0.142	0.000	0.000	0.032	0.034
Obs.	540	540	540	540	540	540	540	540	540	540
R^2	0.00	0.07	0.02	0.13	0.09	0.13	0.06	0.14	0.07	0.17

Note: Standard errors in parentheses. Q-values in brackets. $^{*}\ p < .1$, $^{**}\ p < .05$, $^{***}\ p < .01$.

Table 6 Estimates of collective and individual WTP

	Public goods game		Collective monetary WTP		Individual monetary WTP		Collective labor WTP		Individual labor WTP	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Collective	0.649***	0.726***	-0.004	-0.011	0.076*	0.064	0.005	0.006	0.062**	0.041
	(0.251)	(0.257)	(0.036)	(0.038)	(0.046)	(0.048)	(0.012)	(0.009)	(0.025)	(0.025)
		[0.009]		[0.492]		[0.181]		[0.510]		[0.125]
Individual	-0.048	0.133	-0.015	0.011	0.119***	0.145***	-0.006	-0.006	0.047*	0.033
	(0.227)	(0.238)	(0.036)	(0.036)	(0.044)	(0.043)	(0.014)	(0.013)	(0.026)	(0.027)
		[0.425]		[0.510]		[0.002]		[0.372]		[0.181]
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Wald Chi-2 p-value	0.002	0.013	0.771	0.536	0.310	0.049	0.439	0.241	0.442	0.743
Obs.	540	540	540	540	540	540	540	540	540	540

Note: Standard errors in parentheses. Q-values in brackets. $^{*}\ p < .1$, $^{**}\ p < .05$, $^{***}\ p < .01$.

Table 7 Regression results for self-efficacy and outcome expectancy

	Collective efficacy		Personal self-efficacy		Collective outcome expectancy		Personal outcome expectancy	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Collective	0.174**	0.199***	0.164***	0.191***	0.268***	0.316***	0.247***	0.293***
	(0.069)	(0.075)	(0.061)	(0.064)	(0.065)	(0.071)	(0.068)	(0.069)
		[0.013]		[0.006]		[0.001]		[0.001]
Individual	0.054	0.131	0.192***	0.270***	0.311***	0.391***	0.374***	0.447***
	(0.074)	(0.081)	(0.060)	(0.065)	(0.060)	(0.068)	(0.066)	(0.071)
		[0.128]		[0.001]		[0.001]		[0.001]
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Mean dep. var.	4.24	4.24	4.46	4.46	4.45	4.45	4.33	4.33
Wald Chi-2 p-value	0.132	0.418	0.650	0.222	0.480	0.239	0.061	0.028
Obs.	540	540	540	540	540	540	540	540
R^2	0.01	0.06	0.02	0.09	0.05	0.12	0.06	0.16

Note: Standard errors in parentheses. Q-values in brackets. $^{*}\ p < .1$, $^{**}\ p < .05$, $^{***}\ p < .01$.

Figures

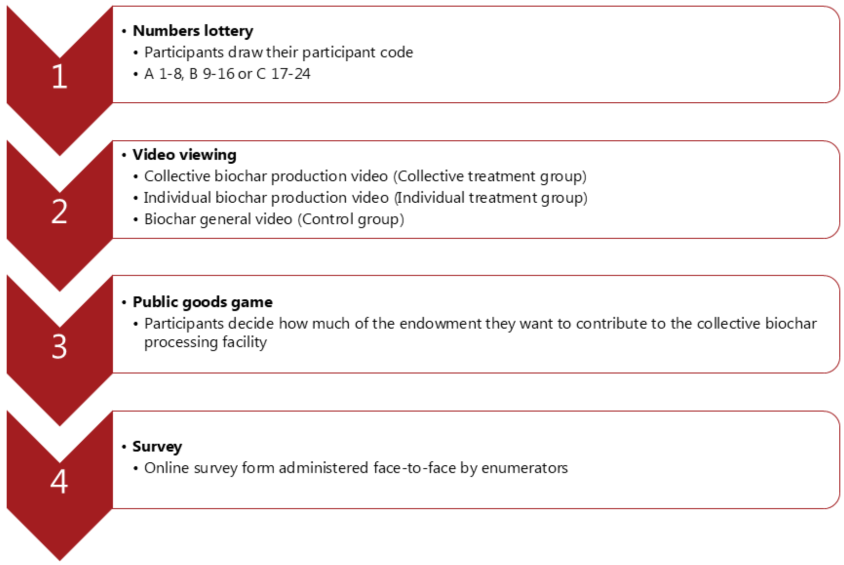

Figure 1 Overview of the study design

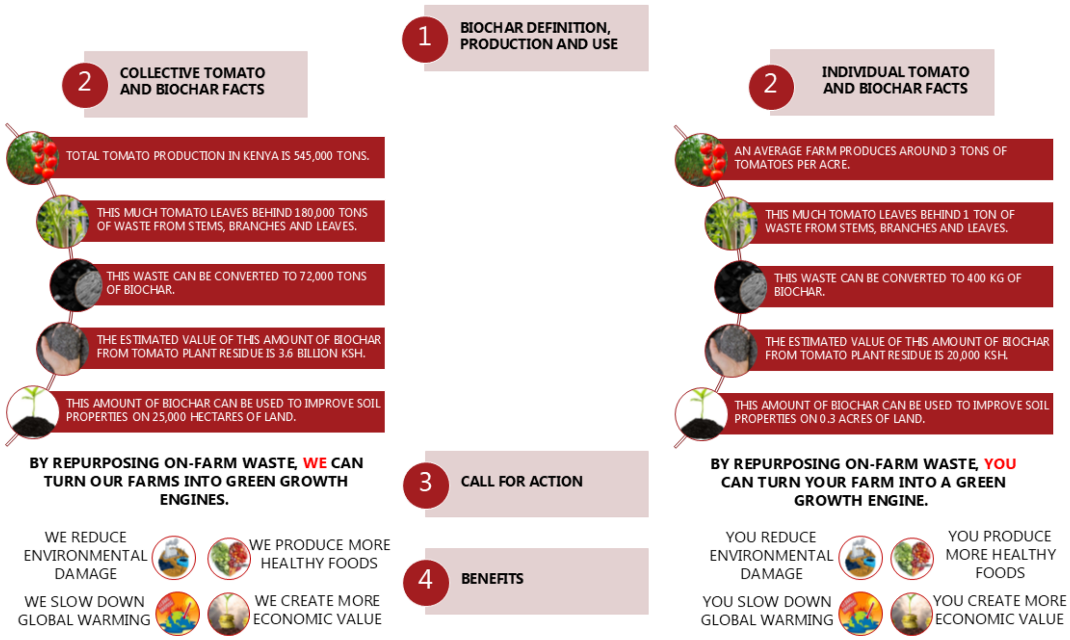

Figure 2 Information presented in treatment videos

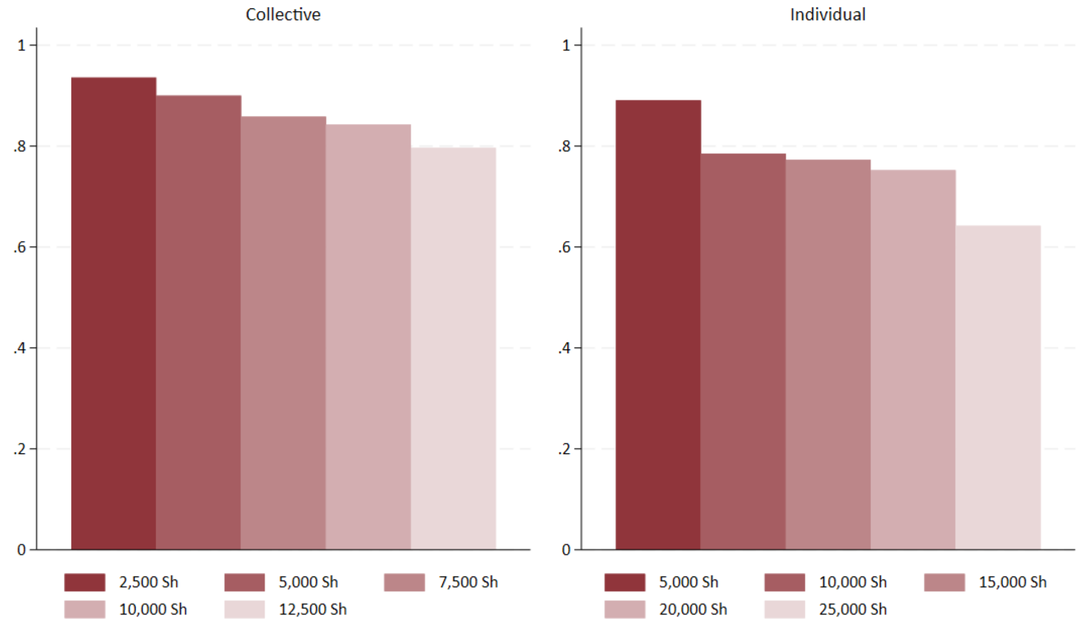

Figure 3 Proportion willing to pay for biochar production

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Appendix

Table A1 Mean values of video evaluation

	(1) All	(2) Control	(3) Collective	(4) Individual	(5) Kruskal-Wallis p-value
The video …					
… showed me benefits of tomato biowaste conversion to biochar	4.50	4.45	4.37	4.69	0.000
… makes me think about negative consequences of a lot of tomato biowaste	3.96	3.51	4.12	4.27	0.000
… makes me consider tomato biowaste conversion to biochar	4.48	4.38	4.43	4.62	0.000

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