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A future design social experiment for sustainable agricultural production

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Abstract

Sustainable agricultural production (SAP) is essential to make food systems sustainable through increasing crop yields and reducing environmental hazards in the long run. However, little research has been conducted on policies or futures-studies approaches for a persistent change in food production towards SAP. This study utilizes a future design (FD) approach where people are asked to think of a vision, a mission and a strategy for problem solving through taking a perspective of future generations, investigating a research question "how does FD affect fertilizer practices for food production?," and the hypothesis "FD induces a persistent change in farmers' productions towards SAP." We design a double-round social experiment with four treatments of "baseline," "visioning," "one-person FD (OFD)" and "group FD (GFD)," collecting data on organic and inorganic fertilizer practices from 400 family farms in Bangladesh over five months. Family farms in baseline report fertilizer practices. In visioning, they additionally deliberate with their family members to have a vision, a mission and a strategy. In OFD and GFD, they additionally take each perspective of past, present and future generations in a person and in a group of family farm's members, respectively, then deliberating and thinking of the same issues. The results demonstrate that GFD induces family farmers to a more sustained increase (decrease) organic (inorganic) fertilizer practices than do any other treatment, and the magnitude under GFD is almost twice as much as those under visioning or OFD. Thus, it is advisable that applying FD to a group of people is the most effective for sustained changes of farming productions towards SAP, potentially due to sympathy, empathy and peer effects among group members sharing the same vision, mission and strategy.

Keywords: Future design; visioning; organic & inorganic fertilizer; social experiment; Bangladesh

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Contents

Nomenclature

BDT Taka, Bangladeshi currency

CFP Compost fertilizer production

FD Future design

GFD Group future design

GLM Generalized linear model

GOs Government organizations

GSEM Generalized structural equation model

IFA Inorganic fertilizer application

LL Log likelihood

LP Log pseudolikelihood

MAPE Mean absolute prediction error

ME Marginal effect

MSE Mean square error

NGOs Non-governmental organizations

OFA Organic fertilizer application

OFD One-person future design

OLS Ordinary least square

RAs Research assistants

SAP Sustainable agricultural production

1 Introduction

Agricultural systems face the challenge of increasing food production to meet the needs of a growing population without damaging the environment. This challenge is further exacerbated by modern agriculture that depends on inorganic fertilizer to achieve high yields, posing a significant threat to environment and human health (Wu, 2011, Zhang et al., 2013, Smith and Siciliano, 2015, Walling and Vaneeckhaute, 2020). To cope with this situation, there is an urgent need to prioritize sustainable agricultural production (SAP) as a means of fulfilling the needs of present generation, safeguarding the environment and ensuring a balance between current and future generations. Numerous studies document that prospective thinking and experiences related to future events and future generations affect people's ways of thinking and strategies, influencing their decisions and behaviors not only for the betterment of their own future but also for upcoming generations (Schacter et al., 2012, Szpunar et al., 2014, González-Ricoy and Gosseries, 2016, Corcoran et al., 2017, Lalani et al., 2023). This study utilizes a future design (FD) approach where people are asked to think of a vision, a mission and a strategy for problem solving through taking a perspective of future generations and examines its effectiveness for a persistent change in food production towards SAP by conducting social experiments.

Sustainable agriculture aims to achieve sustained production, maintain quality, ensure ecological soundness and uphold socioeconomic viability by conserving natural resources and promoting self-regulation and evolution for the benefit of all (OFPA, 1990, Neher, 1992, Velten et al., 2015, Begho et al., 2022). The concept SAP has emerged recently, being defined as a system that seeks to maintain long-term food production and quality without increasing the demand of chemical inputs (Imadi et al., 2016, Selvakumar et al., 2018, Karmakar et al., 2020). The use of organic fertilizers significantly contributes to the production and environmental aspects, making it an economically and environmentally feasible practice for acheiving SAP (Behera, 2009, Wang et al., 2018, Yang et al., 2021, Li et al., 2022, Wang et al., 2022b, Xiang et al., 2022, Das et al., 2023, Fan et al., 2023). A shift from inorganic fertilizers to organic ones or a minimal use of inorganic fertilizers with organic ones has received great attention for keeping high yields and quality as well as protecting the environment (Islam et al., 2017, Liu et al., 2021, Troza et al., 2021, Abdalla et al., 2022, Jin et al., 2022, Wang et al., 2022a, Yimer, 2022). Overall, SAP is established to be crucial for ensuring sustained production and addressing environmental issues on a global scale.

A series of studies investigates two distinct cognitive processes of human behaviors to comprehend how people make decisions and change behaviors (Kahneman and Frederick, 2007, Hofmann et al., 2009, Evans and Stanovich, 2013). One process is an automatic governed by implicit cognitions and habitual activities retrieved from associative memory, resulting in quick and unconscious responses, while the other process is a deliberative regulated by cognitive thought, logical understanding and reflection on the future, leading to slow and conscious responses (Strack and Deutsch, 2004, Daniel, 2017, Hagger, 2019). The automatic processes, such as nudging strategies, can influence farmers' behaviors, although the effects tend to be limited in the short run (Blumenthal-Barby and Burroughs, 2012, Kuhfuss et al., 2016b, Pellegrin et al., 2018, Ferrari et al., 2019, Kaufman et al., 2021, Wuepper et al., 2023). Duflo et al. (2011) conduct an experiment demonstrating that a time-bound discount nudge effectively increases fertilizer application among small-scale farmers without influencing their investment decisions or promoting overuse of fertilizers. Kuhfuss et al. (2016a) show that implementing a conditional collective bonus nudge enhances farmers' participation rate in agri-environmental contracts, fostering their pro-environmental behaviors. On the other hand, the deliberative processes, such as informational strategies, have significant impacts on shaping and altering people's decisions and behaviors, while the long-term effects are not well documented (Allcott and Rogers, 2014, Masset and Haddad, 2015, Steg and Nordlund, 2018, Abrahamse and Matthies, 2018, Peth et al., 2018, Abrahamse, 2020, 2023). For example, Lokhorst et al. (2010) finds that tailored information along with public commitment effectively encourages farmers to enhance the environmental quality and biodiversity of their land. However, long-term behavioral changes can be achieved through development of habits, shifts in mental cognition, ongoing social interactions and future benefit assessments in deliberative cognitive processes (Rogers and Frey, 2015, Volpp and Loewenstein, 2020).

Future-studies approaches such as visioning, backcasting and scenario planning have been advocated in the past few decades to envision and plan about anticipated futures, providing insights and opportunities for changing behaviors and strategies through logic-based reasoning (Swart et al., 2004, Bell, 2009, Phdungsilp, 2011, Amer et al., 2013, Timilsina et al., 2020). Most of future-studies approaches utilize visioning methods to creat, assess and understand shared visions through logic-based reasoning among participants as well as to evalute their impacts for the betterment (Costanza, 2000, Van der Helm, 2009, Potschin et al., 2010, Wiek and Iwaniec, 2014). These approaches have been applied in various fields such as business, economics and resource management within a society to address problems sustainably (Chermack et al., 2001, Thorén and Vendel, 2019, Sandström et al., 2020). Recently, a new approach called "future design (FD)" has gained attention in research for its impacts on developing strategies and changing behaviors as demonstrated through experiments, although its long-term impact is yet to be fully established (Saijo, 2020a,b, Timilsina et al., 2020, Pandit et al., 2021). FD is a set of processes where people engage in a case-method material to understand the problem and think about it from the perspective of past, present and future generations (Nakagawa, 2020, Pandit et al., 2021, Mostafizur et al., 2024). After taking the future generations' standpoint, people make deliberation and request visions, missions and strategies about the problem for the present generation. Finally, they come back to the present standpoint and suggest their own visions, missions and strategies for the problem. The future ahead and back mechanism and intergenerational accountability are incorporated as components of FD to enhance sustainability (Shahen et al., 2021, Timilsina et al., 2023). MacAskill (2022) introduces the concept of "longtermism," advocating for the prioritization of future generations's interests, acknowledging that the current actions of present people profoundly affect future generations. Overall, FD provides a framework for tackling a problem by creating self accountability through visions, missions, strategies and perspective taking of past, present and future generations.

Previous studies have mainly concentrated on short-term behavioral changes while examining various interventions, both automatic and deliberative. Few studies have focused on sustained behavioral changes and documented how future-studies approaches influence people's behavior in the long run. Recently, some studies claim that the FD approach has a great potential to induce people long-term behavioral changes, as demonstrated by its short-term effects in understanding people's attitides and preferences toward sustainability, forestry and waste management for the betterment of future through lab and field experiments (Nakagawa et al., 2019, Pandit et al., 2021, Shahen et al., 2021, Timilsina et al., 2023). In this regard, we examine farmer's long-term behavioral changes in farming productions towards SAP by FD intervensions through the social experiments. Therefore, this study investigates a research question "how does FD affect fertilizer practices for food production?," and the hypothesis "FD induces a persistent change in farmers' productions towards SAP." We design a double-round social experiment with four treatments of "baseline," "visioning," "one-person FD (OFD)" and "group FD (GFD)," collecting data on organic and inorganic fertilizer practices from 400 family farms in Bangladesh over five months. To this end, answering the research question and hypothesis could be helpful in identifying the most effective intervention for sustained changes in farming productions towards SAP.

2 Methods

2.1 Survey area and sampling strategy

We conducted social experiments in the districts of Lalmonirhat, Rangpur, Tangail, Sylhet, Rajshahi, Mymensingh and Sherpur in northern and north-central parts of Bangladesh, as depicted in figure 1. A multistage sampling procedure was applied to select the required number of family farms. Initially, these seven districts were selected based on their prominence in high-yield vegetable crops in the north-central region of Bangladesh. Subsequently, 7 upazilas, 20 unions and 40 villages were purposively selected from each district to reflect the geographic and socioeconomic diversity, ensuring a comprehensive representation of different crop cultivations and agricultural practices across the districts. Finally, we randomly selected 10 family farms from each of the chosen villages, totaling 400, using a list of vegetable growers and random number generators with the assistance and support of agricultural officers from the Department of Agricultural Extension (see in figure 1). The social experiments were conducted with four treatments over two rounds during the period of September 2021 to January 2022. A randomization process was also followed when selecting the treatment groups by collectiong one-forth family farms to each of four treatments within each district. The first author administered social experiments & surveys, recruited and trained research assistants (RAs) for each aspect of family farms' recruitment, participation and data collection. The social experiments were executed with a real monetary incentive, a fixed participation fee of 2100 BDT to each family farm, aiming at encouraging participants to provide authentic information and actively engage in the experiments. The participating family farms do not know that they are the part of social experiments and the participation rate was approximately 80 %.[1] All family farms willingly participated, and family farm's heads played the main role in the experiments and answering questions, providing written consent signed at the beginning.

2.2 Experimental setup and procedures

Before starting social experiments, a training session related to compost fertilizer production was conducted to each of selected family farm, regardless of their assigned treatments. The training session was organized by the expert trainers who possess profound expertise in composting and fertilizer production processes to educate family farmers on fertilizer production using kitchen or other by-products. The expert trainers visited each family farm and provided hands-on training to family farmers and monitored them regularly. With the guidance and assistance of expert trainers, each family farm successfully produced compost fertilizer during the training period, taking approximately 1 month. After receiving the training, we categorize all family farms into four groups, each consisting of 100 family farms. The social experiments along with questionnaire surveys

[1] The participation rate is calculated by the ratio between the number of family frams that actually participated and the total number of family frams invited to the experiments.

were conducted to collect necessary information about cognitive & sociodemographic factors and fertilizer practices. For fertilizer practices, we collected total amount of compost fertilizer production (CFP), organic fertilizer application (OFA) and inorganic fertilizer application (IFA) over two-months in each round. Information regarding time invariant cognitive & sociodemographic information is collected, such as pre-konwledge of organic food & fertilizer, education, age, gender, family farm's income, family size and land size through questionnaire surveys before starting the experiments. For pre-knowledge variable, each family farm's head is asked 10 multiple-choice questions related to organic food & fertilizer, basically following Tison (2012) and Katirji (2017) (see supplementary material appendix A). The pre-knowledge score is measured by summing up all correct answers, ranging from 0 to 10.

In social experiments, we prepare four treatments: (i) Baseline (ii) Visioning (iii) One-person future design (OFD) and (iv) Group future design (GFD) to examine their effects on fertilizer practices as compared to baseline, consisting of the 1st and 2nd experimental intervensions between two treatment rounds (see figure 2). With this framework, we intend to know how future design (FD) induce a persistent change in farmers' productions towards sustainable agricultural production (SAP). In baseline, family farms are provided with a case-method material to help them understand the facts and engage more deeply with the problem. After that, RAs randomly visit family farms on two days each week and continuously record and report their CFP, OFA and IFA in the 1st and 2nd two-months over two treatment rounds. To facilitate continuous recording of CFP, OFA, and IFA data, RAs use a structured paper format that included written instructions and tables for documenting the dates and amounts of fertilizer production and application. In visioning, family farms additionally deliberate with their family members to have visions, missions and strategies about their food productions. In OFD and GFD, family farms additionally take each perspective of past, present and future generations in a person and in a group, respectively. After receiving experimental interventions in visioning, OFD and GFD, RAs also visit these farms and keep continuously recording and reporting their CFP, OFA and IFA in the 1st and 2nd two-months over two treatment rounds (see figure 2b).

The case-method material provides sufficient information about status & prospects of fertilizer usage and food production in Bangladesh. The material contains a story with visuals to illustrate the following three points: (i) the history of food production and the evolution of fertilizer usage, (ii) the present status of organic and inorganic fertilizer production and application along with their associated advantages & drawbacks and (iii) the reality of how important it is to change the existing fertilizer practices for the environment and sustainability (see supplementary material appendix B). This case-method material is delivered to each family farm through a video lecture along with handouts organized from various documents, including books, articles and reports (EPBS, 1958, Hossain, 1988, Rahman, 1999, Shah et al., 2008, Alam et al., 2011, Basak et al., 2015, Karim and Aktar, 2015, Lacerda et al., 2015, Sultana et al., 2015, Banglapedia, 2016, Rahman and Zhang, 2018, Alam, 2018, Knoema, 2020, Verma et al., 2020). This is line with future-studies approaches that effectively apply stories or narratives in their research (see, e.g., Robinson et al., 2011, Nakagawa et al., 2019, Pandit et al., 2021).

In visioning, family farm's heads are asked to write their initial suggestions of visions, missions and strategies for the improvement of farm's food productions after receiving the case-method material with a video lecture (see in figure 2b). Then, they are asked to make a group discussion with family members, such as father, mother, children, elders and others, to summarize the suggestions by taking the present standpoint for approximately 15 to 20 minutes. Finally, they are requested to write family farm's visions, missions and strategies as the final suggestions for the improvement. In OFD and GFD, after receiving the case-method material with a video lecture, family farm's heads and family farm's members are asked to write their food production systems in the past (2001), present (2021) and future (2041) for understanding different situations and expanding their thinking & viewpoints in a person and in a group, respectively. After taking the future standpoint, they are requested to think and write possible requests of visions, missions and strategies for food productions to the present generation, acting as future people living in 2041. Next, they are asked to make a group discussion with family members to summarize their requests. In OFD, during group discussion, only family farm's head takes the future standpoint and other members take the present standpoint, while in GFD, all family farm's members take the future standpoint. Finally, in OFD and GFD, they are asked to get back to the present standpoint and write their final suggestions of family farm's visions, missions and strategies for food productions, respectively. The procedures and comparison of four treatments are summarized in figure 2.

The social experiments were conducted at the participant's farms and they were informed a week in advance and asked to be present on a specified date and time. The experimental procedures were performed manually due to the lack of access to computers and other internet-connected devices in the study areas. In the beginning of the expeiments, RAs distributed all the necessary documents to family farms and explained experimemtal instructions in their native language (Bengali) (see supplementary material appendix C). During the experiments, family farms used traditional writing instruments, such as pens and papers, to address to each query. If thay had any questions regarding the experiments, RAs provided real-time assistance to answer them. We conduct 20 sessions in total and each session includes 20 family farms for the experimental interventions in baseline, visioning, OFD and GFD, taking approximately 30, 80, 100 and 100 minutes, respectively. After the 1st interventions, RAs randomly monitor each family farm through physical visits and observe their CFP, OFA and IFA processes & keeping records over the 1st two-months. Just before treatment round 2, the 2nd experimental interventions are made by following the same procedures used in the 1st experimental interventions as a followup session. After that, we keep recording and reporting family farms' CFP, OFA and IFA during the 2nd two-months over treatment round 2.[2] After completing two treatment rounds, the fixed participation fee is transfered to family farms through their bank accounts. Figure 3 shows a visual presentation of social experiments with figure 3a, figure 3b and figure 3c, depicting snapshots of family farm's active participation, fertilizer production and application, respectively.

[2]There are two seasons for vegetable cultivation in Bangladesh: Rabi or Winter season (October to March) and Kharif or Summer season (April to October). Social experimants were conducted during the Robi season, which is the main season for vegetable cultivation in Bangladesh. Most winter vegetables in Bangladesh are planted between October and November, while some others are grown from December to January (Bangladesh Bureau of Statistics, 2024). We collect data on total fertilizer production and application in two different segments, the 1st two-months covers the fertilizer practices between October and November and the 2nd two-months covers the practices from December to January. We do believe that we precisely collect fertilizer related data and measure & quantify the persistent change of fertilizer practices over two treatment rounds.

2.3 Statistical analysis

The social experiments and questionnaire surveys are used to collect necessary information which is divided into three factors (i) Treatment dummy variables: baseline, visioning, OFD and GFD, (ii) Cognitive factors: pre-knowledge of organic food & fertilizer and education and (iii) Sociodemographic factors: age, gender, family farm's income, family size and land size. These three factors are used as independent variables, while CFP, OFA and IFA are used as dependent variables. Table 1 provides the definitions of all independent and dependent variables in this study. We apply some statistical tests, such as chi-squared, Kruskal-Wallis and Mann-Whitney tests to identify qualitative differences of the key variables by treatments. Histogram is employed to show the distributions of dependent variables in our study. We evaluate model performance by computing three indicators, such as, log likelihood/log pseudolikelihood (LL/LP), mean square error (MSE) and mean absolute prediction error (MAPE) and identify the best fit model in our study, following by Matsaganis et al. (2009).

To quantitatively identify treatments' effects on CFP, OFA and IFA, we employ a two-part model in our analysis due to a large proportion of true zeros of dependent variables.[3] In general, the first part of the two-part model is a binary choice (logit or probit) model and second part is a ordinary least square (OLS) or generalized linear model (GLM). We apply a probit-GLM framework, where first part is the probit model estimating the probability of observing zero verses positive values and second part is a GLM that is conditional on having positive values of the dependent variable for each cross sectional data in treatment rounds 1 and 2, respectively (see, e.g., Liu et al., 2010, Caballer-Tarazona et al., 2019, Kruse et al., 2021, Cameron and Trivedi, 2022).[4] We also employ a two-part model using the probit-GLM framework for panel data that accounts unobserved subject-specific random effects in the model. A modified Park test is used

[3]To characterize the excessive zero values in data, the two-part model has been developed as an extension of the tobit model by Cragg (1971). The two-part model has been widely employed in situations where excess zeros in resource use, such as cost or health data (Farewell et al., 2017, Ozieh et al., 2017, Pallegedara, 2020).

[4]The GLM with log link has more advantages than the OLS with log-transformed model, the most important advantage of GLM is that it deals the skewed data and circumvents the retransformation coefficient estimation biases (Belotti et al., 2015, Jiang and Ni, 2020).

to determine the appropriate family distribution for GLM in the two-part model (Manning et al., 2005, Matsaganis et al., 2009, Ozieh et al., 2017). We also apply Pregibon's link test to identify the appropriate link function of the model (Pregibon, 1980, Deb and Norton, 2018).

The model specification of a two-part model for panel data is as follows:

$$\Phi^{-1}[Pr(Y_{it}^k > 0|\mathbf{W}_{it})] = \alpha_0^k + \alpha_1^k V_{it} + \alpha_2^k \mathit{OFD}_{it} + \alpha_3^k \mathit{GFD}_{it} + \boldsymbol{\alpha}_4^k \mathbf{C}_{it} + \boldsymbol{\alpha}_5^k \mathbf{X}_{it} + U_i^k \quad (1)$$

$$\log[E(Y_{it}^k|Y_{it}^k > 0, \mathbf{W}_{it})] = \beta_0^k + \beta_1^k V_{it} + \beta_2^k \mathit{OFD}_{it} + \beta_3^k \mathit{GFD}_{it} + \boldsymbol{\beta}_4^k \mathbf{C}_{it} + \boldsymbol{\beta}_5^k \mathbf{X}_{it} + Z_i^k \quad (2)$$

where Φ^{-1} is the probit link function, subscripts $i = 1, \ldots, 400$ and $t = 1, 2$ denote the family farm and time, respectively, Y_{it}^k indicates a dependent variable where $Y_{it}^{\text{CFP}} = \mathit{CFP}_{it}$, $Y_{it}^{\text{OFA}} = \mathit{OFA}_{it}$ and $Y_{it}^{\text{IFA}} = \mathit{IFA}_{it}$ for $k = \{\text{CFP}, \text{OFA}, \text{IFA}\}$; V_{it}, OFD_{it} and GFD_{it} are associated with treatment dummy variables of visioning, OFD and GFD, while $\mathbf{C}_{it}$, $\mathbf{X}_{it}$ and $\mathbf{W}_{it}$ are vectors of cognitive, sociodemographic and all the independent variables, respectively. Finally, U_i^k and Z_i^k are the random intercepts, assuming to be uncorrelated with $\mathbf{W}_{it}$. The α_js and β_js for $j = 0, 1, 2, 3$ are the parameters associated with the intercept, V_{it}, OFD_{it} and GFD_{it}, while $\boldsymbol{\alpha}_4$, $\boldsymbol{\alpha}_5$ and $\boldsymbol{\beta}_4$, $\boldsymbol{\beta}_5$ are the vectors of parameters associated with $\mathbf{C}_{it}$ and $\mathbf{X}_{it}$ for the probit and GLM models, respectively. The parameters are estimated via maximum likelihood methods to characterize Y_{it}^k variables with the specifications of equation (1) and equation (2) in the two-part model framework, enabling to calculate marginal effects of independent variables (Jiang and Ni, 2020, Cameron and Trivedi, 2022). We estimate the two-part model for cross-sectional data in Stata, version 17, using twomp command (Belotti et al., 2015, Caballer-Tarazona et al., 2019). However, we implement the two-part model with random effects by a generalized structural equation model (GSEM) approach to estimate the coeficients and marginal effects without sophisticated additional steps by following Jiang and Ni (2020). A series of two-part models are estimated by taking the CFP, OFA and IFA as dependent variables for robustness check.

Figure 4 shows a conceptual framework that visualizes the relationships of treatments with fertilizer practices, such as CFP, OFA and IFA, along with cognitive & sociodemographic factors. The relationships of key variables with fertilizer practices presented by plane arrows are examined in this research. We are focusing on the marginal effects of ME_1^k, ME_2^k and ME_3^k estimating from the parameters in equation (1) and equation (2) associated with visioning, OFD and GFD, respectively, after the effects of all other variables are netted out (see figure 4). In this framework, the marginal effects of ME_1^k, ME_2^k and ME_3^k represent the changes of fertilizer practices, such as CFP (OFA or IFA), when family farms receive a treatment of visioning, OFD and GFD as compared to baseline, respectively, holding other factors fixed at sample mean. Recall our research question "how does FD affect fertilizer practices for food production?" and hypothesis "FD induces a persistent change in farmers' productions towards SAP." In this regard, the estimated marginal effects of ME_1^k, ME_2^k and ME_3^k are the key parameters enabling us to answer not only the the research question but also the hypothesis, respectively. It is expected that family farm's fertilizer practices, such as CFP, OFA (IFA) increase (decrease) by receiving deliberative cognitive process interventions i.e., FD, over treatment rounds as compared to baseline, representing a sustained change in farmers' productions towards SAP.

3 Results

Table 2 summarizes the basic statistics of major independent variables for family farms in baseline, visioning, one-person future design (OFD), group future design (GFD) and overall sample, respectively. Pre-knowledge of organic food & fertilizer for family farm's head does not vary among treatments and the average pre-knowledge score for the overall sample is 5.36 (see the overall column in table 2). Family farmers possess 8 years of schooling as a median in the overall sample and family farmers have the same level of education across all treatments. The mean age of family farmers remains consistent across all treatments, with an overall mean age of 41 years old. With respect to gender, the percentages of male and female family farmers do not vary among treatments. The average monthly income for family farmers in the overall sample is 20 485 BDT and it does not differ among treatments. The family size and land size remain consistent across all treatments. The median value for the family size is 5, regardless of all treatments. The average cultivable land is 102.67 decimal for the overall sample, implying that the family farmers are marginal. In summary, it can be confirmed that family farmers in the various treatments exhibit homogeneity in terms of cognitive & sociodemographic characteristics, suggesting that they have been randomly and appropriately assigned to each treatment.

Table 3 presents the summary statistics of compost fertilizer production (CFP), organic fertilizer application (OFA) and inorganic fertilizer application (IFA) for family farms in baseline, visioning, OFD and GFD in two treatment rounds and overall sample, respectively. Significant differences are observed for family farms in visioning, OFD and GFD as compared to baseline for each of CFP, OFA and IFA in treatment rounds 1 and 2, respectively. In treatment round 1, family farms in baseline, visioning, OFD and GFD produce total compost fertilizer, on an average, 17.88, 37.99, 43.39 and 102.25 kg/two–months, respectively. At the same time, family farms in baseline, visioning, OFD and GFD apply total organic (inorganic) fertilizer, on an average, 11.31, 18.30, 22.01 and 25.96 kg/decimal/two–months (1.58, 1.18, 1.56 and 1.40 kg/decimal/two–months), respectively. In treatment round 2, the averages of total compost fertilizer production for family farms in baseline, visioning, OFD and GFD are 14.06, 34.91, 41.02 and 89.56 kg/two–months, respectively, while their average usages of total organic and inorganic fertilizer are 17.35, 20.94, 17.98 and 32.90 kg/decimal/two–months and 2.10, 2.03, 1.76 and 1.74 kg/decimal/two–months, respectively. Table 3 reveals that the averages of CFP and OFA (IFA) are higher (lower) for family farms in visioning, OFD and GFD than do baseline over two treatment rounds, respectively. However, the largest magnitude of change for fertilizer practices is observed in GFD, implying that GFD receiving farms react more for each of CFP, OFA and IFA than baseline situation of no treatment over two treatment rounds, demonstrating a sustained change of fertilizer practices.

We apply Mann-Whitney tests to identify the distributional differences of baseline *vs* other treatments for each of CFP, OFA and IFA in treatment rounds 1, 2 and the overall sample, respectively (see table 4). The null hypothesis is that the distributions of CFP between baseline *vs* visioning are the same. The results of Mann-Whitney tests for CFP show that the null hypotheses are rejected for all pairs of treatments in treatment rounds 1, 2 and the overall sample, except the pair between baseline and OFD in treatment round 2. Based on the overall sample, we confirm that distributions of CFP for visioning, OFD and GFD are different from baseline. In case of OFA, the null hypotheses are rejected for all pairs of treatments in treatment round 1, while the null hypothesis between baseline and GFD is only rejected in treatment round 2. In the overall sample, the null hypotheses between baseline *vs* visioning and baseline *vs* GFD are rejected, while null hypothsis between baseline *vs* OFD is rejected at 13 % significance level, considering practically significant in organic fertilizer application in Bangladesh context. Therefore, it can be interpreted that the distributions of OFA are different from baseline based on the overall sample. Regarding IFA, none of the hypothesis is rejected in treatment rounds 1, 2 and the overall sample, implying that the distributions of IFA in visioning, OFD and GFD do not exhibit significant differences from baseline when the effects of other factors are not controlled.

The histograms in figure 5 show the distributions of CFP, OFA and IFA for the overall sample. From figure 5a, figure 5b and figure 5c, it can be said that the patterns of data for each of CFP, OFA and IFA are right skewed and exhibit clumping at zero. A large number of zeros pose difficulty to select the appropriate model for analysis (Neelon et al., 2016, Boulton and Williford, 2018). Therefore, we evalute the model performance formally by computing log likelihood/log pseudo-likelihood (LL/LP), mean square error (MSE) and mean absolute prediction error (MAPE) through three models, such as one-part generalized linear model (GLM), tobit and two-part model for each of CFP, OFA and IFA in treatment rounds 1, 2 and the panel, respectively (see, e.g., Buntin and Zaslavsky, 2004, Matsaganis et al., 2009, Caballer-Tarazona et al., 2019) (see table 1 in supplementary material appendix D). The tobit model clearly shows the out-performance as compared to the one-part GLM and two-part model. Prevoius studies also suggest that tobit model is not appropriate for the variable that contains excessive true zeros (Boulton and Williford, 2018, Amore and Murtinu, 2021). The one-part GLM and two-part model appear to perform well fit in our analysis. However, most of the cases, the two-part model performs slightly better than the one-part GLM in terms of LL/LP, MSE and MAPE for each of CFP, OFA and IFA in treatment rounds 1, 2 and the panel, respectively.[5] To the end, we apply the two-part model for our final analysis.

Table 5 reports the regression results for CFP, OFA and IFA in the two-part models, respectively. We run different model specifications for the regressions to check the robustness of our results. We find that the main results in table 5 remain the same in all models. Models 1-1, 1-2 and 1-3 report the estimated marginal effects of independent variables for CFP, indicating a change in the CFP when the indedendent variable increases by one unit, holding other factors fixed. Similarly, models 2-1, 2-2 and 2-3 (models 3-1, 3-2 and 3-3) present the estimated marginal effects of independent variables for OFA (IFA), showing a change in the OFA (IFA) when the indedendent variable increases by one unit, holding other factors fixed. We find that treatments have significant effects on CFP, OFA and IFA and they are identified to remain significant at 1 to 10 % in treatment rounds 1, 2 and the panel, respectively. However, the estimations also reveal some other significant independent variables for CFP, OFA and IFA, but all these variables are not consistently significant across two treatment rounds and the panel. Pre-knowledge of organic food & fertilizer has a significant positive effect on IFA.[6] An additional year increase of age is associated with an increase (decrease) in CFP (IFA). Regarding gender, female head farms apply higher (lower) amount of organic fertilizer (inorganic fertilizer) than male head farms. An addition of one percent increase in family farm's income leads to a decrease in OFA.[7] The CFP and OFA are estimated to increase with an addition of one family member in the family. An increase of one decimal cultivable land leads to a increase in CFP.

Total productions of compost fertilizer for family farms in visioning (OFD) are estimated to increased by 31.92, 33.48 and 30.71 kg/two−months (37.91, 30.05 and 32.72 kg/two−months) as compared to baseline in treatment rounds 1, 2 and the panel, respectively. Similarly, total productions of compost fertilizer under GFD receiving family farms are estimated to increased by

[5]The one-part GLM is generally applicable when the dependent variable has few true zeros, while the two-part model is appropriate for a large proportion of true zeros (Eisenberg et al., 2015, Smith et al., 2017).

[6]We argue that with increased knowledge enables farmers to readily identify issues concerning plant growth and diseases. However, they may encounter challenges in addressing these problems using organic elements due to their limited availability, while inorganic elements remain the prevailing practice in Bangladesh.

[7]We conjecture that as farmers' income increases, they may experience less financial pressure for family sustenance, which could discourage them from applying organic fertilizer due to its challenging and time-consuming nature.

61.63, 66.22 and 62.15 kg/two–months as compared to baseline in treatment rounds 1, 2 and the panel, respectively. Family farms in visioning (OFD) apply an additional total of organic fertilizer by 9.75 and 8.14 kg/decimal/two–months (15.21 and 7.81 kg/decimal/two–months) as compared to baseline in treatment round 1 and the panel, respectively. Likewise, family farms under GFD apply an additional total of organic fertilizer by 17.37, 14.94 and 16.28 kg/decimal/two–months as compared to baseline in treatment rounds 1, 2 and the panel, respectively. On the other hand, total applications of inorganic fertilizer in GFD receiving family farms are estimated to decreased by 0.65 and 0.47 kg/decimal/two–months as compared to baseline in treatment round 2 and the panel, respectively. These results demonstrate that visioning, OFD and GFD induce family farmers to sustainably practice compost fertilizer production and organic fertilizer application. In case of inorganic fertilizer application, only GFD has found a significant impact. Overall, it is confirmed that GFD induces family farmers to make a more sustained change of fertilizer practices than do baseline and it has more economically significant impacts on CFP, OFA and IFA, with its magnitude approximately 2 times higher than those of visioning or OFD. In addition, we do sub-sample analyses for CFP, OFA and IFA by considering visioning as a base group for panel data, finding a significant positive impact on fertilizer practices that highlights a great potential of GFD as compared to visioning (see table 2 in supplementary material appendix D).[8]

Overall, summary statistics and tests clearly demonstrate that the random assignments of treatments through sampling processes are effective enough and family farms' fertilizer practices, such as CFP, OFA and IFA, are statistically different across treatments. The regression results of the two-part models quantify the effects of visioning, OFD and GFD as compared to baseline for each of CFP, OFA and IFA through different model specifications that are summarized in table 5. The fertilizer practices are characterized by treatments, cognitive & sociodemographic factors described in the conceptual framework, in figure 4 , providing insights into our research question

[8] We do not find any significant effect of GFD on IFA when performing sub-sample analyses by considering visioning as a base group for panel data. This means that the differences in IFA between visioning and GFD are not strong enough to find a significant change. However, there is a decreasing pattern of IFA when family farmers receive GFD as compared to visioning. In developing countries, the unavailability of organic fertilizers and farmers' fear of reduced production prevent a sudden drastic reduction in IFA (Wang et al., 2018).

"how does FD affect fertilizer practices for food production?" and the hypothesis "FD induces a persistent change in farmers' productions towards SAP." The regression results demonstrate that GFD induces family farmers to a more sustained increase (decrease) organic (inorganic) fertilizer practices than do any other treatment, answering the research question that FD interventions affect fertilizer practices for food production. The magnitude under GFD for fertilizer practices almost twice as much as those under visioning or OFD in rounds 1, 2 and the panel, representing a sustained change in fertilizer practices for food productions that supports our hypothesis. Our research establishes that GFD has a great potential to induce family farmers to practice sustainable agriculture. Thus, it is advisable that applying FD to a group of people is the most effective for sustained changes of farming productions towards SAP.

4 Discussion

Sympathy-empathy feelings have powerful effects on enhancing social and interpersonal relationships within in-group members and developing concerns for out-group people by promoting understanding, emotional connection and supportive behaviors (Stürmer et al., 2006, Longmire and Harrison, 2018). The likelihood of empathetic actions and helping behaviors increases when group members have similarities in social preferences, perspective taking, thought processes and future-oriented thinking (Stürmer et al., 2006, Aaldering et al., 2024). Literature suggests that group-based deliberation enhances individual awareness within the group, encouraging members to make conscious decisions that result in sustainable behavioral changes (Geller, 2002, Middlemiss, 2008). In GFD mechanisms where all family members take future standpoint together and share their visions, missions and strategies that successfully induce them to be future-oriented and sustainable in planning for ensuring sustainability. Being consistent with the literature, we conjecture that when people act as a member of future generations through FD interventions, they understand and experience the situations and feel sympathy and empathy for future generations (Kamijo et al., 2017, Timilsina et al., 2020). When they are in the original situation, sympathy-empathy feelings naturally induce them to synchronize or link their actions as future generations with actual actions of the present generation through their conscious and logic-based reasoning, contributing in SAP.

It is generally recognized in the literature that people's decisions and behaviors are affected by interactions with peers and their actions (Hill and Burkhardt, 2021, Wang et al., 2023). The peer effects originate from the imitation mechanism, enabling people to acquire valuable information through learning and communication (Niu et al., 2022). Studies suggest that information sharing among peers plays a crucial role in facilitating the diffusion of sustainable agricultural practices and introducing innovations that contribute significantly to sustainable agriculture (Skevas et al., 2022, Wang et al., 2023). When a group of people shares information about their activities and aligns with a common vision, it motivates them to collaborate and work together towards achieving that vision. Our study findings confirm that FD interventions in a group is the most effective approach for sustained changes of farming productions towards SAP. We argue that peer effects are heightened by taking the same perspectives of different times and sharing visions, missions and strategies to take required actions for achieving the envisioned goals. When people experience past, present and future generations together, their understanding of observing the situations as well as inner group strength, motivations and desire to fulfill the visions increase, inducing them to move forword even when experiencing the challenging situations.

Nowadays several future-studies approaches such as visioning, backcasting, scenerio planing and FD have been utilized in shaping visions, missions and strategies in various business, public and private organizations, demonstrating their effectiveness in promoting sustainability, forestry and waste management (Phdungsilp, 2011, Fotr et al., 2015, McPhearson et al., 2016, Nakagawa et al., 2019, Pandit et al., 2021, Shahen et al., 2021). However, the applications of future-studies approaches at intrahousehold settings have not been practically utilized, particularly for sustainable purposes. This research provides an evidence that group FD can effectively induce family farmers to be future-oriented, collectively guiding them towards their envisioned future by processing information into impactful narratives that promote sustained changes in productions. In future, business, public and private organizations can incorporate group FD into their policy and strategy formulation for intrahousehold agricultural practices, aiming to facilitate sustainable behavioral changes in farming productions. Thus, new institutional and educational arrangements should be established in each local area to educate farmers in developing visions, missions and strategies to address their problems through group FD interventions in the form of social meetings or training sessions, thereby increasing their enthusiasm for SAP. Additionally, new digital platforms and local farming centers should be established to organize and implement group FD workshops at family farm's level, serving as information hubs to guide each farm in resolving their farming problems. This study will open new avenues in the fields of economics, environmental and social sciences for applying group FD not only as a policy instrument to address pressing environmental and social issues but also as a means to encourage family farms to set their visions, missions, and strategies to resolve their problems through sustained behavioral changes.

5 Conclusion

This paper has examined the effects of FD interventions on family farmers' fertilizer practices for food production by investigating a research question "how does FD affect fertilizer practices for food production?," and the hypothesis "FD induces a persistent change in farmers' productions towards SAP." We have implemented a double-round social experiment with four treatments of "baseline," "visioning," "one-person FD (OFD)" and "group FD (GFD)," collecting data on organic and inorganic fertilizer practices from 400 family farms in Bangladesh over five months. The study demonstrates that GFD induces family farmers to a more sustained increase (decrease) organic (inorganic) fertilizer practices than do any other treatment, and the magnitude under GFD is almost twice as much as those under visioning or OFD. Overall, it is suggested that applying FD to a group of people is the most effective for sustained changes of farming productions towards SAP, potentially due to sympathy, empathy and peer effects among group members sharing the same vision, mission and strategy. This research is unique in considering the perspective taking of future generations to make persistent changes in farmers' productions by conducting a double-round social experiment.

We note several limitations of our study and provide some guidelines for future research. First, although social experiments are conducted twice, we could not account the seasonal effect because both instances occurred in the same season. Second, our experiment focuses solely on vegetable cultivation, despite rice cultivation being prominent in Bangladesh, due to constraints in time and budget. Third, there are several other variables, such as subsidy amounts, number of training from government organizations (GOs) and non-governmental organizations (NGOs) and access to extension services, may influence SAP but have not been included in our analysis. We are unable to collect these data because only a limited number of family farmers received these facilities. Fourth, this study does not analyze the pathways through which FD affects farmers's behaviors for sustainable farming productions, however, several pieces of literature have discussed its operating mechanisms (Nakagawa, 2020, Timilsina et al., 2020, Shahen et al., 2021). Future studies should consider seasonal effects, expand the horizon of applying FD beyond the vegetable cultivation, address governmental, non-governmental and service-related variables and examine the pathways of FD interventions using the neuropsychological approach to understand behavioral changes. These caveats notwithstanding, it is our belief that this study is the first attempt to design and conduct FD interventions on fertilizer practices and it confirms that FD in group is the most effective approach for sustained changes of farming productions towards SAP.

Appendix

We provide (A) a document of questions to measure pre-knowledge of organic food & fertilizer (B) an overview of experimental instructions for social experiments, (B) a brief summary of the case-method material on status & prospects of fertilizer usage and food production in Bangladesh as materials of the appendices. We also prepare an appendix D, showing the tables of sub-sample analysis for the effect of GFD on fertilizer practices using visioning as a base group for the panel data to check the robustness of our results.

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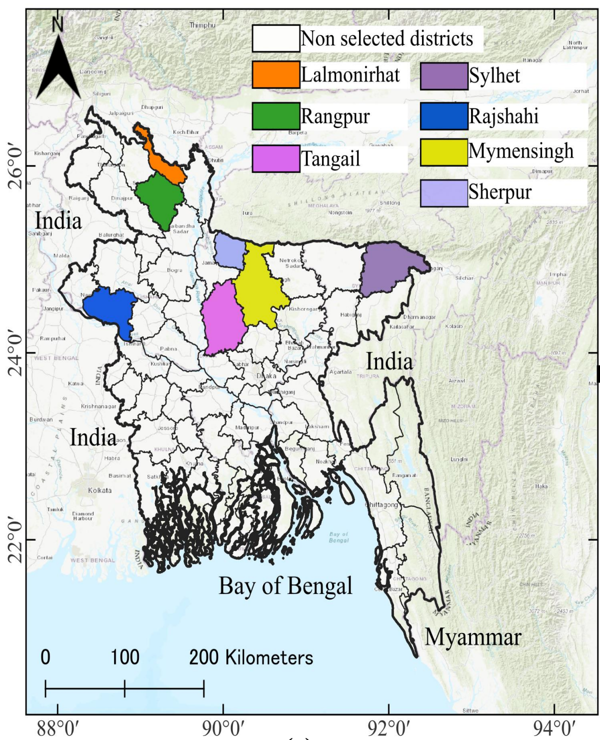
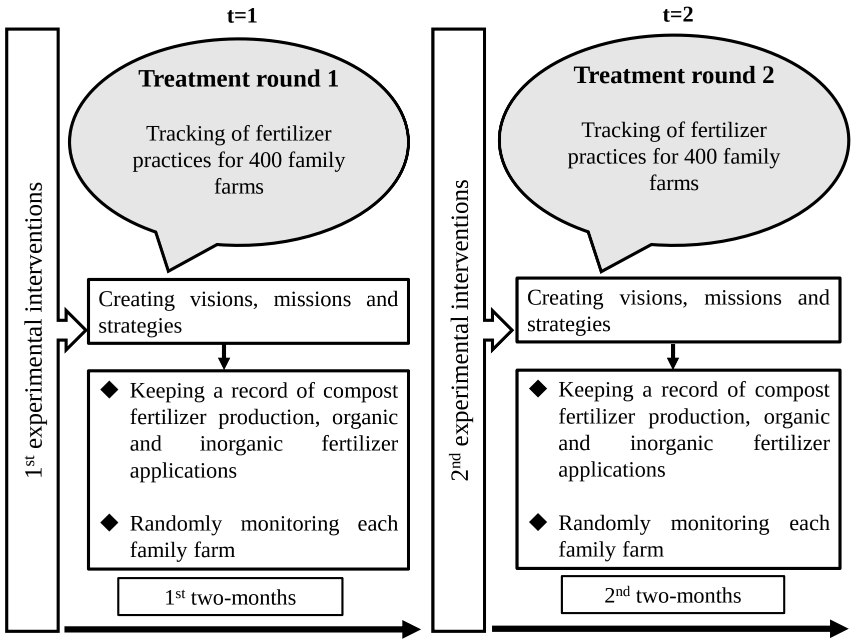


(a)

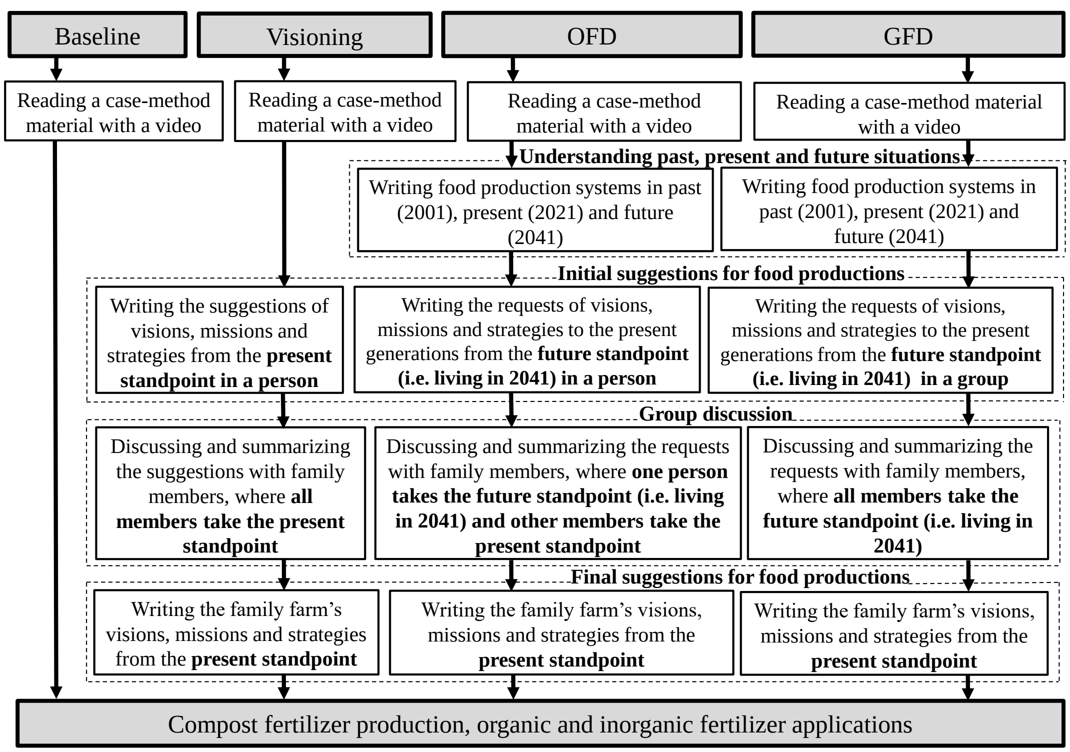
Districts	No. of upazilas	No. of unions	No. of villages	Sample size
Lalmonirhat	1	9	18	180
Rangpur	1	3	6	60
Tangail	1	3	6	60
Sylhet	1	2	4	40
Rajshahi	1	1	2	20
Mymensingh	1	1	2	20
Sherpur	1	1	2	20
Total	**7**	**20**	**40**	**400**

(b)

Figure 1: (a) The location of study areas: Lalmonirhat, Rangpur, Tangail, Sylhet, Rajshahi, Mymensingh and Sherpur districts and (b) Sample size in each selected areas in Bangladesh.



(a) The temporal flows of social experiments over two rounds, treatment round 1 and treatment round 2



(b) The flow chart of the 1st and 2nd experimental interventions for visioning, one-person future design (OFD) and group future design (GFD) treatments as compared to no intervention of baseline treatment

Figure 2: Experimental procedures and the flow of experimental interventions per treatment

(a) Snapshot of family farm's active participation

(b) Snapshot of compost fertilizer production

(c) Snapshot of fertilizer application

Figure 3: A visual presentation of social experiments

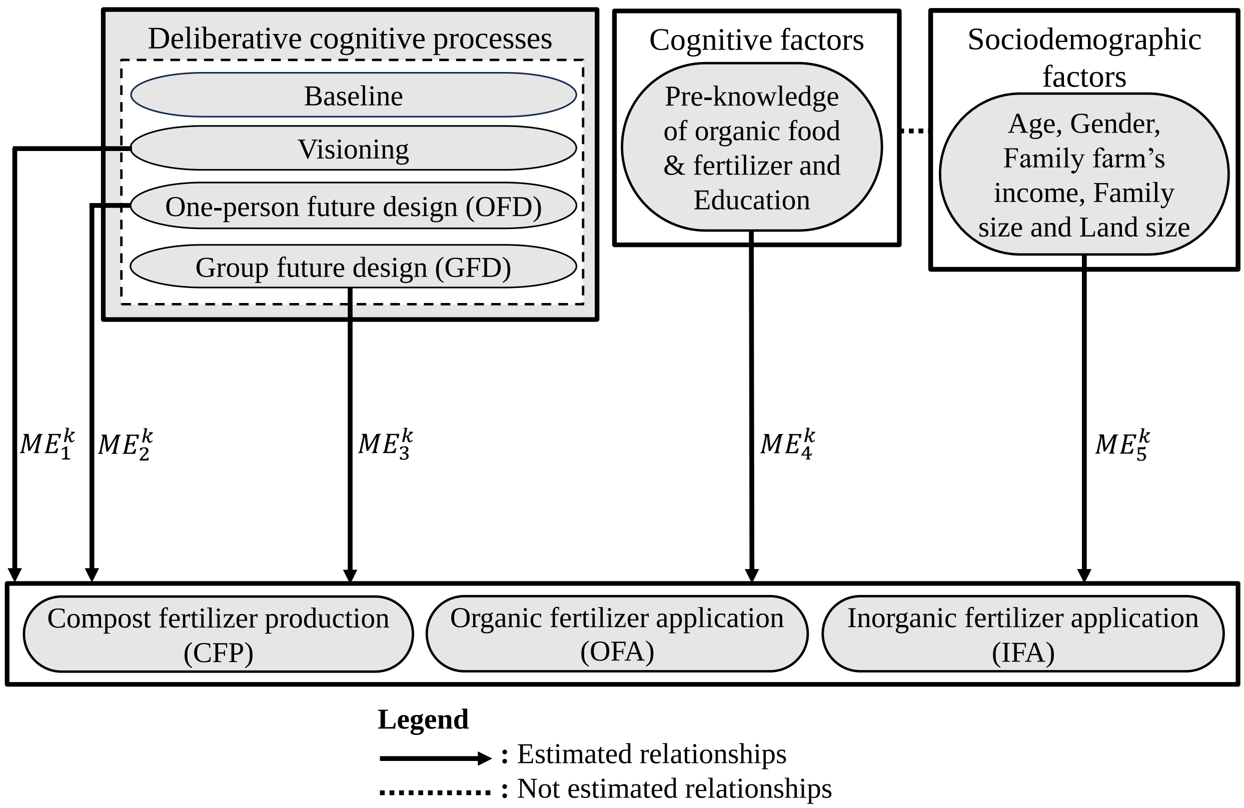
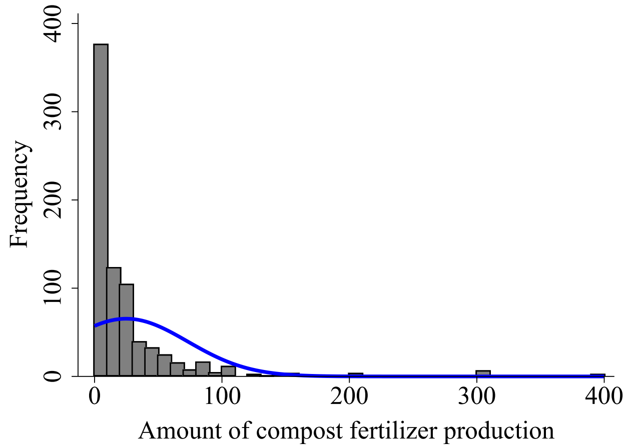
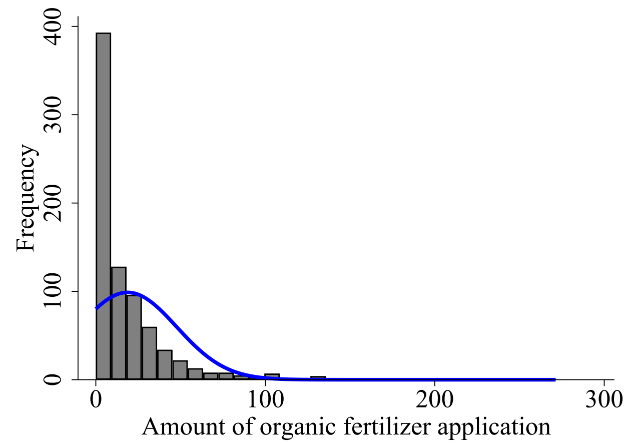


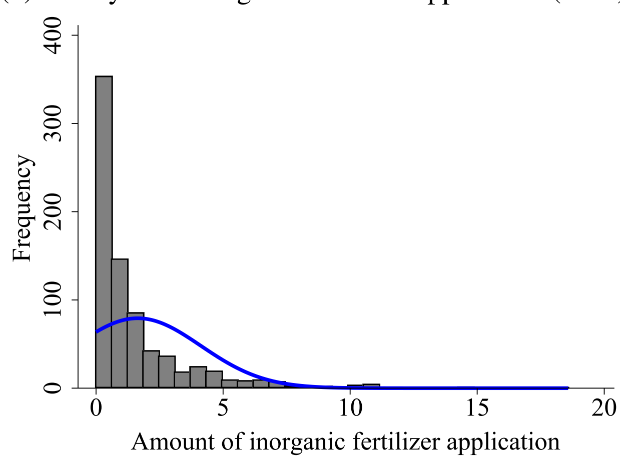
Figure 4: A conceptual framework describing the relationships among treatments: visioning, one-person future design (OFD) and group future design (GFD); cognitive factors, sociodemographic factors and fertilizer practices, i.e. compost fertilizer production (CFP), organic fertilizer application (OFA) and inorganic fertilizer application (IFA) where ME_1^k, ME_2^k, ME_3^k, ME_4^k and ME_5^k are marginal effects for the corresponding factors; and $k = \{\mathit{CFP}, \mathit{OFA}, \mathit{IFA}\}$



(a) Family farms' compost fertilizer production (CFP)



(b) Family farms' organic fertilizer application (OFA)



(c) Family farms' inorganic fertilizer application (IFA)

Figure 5: Histograms of compost fertilizer production, organic and inorganic fertilizer applications

Table 1: Definition of the variables

Variables	Description
Dependent variables	
Compost fertilizer production (CFP)	Total compost fertilizer production in kg/two−months.
Organic fertilizer application (OFA)	Total organic fertilizer application in kg/decimal/two−months.
Inorganic fertilizer application (IFA)	Total inorganic fertilizer application in kg/decimal/two−months.
Independent variables	
Treatment dummy variables (Base group = Baseline)	
Visioning	Baseline 0 and Visioning 1.
One-person future design (OFD)	Baseline 0 and One-person future design (OFD) 1.
Group future design (GFD)	Baseline 0 and Group future design (GFD) 1.
Cognitive factors	
Pre-knowledge of organic food & fertilizer	This is a score of total correct answers out of 10 questions related to organic food & fertilizer.
Education	Years of schooling 0 to 14 (0 = No schooling, 1 = Class one, 2 = Class two, 3 = Class three, 4 = Class four, 5 = Class five, 6 = Class six, 7 = Class seven, 8 = Class eight, 9 = Class nine, 10 = SSC/equivalent, 11 = Eleven class/equivalent, 12 = HSC/equivalent, 13 = Graduate/equivalent, 14 = Post graduate/equivalent).
Sociodemographic factors	
Age	Years.
Gender	Male 0 and Female 1.
Family farm's income	Monthly income in BDT.
Family size	Total family members in numbers.
Land size[1]	Total cultivable land in decimal.

BDT stands for Bangladeshi currency in taka.

[1] The land size variable is only used as an independent variable for CFP.

Table 2: Summary statistics of independent variables by treatments

	Treatments				Overall	p-value
	Baseline	Visioning	OFD	GFD		
Pre-knowledge of organic food & fertilizer						
Average (Median) [1]	5.14 (5.00)	5.30 (5.00)	5.55 (6.00)	5.46 (6.00)	5.36 (5.00)	0.15[2]
SD	1.43	1.51	1.65	1.76	1.60	
Education						
Average (Median)	6.54 (8.00)	6.39 (6.50)	6.90 (8.00)	7.41 (8.00)	6.81 (8.00)	0.31[2]
SD	4.27	4.43	4.50	4.33	4.38	
Age						
Average (Median)	40.26 (36.00)	42.71 (40.00)	40.17 (37.50)	39.35 (38.00)	40.62 (38.00)	0.28[2]
SD	13.05	12.29	12.36	11.92	12.43	
Gender (Base group = Male)						
Average (Median)	0.56 (1.00)	0.51 (1.00)	0.56 (1.00)	0.43 (0.00)	0.52 (1.00)	0.21[3]
SD	0.50	0.50	0.50	0.50	0.50	
Family farm's income						
Average (Median)	20955.00 (16500.00)	21935.00 (19500.00)	18730.00 (15000.00)	20320.00 (15000.00)	20485.00 (15500.00)	0.54[2]
SD	14970.19	16446.37	11243.72	13295.12	14117.52	
Family size						
Average (Median)	5.23 (5.00)	5.00 (5.00)	4.82 (4.50)	4.80 (5.00)	4.96 (5.00)	0.27[2]
SD	2.15	1.61	1.79	1.88	1.87	
Land size						
Average (Median)	104.15 (84.00)	104.43 (84.50)	92.88 (71.00)	109.23 (69.00)	102.67 (74.88)	0.85[2]
SD	94.81	115.90	91.06	126.84	107.93	
Sample size	100	100	100	100	400	

OFD stands for one-person future design.
GFD stands for group future design.
SD stands for standard deviation.
[1] Median in parentheses.
[2] Kruskal-Wallis test is applied to check the distributional differences of the variables by treatments.
[3] Chi-squared test is applied to examine whether or not the frequencies of the variables are independent among treatments.

Table 3: Summary statistics of dependent variables by treatments

	Treatment round 1				Treatment round 2				Overall
	Baseline	Visioning	OFD	GFD	Baseline	Visioning	OFD	GFD	
Compost fertilizer production (CFP)									
Average	17.88	37.99	43.39	102.25	14.06	34.91	41.02	89.56	47.63
Median	6.50	11.50	17.00	19.00	2.00	8.00	6.00	12.00	10.00
SD	61.52	93.16	100.72	617.11	25.53	78.29	108.19	602.07	313.17
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max	600.00	600.00	900.00	6051.00	150.00	500.00	710.00	6010.00	6051.00
Sample size	100	100	100	100	100	100	100	100	800
Organic fertilizer application (OFA)									
Average	11.31	18.30	22.01	25.96	17.35	20.94	17.98	32.90	20.81
Median	6.30	10.79	10.30	10.75	7.59	13.16	9.00	10.93	9.33
SD	20.45	33.83	52.46	45.31	27.09	40.84	27.48	50.89	39.17
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max	180.00	300.00	436.84	316.00	160.00	380.00	174.84	320.00	436.84
Sample size	100	100	100	100	100	99	100	98	797
Inorganic fertilizer application (IFA)									
Average	1.58	1.18	1.56	1.40	2.10	2.03	1.76	1.74	1.67
Median	0.83	0.63	0.82	0.58	1.06	0.83	0.81	0.88	0.79
SD	3.29	2.24	2.25	1.98	2.68	2.67	2.81	2.63	2.60
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max	23.73	18.58	11.03	9.01	15.00	14.12	14.35	16.00	23.73
Sample size	100	100	100	100	100	99	100	98	797

OFD stands for one-person future design.
GFD stands for group future design.
SD stands for standard deviation.

Table 4: Mann-Whitney test for baseline *vs* other treatments

	Treatment round 1			Treatment round 2			Overall		
	Sample size	z-value	p-value	Sample size	z-value	p-value	Sample size	z-value	p-value
Compost fertilizer production (CFP)									
Baseline *vs* Visioning	200	−2.89	0.01	200	−1.68	0.09	400	−3.13	0.01
Baseline *vs* OFD	200	−4.65	0.01	200	−1.33	0.19	400	−4.10	0.01
Baseline *vs* GFD	200	−4.22	0.01	200	−2.39	0.01	400	−4.53	0.01
Organic fertilizer application (OFA)									
Baseline *vs* Visioning	200	−2.00	0.04	199	−0.81	0.42	399	−1.97	0.04
Baseline *vs* OFD	200	−2.13	0.03	200	−0.03	0.98	400	−1.51	0.13
Baseline *vs* GFD	200	−3.03	0.01	198	−1.73	0.08	398	−3.26	0.01
Inorganic fertilizer application (IFA)									
Baseline *vs* Visioning	200	0.90	0.37	199	0.41	0.68	399	0.90	0.37
Baseline *vs* OFD	200	−0.43	0.67	200	1.44	0.15	400	0.72	0.47
Baseline *vs* GFD	200	0.30	0.76	198	1.30	0.20	398	1.15	0.25

OFD stands for one-person future design.
GFD stands for group future design.

Table 5: Marginal effects of independent variables on compost fertilizer production (CFP), organic fertilizer application (OFA) and inorganic fertilizer application (IFA) in the two-part models

	Treatment round 1			Treatment round 2			Panel		
	CFP	OFA	IFA	CFP	OFA	IFA	CFP	OFA	IFA
	Model 1-1	Model 2-1	Model 3-1	Model 1-2	Model 2-2	Model 3-2	Model 1-3	Model 2-3	Model 3-3
Treatment dummies (r = Baseline)									
Visioning	31.92***	9.75*	−0.41	33.48*	7.20	−0.14	30.71***	8.14**	−0.26
OFD	37.91***	15.21**	−0.07	30.05**	1.05	−0.49	32.72***	7.81**	−0.31
GFD	61.63**	17.37***	−0.33	66.22**	14.94***	−0.65**	62.15***	16.28***	−0.47**
Cognitive factors									
Pre-knowledge of organic food & fertilizer	−0.50	−0.26	0.09	3.25	0.85	0.16	1.56	0.36	0.12**
Education	1.10	−0.39	−0.01	0.39	−0.45	0.002	0.73	−0.43	0.002
Sociodemographic factors									
Age	0.54	−0.15	−0.02**	0.75*	−0.06	−0.02	0.63***	−0.08	−0.02**
Gender (r = Male)	−10.66	7.03**	−1.62***	5.93	11.51***	−1.21***	−3.32	9.37***	−1.38***
Family farm's income[1]	−8.28	−4.27	−0.03	4.14	−9.31***	−0.04	−3.70	−6.65***	−0.04
Family size	8.13***	1.05	0.09	4.11	3.03***	−0.02	6.66***	2.01***	0.03
Land size	0.13***	-	-	0.11*	-	-	0.12***	-	-
Observations	400	400	400	400	397	397	800	797	797

***significant at the 1 percent level, **at the 5 percent level and *at the 10 percent level.
CFP, OFA and IFA stands for compost fertilizer production, organic fertilizer application and inorganic fertilizer application, respectively.
OFD and GFD stands for one-person future design and group future design, respectively.
r stands for base group.
[1] The two-part models are computed with the natural logarithm of family farm's monthly income.