# Deliverable 5.2:

# Estimating the Marginal Propensity to Invest in SDGs: A Trade Game Approach

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000551

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TRADE4SD

Fostering the positive linkages between trade and sustainable development

Programme: H2020-EU.3.2.1.3. - Empowerment of rural areas, support to policies and rural innovation
Topic: RUR-21-2020 - Agricultural markets and international trade in the context of sustainability objectives
Call: H2020-RUR-2020-2
Type of action: Research and Innovation Action (RIA)
Duration of the project: 01 June 2021 – 31 May 2025

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# Estimating the Marginal Propensity to Invest in SDGs: A Trade Game Approach

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**Deliverable leader: UniKent

**Workpackage No. 5.**

**Due date:** 31 January 2025 (M45)

**Actual date:** 30/01/2025

**Dissemination level:** Public

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**About TRADE4SD Project**

Trade policy is a central factor in shaping global, regional and local development. It has an especially important part to play in achieving the UN Sustainable Development Goals (SDGs). The starting point of the TRADE4SD project is that trade has the power to produce positive and sustainable outcomes when the policies, which define the rules of the game, are framed and designed in a way to promote access to markets, fair prices and standards of living for farmers, as well as alleviating rural poverty and ensuring sustainable farming practices. Addressing the relation between trade and SDGs requires an integrated approach to policy-making and inclusive governance.

The main objective of the TRADE4SD project is to contribute to build new opportunities for fostering the positive sustainability impacts of trade supported by improved design and framing of trade policy at national, EU and global level, including WTO modernisation, increased policy coherence at different domains including agricultural, energy, climate, environmental and nutritional policies.

To meet this objective, the project develops an integrated and systematic approach that combines quantitative models from different perspectives, and several qualitative methods recognising that SDGs and trade are highly context-related. On the one hand, a robust analysis of economic, social and environmental impacts is given by using diverse but integrated modelling techniques and qualitative case studies. On the other hand, a wide consultation process is implemented involving stakeholders both in the EU and in partner countries as well as those with a wide international scope of activity, providing opportunities for improved understanding, human capital building, knowledge transfer and dissemination of results. To this extent, the consortium involves, as co-producers of knowledge, a number of decision-making, research and stakeholder participants with different backgrounds who will use their networks to facilitate the civil society dialogue and build consensus on the subject of gains from trade in view of sustainability.

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## Project Consortium

| No. | Participant Organisation Name | Country |
|---|---|---|
| 1 | Corvinus University of Budapest (CORVINUS) | HU |
| 2 | University of Kent (UNIKENT) | UK |
| 3 | Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria (CREA) | IT |
| 4 | Johann Heinrich von Thünen-Institut, Bundesforschungsinstitut für ländliche Räume, Wald und Fischerei (THUENEN) | DE |
| 5 | The University of Sussex (UOS) | UK |
| 6 | University of Ghana (UG) | GH |
| 7 | Luonnonvarakeskus (LUKE) | FI |
| 8 | Centrum Analiz Spoleczno-Ekonomicznych-Fundacja Naukowa (CASE) | PL |
| 9 | Food and Agriculture Organization of the United Nations (FAO) | IT |
| 10 | Institut national de recherche pour l'agriculture, l'alimentation et l'environnement (INRAE) | FR |
| 11 | Confederazione Generale Dell'Agricoltura Italiana (CONFAGRICOLTURA) | IT |
| 12 | Truong Dai Hoc Kinh Te Thanh Pho Ho Chi Minh (UEH) | VN |
| 13 | Luminaconsult Sprl (LUMINA) | BE |

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# Estimating the Marginal Propensity to Invest in SDGs: A Trade Game Approach

Alastair Bailey**[1] and Alexandra Kirtley[1]

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## 1. Summary

This Deliverable reports on the design, development and implementation of a Sustainable Farming Game produced by the UniKent Team specifically for use in Trade4SD project. The objective of the game is to generate data which can be subjected to econometric analysis to estimate the marginal propensity to invest in the sustainable development goals (SDGs). Game subjects are based in Vietnam, Ghana and Hungary and our target group of interest are those individuals who are farmers themselves, have farmer family members or who live and work in rural areas. As such, data generated from game play is expected to be informed by respondents' lived experience. Milestone MS12 provided a protocol for the game used here and the content of that will not be repeated here. Players were able to access and play the game online using either a computer or basic smart phone. The objective behind the game of strategy was to stakeholders are presented with production and trade choices that required them to consider the forward-looking consideration of the sustainability of their default practices. Through the choices they make within play, we are able to measure the frequency and scale with which they elect more sustainable production options enabling analysis for their marginal propensity to invest. This measure of stakeholder's intention to invest in sustainable development and may be used to evidence the priorities for EU trade policy with developing countries parties and subsequently to identify means to accelerate the adoption of sustainable farming practices.

## 2. Introduction

The primary focus of the work conducted under WP5 of the TRADE4SD project involves exploring the coherence of current EU trade policy frameworks. As such, an online trade game was proposed which will be played by relevant stakeholders in the agri-food chain to capture their behaviour, in the form of the choices they make in a familiar but hypothetical and simplified setting, towards trade and sustainability. By reducing the number of variables and therefore limiting the choices a 'farmer' would make, gameplay becomes less complicated, and participants focus on fewer decisions at one time (Tjernström, Lybbert and Hernández 2021; Gneezy and Imas 2017). Using a game to capture, and then analyse, behaviour is a novel behavioural research method. It has strong similarities to the experimental approach employed in WP4 in the form of the Threshold Public Good experiment. However, the setting itself, and the need for investigator input at the point of data collection is drastically different. Indeed, a strong case for the use of a web-based game playable on simple smart phone has significant research cost advantages over the Lab in the Field approach which is currently ubiquitous in development micro economic research. Furthermore, a web-based game can be used as an education tool in the field to greater awareness for stakeholders with respect to, in this example,

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the relationship between agricultural trade and the SDGs. This method presents players with the different trade scenarios over multiple rounds (representing different periods in production) and highlights the various trade-offs a country may encounter when adapting towards more sustainable practices. Milestone MS12 was produced to illustrate the design of the trade game prior to implementation in two EU trading partner countries: Ghana and Vietnam.

### 2.1 Aim

The aim of developing this Trade4SD online sustainability game is to create a tool that allows relevant agricultural stakeholders to make production decisions in a controlled environment emulating reality, in which they can trial sustainable production methods risk free while generating a database for use in further analysis. In the analysis reported in this Deliverable, our primary focus is on the measurement of their marginal propensity to invest in the sustainable development goals based on how often they elect sustainable farming practices. Providing a platform that enables experimentation with different ways to farm is a novel method of information collection and provision. Hence, an overarching aim of this work is to provide an interactive information provision tool outlining potential consequences of unsustainable practices and the potential production outcomes if sustainable practices are adopted.

### 2.2 Contribution and Legacy

Due to the online method of implementation, this trade game adds an extra dimension to the output generated from the lab-in-the-field experiments in WP4 through its ability to research a wider audience and involve a greater array of stakeholders. Aker and Ksoll (2016) found that the use of mobile phones to provide farming households with useful information altered the production decisions that households made. Hence, this Trade4SD game has the potential not only to reach a wider audience than a standard experiment but also improve the economic benefits for rural farmers by providing extension workers with a tool they can use to educate and inform farmers to make more sustainable production choices.

For EU policy purposes, repeated use of the game will have the power to show which broad areas of sustainability, either in community education, the adoption and certification of environmentally sustainable farming practices or simple economic sustainability of the farm, agents are most open to invest in. The EU may then need to focus its efforts in these areas to design more effective trade policies in the future. Additionally, the results from games may aid our understanding of the role of export price premia in encouraging investment in SDGs. The game will have an educational component for the participating stakeholders, helping them to comprehend how their welfare may increase if they make non-product specific investments that increase sustainability. A discussion and explanation of the outcomes following the game will strengthen this educational component. In addition to this, the proposed game can later be used as a teaching aid in classrooms about sustainability and trade choices in a similar manner to Sloman (2002) and Christian Aid (2008).

## 3. The Literature

### 3.1 The Sloman (2022) World Trade Game

Firstly, the inspiration for a sustainable trade game to capture the marginal propensity to invest in the SDGs stemmed from an existing world trade game developed in the 1990s by an anti-poverty charity Action Aid (World Council of Churches 2001). This world trade game was designed to demonstrate how trade can alter the development of a country and facilitate discussions amongst participants regarding the equity of trade in both developed and developing countries. This world trade game was then adapted by Sloman (2002) as an educational tool for students to be played with approximately 15-30 students at a time.

The game play for Sloman (2002) centred around an individual player or team being randomly endowed with different levels of inputs. These inputs include capital (the machinery/tools used to harvest produce), labour (the workers required to manufacture produce) and input materials (the raw materials required for production, for example, water). The level of endowment you are subject to at the beginning of the round will dictate which of the three types of countries you are representing. In essence, players are unaware what type of country they are part of. High income countries have relatively large endowments of all inputs. Middle income countries have a reasonable endowment of all the inputs but still need to trade to begin production. Low-income countries have a small input endowment and must trade to produce. Practically, this world trade game is played in a room with individuals randomly assigned to tables with different quantities of scissors, paper, compasses and rulers. Their goal is to compete against each other to manufacture paper shapes and sell them to an international commodity market trader (the game administrator) at posted prices, which vary with supply and demand. They are shown a reference sheet with measurements of the different triangles, rectangles and circles they must manufacture and the price they will receive for producing these shapes. The complexity of producing the shape dictates the price; circles and semi-circles require compasses, scissors and rulers to manufacture and thus sell for a higher price. The triangles and rectangles will be produced in large quantities for a lower price. The international market trader will examine the quality of the produced shaped, if they are the wrong dimensions or not cut out using scissors then they are either rejected or the trader will offer a lower price. Once the game begins, rich countries will begin making shapes as they have the necessary equipment and materials but will soon run out of paper (raw materials) and attempt to buy some from the other countries. The observers of the game play take note of the trade negotiations for input materials and report any malpractice such as theft of materials. The game administrator settles disputes and sets new prices for output depending on supply and demand. The game ends with players counting the shapes they produced and totalling the money they earned.

The Sloman world trade game is simplified abstraction of a complex world, yet captures the reality of trade amongst countries in differing states of development in a manner that suits audiences with little prior knowledge of the trade relationships between countries.

In a similar way, Christian Aid (2008) developed a chocolate trade and production role-playing game using paper and scissors. The players were divided into different groups representing different stakeholders in the cocoa value chain. These groups include fair-trade farmers, independent cocoa farmers, fair-trade and standard chocolate companies, supermarkets, and consumers. Each group is also endowed differently, and once cocoa shapes are created by 'farmers' they can be traded for different prices in the market. The introduction of four seasons in the game creates different rounds for players and allows game leaders to introduce exogenous shocks that will impact gameplay. By forcing players to respond to market shocks (such as a fall in the world price of cocoa, loss of crops due to black pod disease and increased demand for fairtrade products from consumers) this trade game captures an extra dimension of realism. Some cocoa stakeholders are impacted differently depending on their position in the cocoa value chain and these shocks make players acknowledge the financial implications on different groups and how trade must adapt to raise the fairness of international trade.

The primary purpose of both the Sloman and Coco examples is to educate the players. Neither has been used as a data collection tool, beyond that collated in play for use in feedback for current players education itself.

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### 3.2 Literature Review

A review of the relevant literature concerning variations of trade games and the variation of implementation approaches one may consider, was reported in Milestone 12 in order to facilitate the design of this Trade4SD game. The literature included in that review was compiled using various search strings reported in Table 1, each run on several databases including Scopus, Web of Science and Google Scholar. The literature review highlighted issues to consider when designing and conducting virtual experiments in developing countries and only these points are summarised again here. Specific focus was given to examples of gamification methods to collect the opinions of agricultural stakeholders (Kovács et al., 2017; Tjernström et al., 2021).

**Table 1**

| **Field** | **Search String** | **Logic Operator** |
|---|---|---|
| Title, abstract or keywords | "trade" AND "game" | AND |
| Title, abstract or keywords | (trade) AND (game) AND "sustainab*" | AND |
| Title, abstract or keywords | (e-learning) AND “agro*” OR “agri” | AND/OR |
| Title, abstract or keywords | (developing) AND (game) AND (online) AND “farm*” AND (STUDY) | AND/OR |

Faced with the observation of low rates of adoption of sustainable farming practices world-wide, a number of researchers have experimented with different ways to disseminate information to farmers to increase their adoption of new techniques and technologies (see Magruder, 2018). In a world where online gaming is growing in popularity, games have become a novel approach to distribute messages to a wider audience (Kovács *et al.* 2017). Games can then be designed to deliver information to reflect the benefits of sustainable agricultural practices. Abrahamse et al., (2007) found that tailoring information provision towards sustainability can contribute to changes in behaviour if agents receive feedback as to how their altered behaviour had influenced key outcomes of play. (Su and Cheng 2014) and (Girard, Ecalle and Magnan 2012) have noted similar benefits of gamification to help promote behavioural change and adoption to solve of real problems.

When games are designed to model reality, they can allow agents to experiment with new concepts in a consequence free environment. Kovács et al., (2017) and Tjernström et al., (2021) use online role-playing games to simulate the different returns to farmer’s production choices on a virtual farm. Both studies found that online games can induce real learning and alter farmer’s beliefs and real production methods.

Games allow us to expose agents to multiple periods (rounds). This adds a time dimension to their decisions. We can use this to demonstrate how yields may change over time as a consequence of altering their current production methods (Christian Aid 2008; Kovács *et al.* 2017; Tjernström, Lybbert and Hernández 2021). In a similar way, Fiore et al. (2009) argue that virtual experiments

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give players an opportunity to experience the long-run effects of the decisions which upon reflection can lead to an improvement in their current decision making.

Virtual games emulate the environment that players encounter in their own lives, by allowing real agricultural stakeholders to participate in this experiment, we can gather more contextualised and relevant responses (Harrison *et al.* 2004; Fiore *et al.* 2009).

Simões, Redondo and Vilas (2013) propose that the feedback from their decisions in each round should be quick and they should be given enough time to update their preferences for the next round. This paper continued by advising that the goals of the game should be clear at the beginning of the experiment and that the player should have the freedom to see their choices lead to failure in the context of the game.

Moreover, the literature presented many practical considerations with respect to conducting an experiment online with participants. Barchard et al., (2005) highlighted a few disadvantages with the method as not all people have been exposed to online technology environments, a point reiterated by Mathrani, Sarvesh and Umer (2022).

The literature surveyed offers a very wide range of settings in which games have been used to study, and aid learning in, the area of economic development and, more specifically in sustainable development. The vast majority of work in this area has focused attention on games as a means of making problems real in teaching. While our objective in developing a game does also include a desire to generate data for econometric estimation, much can be learned from the literature reviewed above. The review informs us of the importance of striking a balance between realism and tractability, in focusing the players attention on what is important only and abstracting, through simplification and the compression of time, in order to ensure focused and rapid feedback on the decisions made. The next section presents the game design adopting in this study. It considers the design of both the game algorithm and the tool created to deliver the game to respondents and from which data is collected.

## 4. Game Design

The design of the game we devise and implement here owes only passing inspiration from the Sloman Trade Game. This inspiration extends to the random assignment of initial resource endowments and the ability of players to trade profits for additional resources. From there, deviations emerge to permit the inclusion of sustainability in farming and society to be included. Participants play the role of a farmer. Each player holds a given area of land and is asked to farm using labour, materials, tools and their fixed land resources. Before play begins, players are informed that they have just taken control of a farm from their retired parent or predecessor. They are also informed that the farm currently makes use of modern chemical fertilisers and pest control methods and relies on spray and flood irrigation techniques. Players are then randomly assigned to one of two groups. Group 1 are told that their predecessor told them that farming yields had been falling in the years prior to today while players in group 2 are told that the farm had produced stable yields in recent years. In addition to the observation text which players see at introduction (see Figure 3), farms in group 1 inherit a production function for convention farming practices which declines in productivity over time at a faster rate than those of group two. This random assignment permits us to test whether Brander and Taylor's (1998) finding that observation matters in decision makers responses to longer run, or slow, sustainability decline and to do so in a way that permits unbiased estimation.

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The Game we describe here is played as a decision game as a sole activity. It is not a true strategic game which requires coordinated play. It therefore, lacks the facility for feedback from the behaviour of others since the competitive and coordination elements are missing. However, this permits play to occur anywhere and at any time and players will not notice this difference and coordination is incorporated in other ways.

Players are then presented with detail on the financial and resource endowment available for their use in the game before being asked to make production decisions for their first farming season. Unbeknown to the player at the outset, play lasts for 10 production seasons. At the end of each season, players are presented with the results of their farming activity and ready themselves for the subsequent season. Each season requires players to make a minimum of 4 other decisions each production season. These include the quantity of materials (seeds, fertilisers and crop protection) to use, a level of spending to maintain and enhance their farming tools, whether to invest private resources in the education of future employees and to purchase technical advice. In season 3, players are asked whether, or not, they wish to adopt sustainable farming practices. If they choose to adopt sustainable practices, their productivity first falls, to represent the reality of the changes needed, and then begins to grow See Graph 1 for a stylised productivity path for each of the 3 possible approaches farm technology evolution offered within this game. In season 7, all players are informed of the signing of a bilateral trade agreement with a major importing country who promises to pay higher prices for sustainably source product. Those who chose not to adopt sustainable practices in season 3 are offered a second chance to switch to sustainable methods. In recognition that there are external spillovers of sustainable farming, and because traders face economies when buying product of the same 'quality' at a village level, 'sustainable adopters" are offered the opportunity to persuade their fellow villagers to follow suit. Players face a predefined cost for both technology switch and village outreach but are informed that both can positively impact the price of their output. Output price response to the decisions made in regard to sustainable production and farmer networking is determined by probability programmed into the game.

Central to the game itself is a production function which transforms inputs, determined by player purchasing decisions and prior endowment into saleable farm outputs. This production function is programmed into the game as a is by a Cobb Douglas function as follows:

$$Y = a + B_1 \log L + B_2 \log M + B_3 \log T + B_4 \log A$$

Where L is labour, M is materials, T are tools and A is land area. $B_1$ to $B_4$ are the output elasticities. These parameters take the following base values, $a$=1, $B_1$=0.1, $B_2$=0.4, $B_3$=0.1 and $B_4$=0.4. Declining farm sustainability is programmed in between seasons in the absence of specific sustainability investment.

The parameters are further modified by the decisions players/farmers by investment of profits in:

- Tools depreciate at 20% between seasons and require some investment to maintain.
- Investment in farm sustainability practices can improve the productivity of land, which is itself fixed.
- Investment in education improves productivity of labour.
- Investment in Technical Advice improves overall productivity.

Investment in new tools or additional materials only increases the number tools or material inputs and not the parameters of the function.

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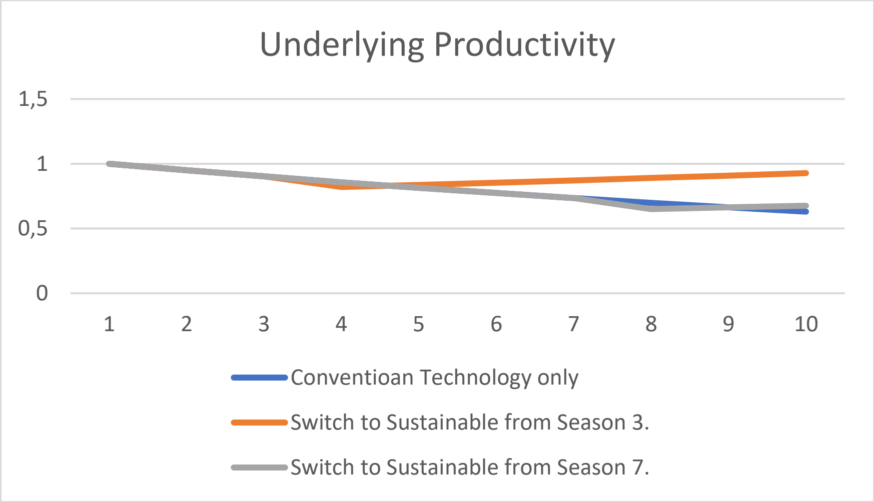
**Graph 1. Stylized production path for the 3 approaches to sustainable production offered in the game.**




The game recognises that the first objective of a small-scale farmer must be provide for their family. It also recognises that household who are richer will spend a greater level on household consumption. To recognise this imperative and immediate call on finances, the game assumes that 35% of profit is used for Household Spending purposes.

The practices adopted by players has the power to alter the price they receive for their output. Product produced using sustainable methods can attract a premium and success in persuading fellow farmers in the village to also produce sustainability can lead to marketing premia as traders face smaller costs in bulk transport of products of similar quality or 'standard'. The price a player receives, depends on the sustainability choices she makes along with a random number generator which scales the maximum prices set out in Table 2. Those farmers who do adopt sustainable farming practices receive a price based on the price in row 3 while those adopters who also engage in effort to encourage their neighbours to follow suit receive a price based on the maximum price in row 4 of Table 2. The justification for these differing prices rest on expected price premia for single farm sustainable certification and certification plus network economies passed-on by traders respectively.

**Table 2. Maximum prices for product produced under the 3 respective practices.**

| **Prices** | |
|---|---|
| Standard | 4 |
| High Sustainability Standard | 4.4 |
| Sustainability Village Network | 4.84 |

Before play begins, players are presented with the following 6 screens, Figures 1 to 6, which respectively permit players to choose the language they wish to use, read and agree to a data privacy statement, receive play instructions and to record basic information about themselves. They are also provided with the basic instruction required for then to understand their objective, and the tasks and decisions needing their attention.  Important to note, all players commence at the same stage, as an agent who has just taken control of a small farm with a fixed supply of both Labour hours and Land. Each share the same objective, to farm in a way that maximises their utility though money income in retirement. Farms only differ from one another in the history of yield evolution, the state of which

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they know from Figure 3. No explicit information is provided about the number of seasons they are expected to play.


Figure 1. Landing and Language choice.


Figure 2. Welcome and informed consent.


Figure 3. Play instructions and Group 1 warning.

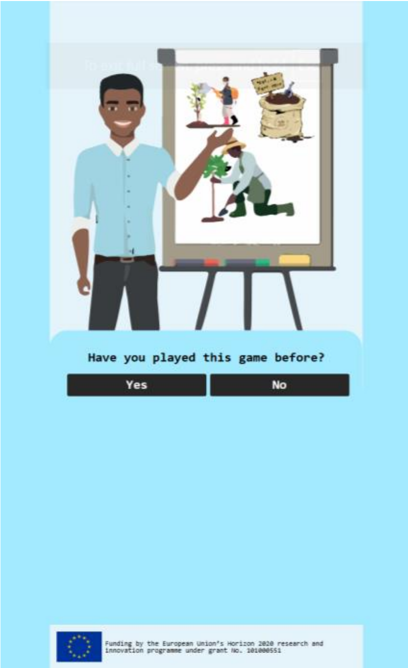


Figure 4. Repeat or New Player code.

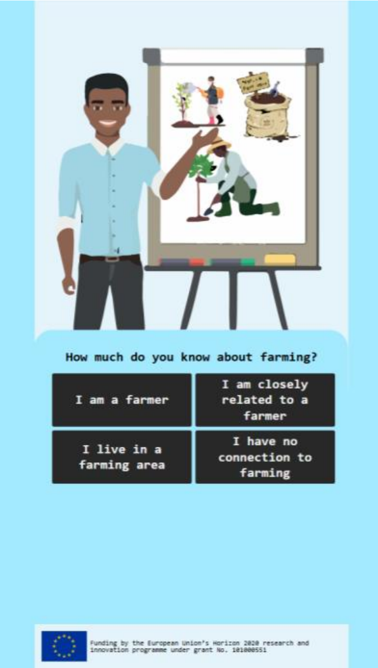


Figure 5. Coding page, play experience.

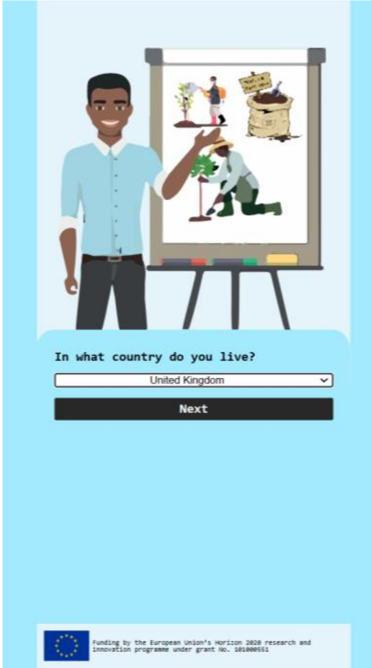


Figure 6. Country coding page.

Having completed the reading and prompted responses in the first welcoming pages, players see the first specific data on their farm and are then prompted to make their first production choices. Figures 7 and 8 represent the player views requesting decisions from Season 1 of play. Each of these pages include definition help for each of the variables shown. This help is accessed by clicking the "?" visible on each section.

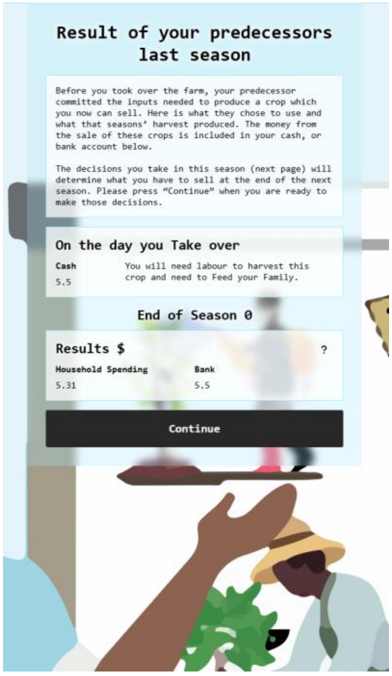


Figure 7. First round pre-season information.

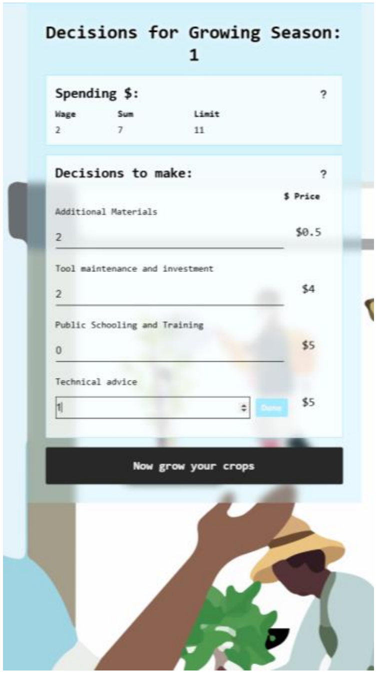


Figure 8. Season 1 decisions page.

The screen depicted in Figure 7 lists the resources players have on the farm at the start of the game while Figure 8 offers the opportunity to buy more resources (at prices stated on the screen) to add to their land. These then determine output, revenue (once output prices are defined by technology) and other key results are presented. Season 1 starts with every player farming with conventional,

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unsustainable, technology. Should the decisions they make result in an overspend of the resource available to them, they receive a warning message and are asked to alter their purchasing decisions. Just as in life, players each face a constraint on the availability of finance. However, in extreme cases, a player's prior decisions could result in severe lack of finance in a subsequent season. In these cases, the farm is declared Bankrupt and players are offered the chance to begin once more from Season 1. Data from Bankrupt plays are recorded since they example economically unsustainable plays.

Figure 9 represents a typical Season results page which reports the performance of the players last growing season, records the current technology of production and contains repeats of the help on offer under the "?".

The decision screens from Season 3 onward, see Figure 11 for example, inform players what technology they are using currently.

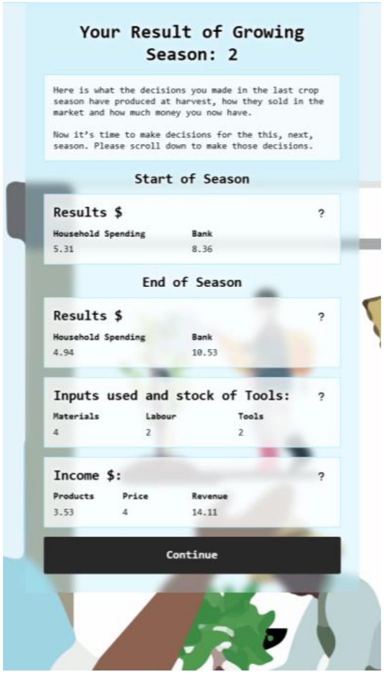


Figure 9. Typical Season results page.


Figure 10. Season 3 technology switch choice.

The decision screen in for Season 3, see Figure 10, offers players the first opportunity to switch from conventional to sustainable farming practices. The box in red setting out the additional choice to be made at this point in time.

Play continues to season 7, when again, the option of technology change is presented, a second chance to switch to sustainable technology for those who have yet to adopt or revert for those who had already made the change in season 3, change can be made in either direction at this point. However, a change from Sustainable to conventional technology will reduce output price and switch the production function back to a declining path. From season 7 onward, sustainable farmers are asked if they wish to share their experiences of farming with those close by, see Figure 11. If they choose to do this, then they will receive a higher network output price determined by the maximum set out in Table 2 and a random fractional multiplier built into the game.

Play continues, asking for repeated networking activity, which they must continue to commit if they are to benefit from the higher network price. At the end of Season 10, the game ends and the results as in the sheet "Results" reproduced in Figure 12 is shown.

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Figure 11. Season 8 networking option.

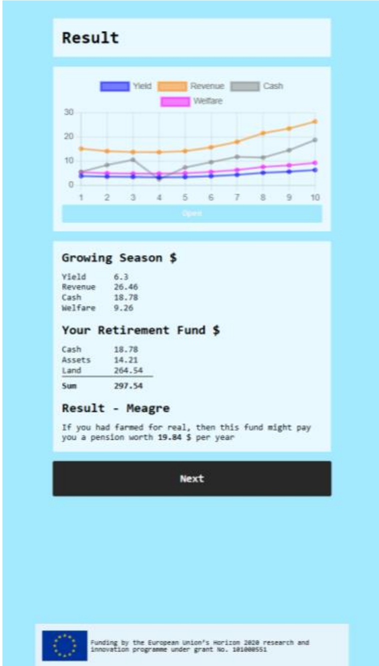


Figure 12. Player feedback page.

On completion of the game, players are offered the opportunity to play again should they wish to. In addition, player characteristics and decision data for each season of play are recorded in a single data file for subsequent analysis.

The Game is programmed into a data efficient web-based app accessibly via a URL link. The delivery of the game to the player requires only the supply of the URL to a player with access to either a PC or a simple smart enabled mobile phone of the type which is now ubiquitous across the world. The game App itself can be found here: https://trade4sdgame.com. Although we take caution from the warnings given by Barchard et al., (2005) and Mathrani, Sarvesh and Umer (2022) regarding access to such technologies, we take comfort from our own visits to the target locations and reassurances from our project country partners, which tell us that the majority of the target population either own, or have access via a neighbour or family member to, a mobile phone. By design, the game can reach a very wide audience dependent only on access to a smart phone and participant literacy. As such, we expect that the game will provide a simple means of collecting data from a wide range are subjects at a distance and at a time which is convenient to them. The game is envisaged to fill the void between the strong internal validity that the experiment brings and wider external validity.

The Focus of the game is on the decisions made by a farmer in their task they play in allocating the profits their farm produces toward internal farm investment, their own farms sustainability and investment in an education public good. Data will be harvested for each player as a series of expediture decisions and associated pay-offs from which a propensity to invest in materials, capital (tools), village schooling and sustainable farming practices.

The Game concludes after 10 seasons and the players score is recorded as the value of cash holding, the value of their land and other assets The calculation of the valuation of land will use the tenth season's addition to profit before investment to calculate a land sale price as the discounted value of profit into perpetuity. These values are then presented as a pension annuity equivalent including a qualitative comment that tells players how comfortable they would be in their retirement.

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### 4.1 Marginal Propensity to Invest

The game will see the players able to use their virtual game income to buy new sustainable inputs that will see a return in future periods. As such, we aim to be able to calculate the marginal propensity to invest in sustainable inputs by looking at the frequency with which they adopt these practices during gameplay.

In economic theory, to calculate the marginal propensity to invest ($MPI^S$) the formula is:

$$MPI^S = \frac{\Delta\, Investment}{\Delta\, Income}$$

Where Δ represents a "change in" in the variable of interest. From the data captured by the game, we can use season profits as income while the players investment in sustainability, across all available spheres, will be proxied by their proportional spending on Schooling, Sustainable technology adoption, the perchance of technical advice services and the cost they incur in persuading their neighbours to farm sustainably. We will measure this quantity directly using an OLS regression model.

## 5. Analysis for Data Collected from Game Play.

### Summary Statistics

At the time of preparing this Deliverable (January 24$^{th}$ 2025), some ** players had completed the game and deposited play data in the built-in database. Of these,55 reside in Vietnam and 19 in Ghana, a further 21 Hungarians had completed the game. Each completed pay of the game yields 10 data observations, 1 per season of play. Those plays that result in Bankruptcy generate data on only those seasons completed prior to farm failure. The resulting data represents a partially unbalanced panel.

**Table 3: Summary Statistics.**

| Variable | Obs | Mean | Std. dev | Min | Max |
|---|---|---|---|---|---|
| Profit | 992 | 12.24 | 19.67 | 0.16 | 228.86 |
| Yield | 992 | 4.18 | 5.00 | 1.72 | 59.21 |
| Price | 992 | 4.08 | 0.15 | 3.99 | 4.63 |
| Total Cost | 992 | 9.26 | 10.65 | 2.40 | 174.00 |
| SDG Spending | 992 | 2.32 | 2.95 | 0 | 18.00 |
| Share of SDG Spending | 992 | 0.23 | 0.21 | 0 | 0.86 |
| Tool Inventory | 992 | 1.42 | 0.54 | 0.39 | 3.60 |
| Materials | 992 | 3.83 | 9.70 | 0.10 | 150.00 |
| Tools | 992 | 1.10 | 1.08 | 0 | 7 |
| School | 992 | 0.81 | 1.14 | 0 | 11 |
| TechAdv | 992 | 0.82 | 1.06 | 0 | 10 |
| Sustainable Adoption | 992 | 0.32 | 0.47 | 0 | 1 |
| Sustainable Networking | 992 | 0.21 | 0.61 | 0 | 2 |
| Ist Play | 992 | 0.74 | 0.44 | 0 | 1 |
| Bankrupted Plays | 992 | 0.04 | 0.21 | 0 | 1 |

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000551

Probability of adopting Sustainable Farming in Season 3, the first adoption opportunity. The probability of adoption was estimated using a Probit regression which uses a, post-play created, binary adopt/not adopted variable as its' dependant variable.

**Table 4: Probit Regression Results, factors influencing Sustainable Technology Adoption**

| Sustainable Adoption | Coefficient | P>z |
|---|---|---|
| Falling Yields | -0.39 | 0.000 |
| Farmer | -0.80 | 0.000 |
| Farm Family | 0.39 | 0.001 |
| Rural Resident | -1.14 | 0.000 |
| Ist Play | -0.53 | 0.000 |
| a | 0.57 | 0.000 |
| Number of Iterations: | 4 | |
| Number of Observations: | 782 | |
| Pseudo R2 | 0.1369 | |

The Probit regressions results reported in Table 4 estimate the impact of a change in a given factor on the probability of the binary outcome variable. In this case, the outcome variable equals 1 if the player has chosen to adopt sustainable production practices at either Season 3 or 7. Our prior assumption was that players who received pre-play information indicating that their farm had a sustainability problem would be more open to adopt sustainable practices. The estimated coefficient for *Falling Yields* indicates the opposite behavioural response has been taken, a result which we find to be strongly statistically significant. Players who, in their own life, are Farmers or who are non-farming rural residents and those who are playing the game for the first time, all display a strong tendency to avoid sustainable technology adoption in play. However, farm family members, members of farming households who do not identify themselves as the farmer, appear to have a statistically significant association with adoption.

**Table 5: Regression Results, factors influencing spending toward SDGs in the Early Seasons of Play**

| Share of SDG Spending | Coefficient | P>t |
|---|---|---|
| Share of SDG Spending(t-1) | 0.40 | 0.000 |
| Price(t-1) | -15.08 | 0.040 |
| Tool Inventory(t-1) | -0.25 | 0.004 |
| Falling Yields | -0.04 | 0.244 |
| Farmer | -0.03 | 0.536 |
| Farm Family | 0.04 | 0.336 |
| Rural Resident | -0.08 | 0.068 |
| a | 61.06 | 0.038 |
| Number of Observations: | 209 | |
| R-squared | 0.1739 | |

Tables 5 and 6 report the results of a pair of Pooled OLS regressions of an identically specified model aimed at estimating the impact of player characteristics, initial farm productivity endowment and 'predetermined game play results from an earlier round (those denoted (t-1) are simple 1 period lags of that variable and can be interpreted as exogenous to the current decision process). In Table 5, the regression is run on data from Seasons up to Season 3 only. The reason for the truncation used is that we would expect that the information given to each farm productivity endowment group would likely have the greatest impact on player decisions early in the game and that players would update their understanding of their situation as information from further Seasons emerged. The results in Table 5 report an estimated coefficient which, although possessing a negative (and counterintuitive) sign, is indistinguishable from zero. Productivity endowment does not appear to influence the share of total spending committed to SDGs. Indeed, in these early Seasons, it is only last seasons' output Price that shows any level of statistical significance, and here players are estimated to reduce their spending on SDGs in the presence of rising prices.

**Table 6: Regression Results, factors influencing spending toward SDGs in the Later Seasons of Play**

| Share of SDG Spending | Coefficient | P>\|t\| |
|---|---|---|
| Share of SDG Spending(t-1) | 0.288 | 0.000 |
| Price(t-1) | 0.239 | 0.000 |
| Tool Inventory(t-1) | 0.035 | 0.009 |
| Falling Yields | 0.016 | 0.239 |
| Farmer | 0.008 | 0.678 |
| Farm Family | 0.025 | 0.158 |
| Rural Resident | 0.003 | 0.853 |
| a | -0.902 | 0.000 |
| Number of Observations: | 678 | |
| R-squared | 0.1932 | |

The results presented in Table 6 show some difference in the behaviour of players from that displayed in Table 5. In the later Seasons of the game, players behaviour has switched. Statistical significance is now present for Tools Inventory, but most interesting is the change in sign for Price. Now, as farmers see higher output prices in their last results sheet, they appear much more willing to spend their resources on SDG related factors.

Turning now to attempt to answer the key objective of this analysis, we turn our attention toward the propensity to invest in sustainability.

Table 7 reports the necessarily simple regression to explain the impact of income level, measured here by current season Profit, on the level of spending on SDG related factors. The dependant variable used here is the sum of all money (Game $) spending on switching from conventional to sustainable technologies, on Technological Advice, local Schooling and the costs incurred in persuading neighbouring farmers to also switch to sustainable farming practices.

**Table 7: Regression results, MPI estimate**

| SDG Spending | Coefficient | P>t | [95% conf. | interval] |
|---|---|---|---|---|
| Profit(t-1) | 0.09 | 0.000 | 0.0667 | 0.107 |
| a | 1.49 | 0.000 | 1.205 | 1.781 |
| Number of Observations: | 887 | | | |
| R-squared | 0.0726 | | | |

The estimate, the average propensity to invest in sustainability, reported in Table 7 is statistically distinguishable from zero and positive. It suggests that for every $1 increase in Profits made during the Game, players spent 9 cents in every $, or 9%, of profit on improving the sustainability of their game farm. Reference to the confidence interval for this estimate gives us an insight into the range of sustainable development behaviour shown by players. In these results we can be 95% confident that players invest between 6.7 and 11 cents of every $ of profit they made in the previous season's farming. Although statistically significant, this estimate might be considered relatively small when compared to the potential gains afforded to those who farm in more sustainable ways in the longer run. However, it does appear that players have understood that sustainability investment is an important component of success within this game.

# 6. Conclusion

The game as designed will be programmed into an application (or App) for use on mobile devices of a form widely used throughout the study regions. So far, farmers from within the key project study regions have been able to engage with, and play, the game and data for estimation has been generated. Our first conclusion is that the use of a game, delivered over and hosted on the internet is a viable means of both engaging local research subjects and collecting data in an experimental setting.

To date, the number of farmers who have played the game remains relatively few. However, since the cost of data collection in this manner is committed almost entirely up-front during the game development and programming phase, it holds real promise for those researchers who need to collect large data sets covering subject behaviour expressed in a relatively controlled experimental setting. The choice of architecture for the game permitted us to bring questions of resource degradation and farm sustainability and social sustainability and education to the fore. Yet the game relied on a very small set of decisions which players needed to make in any given season or round and avoided the necessity to see simultaneous play that would have required significant coordination had a strategic design been adopted. This resulted in a tractable and practical game play process that helped respondents complete the task in front of them and to permit the widest possible engagement with the target audience. Rather than programmed strategic interaction, some strategic interaction has been built into the design by offering players the chance to influence the sustainable behaviour of their neighbours.

From the outset, we were aware of the risk that the results of this game would suffer from selectivity bias caused by differing literacy levels and cell-phone ownership. Indeed, this has been an issue for our Ghana study region. The game was translated into, and delivered in, Twi, the most populous local language in the region, however, few farmers were able to complete the game due to language difficulties and some have used the English Language version in Ghana. Evidence has also emerged that, while mobile phone access is extensive, those with access to a smart phone is a limiting factor. We have begun to consider what would be needed in order to create and deliver an audio version of the game should it become necessary to play these types of games in low literacy and smartphone coverage regions and have made some progress on principles to move in that direction. However, the development costs of such a translation are high and the design and development required extends beyond the duration of this Deliverable. Work has already begun on this extension to the project.

The results of the analysis of game data show that simply 'being told' that a sustainability problem is present appears not to alter behaviour toward rectifying the problem. Indeed, players who were told that their new farm had experienced falling productivity appear to have focused their attention on measures to intensify their use of convention and recurrent inputs, rather than address sustainability head-on. Perhaps this response is a result of the way we think of sustainability itself? The general understanding of most people is that sustainability relates to the environment and externalities in general. The linking economic, environmental and social sustainability (as was discussed at length in WP 2 of Trade4SD) are rarely made explicit. Potentially, players of the game have believed that the productivity decline they were warned of rested only on private actions and remedy? An alternative explanation could simply be that players have failed to register or to hold memory of, the pre-play warning they received. Future incarnations of such a game should test alternative means of information delivery, perhaps with the use of graphs or graphics, to convey the message to players.

Despite the novel nature of this data collection approach and some of the teething issues in the design and use of the game for this purpose, the data analysis has generated some quite interesting results that deserve discussion. The analysis suggests reproduced above highlights that respondents are minded to invest in the sustainability of the future of their farm and their village and to forego current private gains to do so. The estimate of the propensity to invest in sustainability found here, on average, sits at 9% of money income. This shows that players appear to have viewed sustainability to be an important factor is their simulated farming strategy. Players have seen the importance of making investments in their private and collective local futures and this result offers some optimism in terms of sustainable preferences and behaviours of these research subjects. However, our results also suggest that respondents who are current farmers have a smaller likelihood of investing in sustainability or making the switch in farming technology needed to affect change.

# 7. Policy Implications

Form the results of this exercise and analysis it is difficult to rule-out the influence of the observation of productivity decline on the approaches taken to sustainability by actors in farming. It remains an open question as to whether second-hand observations of productivity decline, as presented in this game, does mimic the reality they were designed to replicate. More work is needed on this question before a recommendation can be made, but it does appear clear that players have noticed some productivity decline within play that appears to have altered their sustainability investment decisions as seen in the differing results across Table 5 and 6 here. Extension work aimed to promote sustainability investment may wish to focus on information provision which rests heavily on the interpretation of farmers own observations.

Approximately 20% of players did appear to respond positively to messages which first announced the signing of the sustainable product Bilateral Trade Deal and did engage by investing private time and resource in working with their neighbouring farmers to make network marketing gains to share. This result suggests there is a real opportunity to use the announcement of trade policy changes at a very local level in order to promote sustainability investment and shared collective action. While 20%

may appear small in this case, because the proposed action required players to consider 'persuading' up to 7 neighbouring farmers to follow the sustainable path, even a small number of players can have a disproportionately large impact of SDG outcomes.

Beyond the results of data analysis presented above, this deliverable makes two important contributions. First, that it has produced an easy and cheap to use tool to educate farmers, traders and agricultural students through play. It, therefore, provides an accessible and enjoyable demonstration of the longer-term consequences of the decisions farmers make on a regular basis and how such decisions can promote sustainability and generate benefits to farmers and society. As this tool (the game) also produces live time data, it can help develop more targeted provision of information in accordance with the results in different countries and localities. The game delivered in this workpackage will be made freely available for future use. Further development of this game will continue but, moreover, we have shown that gamification is a viable means to run experiments in the field and the approach could help to change the way we collect data in developing economics.

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