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Exploring farmer choices in Southern Togo: Utilizing a strategy game to understand decision-making in agricultural practices

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HIGHLIGHTS

- In-game household structure has an impact on the decisions players make.
- Regardless of their household structure, players prioritize fulfilling their basic needs before any other investments.
- In the context of food insecurity, long-term investment in agricultural innovation is not a priority for farmers.

GRAPHICAL ABSTRACT

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ABSTRACT

CONTEXT: Agriculture plays a vital role in African countries, driving economic growth, employment, and non-agricultural sector improvements. However, persistent food insecurity and poverty among smallholder families raise concerns. Land fragmentation compounds these issues, limiting agricultural productivity and pushing farmers towards off-farm activities, despite Africa's potential agricultural markets.
OBJECTIVE: The study's focus is Donomadé, a remote village in southern Togo. This study pursues a dual objective. Firstly, it investigates how household characteristics, including family size and resource availability, influence farmers' resource management decisions. Secondly, the research employs serious games to comprehend farmers' livelihood strategy choices within constrained real-world-like conditions.
METHODS: The iterative and participatory Companion Modelling (ComMod) approach was utilized for the co-design and co-development of a serious game. This involved close collaboration with a local research team from the University of Lomé, a local NGO, and Donomadé village farmers. Various farming systems were characterized, and collective insights into Donomadé's agricultural dynamics were gathered through surveys, interviews, and workshops.

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RESULTS AND CONCLUSIONS: Regardless of their in-game roles, farmers prioritize fulfilling basic family needs, such as food security and education instead of investing in agriculture. The study underscores the significance of household composition and resource availability when designing technology interventions or support mechanisms for farmers. Aligning interventions with farmers' overarching goals and challenges can enhance technology adoption. Furthermore, addressing food security remains crucial for sustainable development, as it not only improves human welfare and alleviates hunger but also forms the foundation for comprehensive solutions in the face of climate change, resource constraints, and population growth.
SIGNIFICANCE: This research highlights that heavy investment in agriculture is not the priority for many farmers in southern Togo, despite it being their main source of sustenance and income. Addressing immediate family needs, especially food security, education, and housing, takes precedence over long-term agricultural investments. Given the persistent challenge of food security amidst global uncertainties, addressing these priorities is paramount to stimulate more significant interest in agricultural investment.

1. Introduction

Agriculture in most sub-Saharan African countries is strongly correlated to the growth of the economic sector and GDP (Jayne and Sanchez, 2021) while also being related to the expansion of employment and improved livelihood in the non-agricultural sectors (Jayne et al., 2021). Agricultural systems must often accommodate several needs such as food production for a growing population, income generation, and conservation of natural resources, inter alia. Nonetheless, most smallholder families are still food insecure and live in poverty (Giller et al., 2021; Noort et al., 2022; Van Ittersum et al., 2016).

The mounting land pressure caused by continuous land fragmentation has made agricultural activities incapable of satisfying the basic needs of smallholder families (Bjornlund et al., 2020; Jayne and Sanchez, 2021; Novotny et al., 2023; Van Dijk et al., 2021). The expanding markets for agricultural goods and low agricultural productivity in sub-Saharan Africa offer great potential to improve yields. Yet, farmers tend to favour exploring off-farming activities instead of investing in their food systems (Giller et al., 2021; Ritzema et al., 2017). Farmers are decision-makers who must manage limited resources such as land, labour, and input to guarantee their family's quality of life. To tackle the challenges of food insecurity and subpar agricultural production more effectively, it is crucial to gain insights into the methods by which smallholder families handle their resources, as well as the underlying drivers behind their choices (Brown et al., 2021; Edwards-Jones, 2006; Robert et al., 2016).

Several recent studies have focused on understanding structural differences between smallholder families (Alvarez et al., 2018; Hammond et al., 2020; Modernel et al., 2018; Teixeira et al., 2018; Tittonell et al., 2020). The idea behind this research is to better target technology interventions to solve the problem of poor yields in heterogeneous smallholder systems (Tittonell et al., 2010). Kaur et al. (2021) demonstrated the customization of cost-effective interventions based on household characteristics, such as family size, plot size, and animal flock composition, to enhance production and income. Yet, these studies do not assess whether these households are willing, or even capable of changing their systems. Furthermore, as acknowledged by the same authors, different household types face different constraints. We thus infer that, because of differences in family structure and resource endowment, households are limited in their strategical capacity to make decisions based on the information available to them, which is often limited. These households respond differently to risks, take into account various timeframes, and are careful when adjusting to changing conditions (Findlater et al., 2019).

Strategy games offer several advantages for understanding farmers' perspectives (Edwards-Jones, 2006). Strategy is "*a long-range plan for achieving something or reaching a goal, or the skill of making such plans*" (Heacock, 2009). Strategy games enhance engagement, provide a risk-free environment for decision-making, allow exploration of uncertainties, promote inclusivity, and support evidence-based policy development. By doing so, the player can explore different alternatives and reflect upon them (Fisher et al., 2012). Games have been used in agricultural systems research to facilitate education (Ditzler et al., 2018), co-design pathways for landscape transitions (Fauvelle and Garcia, 2018; Reibelt et al., 2019), conciliate contrasting interests between farming activities and biodiversity conservation (Adolph et al., 2023; Hélan, 2012), and displaying trade-offs between ecosystem services and management (Speelman et al., 2018; Moreau et al., 2019). Yet, only a few studies have explored households' decision-making processes (Ashraf, 2009; Iversen et al., 2006; Michalscheck et al., 2020). To our knowledge, no study has used strategy games to simulate how the decision-making process of farmers is influenced by household structures and available resources (e.g., land and family size, agricultural output, animal husbandry).

This research employs a strategy game designed to simulate real-world challenges (e.g., Reibelt et al., 2019; Waeber et al., 2023) to explore the impact of household structure, encompassing elements such as family size and resource availability, on the decision-making processes of farmers regarding resource management. The study aims to elucidate the factors that shape decision-making in the context of farming by concentrating on the village of Donomadé in southern Togo. Donomadé was selected due to its distinctive blend of geographical isolation and diverse farming systems, providing a unique setting for investigating these influences (Novotny et al., 2023).

2. Materials and methods

2.1. Ethics declaration

The study was conducted in compliance with the ethical guidelines and principles outlined by the Ethic Commission of ETH Zurich (EK 2021-N-09).

2.2. Study area

With the aid of an NGO, Happy Togo, this research took place in Donomadé, a small village in southern Togo, West Africa. Donomadé is composed of around 600 inhabitants. Most of its population relies on rainfed agriculture as their main source of food and income. Rainfed agriculture with two annual cropping seasons in the village mostly accomplishes the role of subsistence, while a small goat flock is maintained to ensure security in moments of financial stress (e.g., sickness events, funerals, and payment for tuition fees). A previous study conducted in Donomadé identified five key household archetypes represented in the village, based on the household structure (e.g., number of family members and gender and age distribution), arable land availability, input and labour allocation, income sources, and food security status (Novotny et al., 2023). Archetypes in household analysis, especially in farming systems, serve as idealized representations of functional types, capturing generalized features of responses found in a sample of households. It is crucial to note that these archetypes do not necessarily depict the specific strategies of real farmers but rather symbolize diverse

and probabilistic responses within a community or group (Tittonell et al., 2020).

2.3. Data collection

The data used in this study was obtained from household surveys, semi-structured interviews, workshops, and game sessions. One field mission was done for each step between February 2021 and March 2023. A total of 81 household heads were surveyed to collect information on household structure and nutrition, agricultural practices, and economic activities. 28 household heads from the 81 surveys were interviewed to gain insights into farmers' motivations, intentions, shifts in farming systems, and socio-economic obstacles. One workshop was done with a local research team from the University of Lomé, another with a local NGO, and three workshops with farmers from the village of Donomadé to identify their understanding of key issues related to the food production systems and the main actors and resources.

We combined surveys, interviews, and workshops to develop a conceptual model of the farming system. This model identifies crucial system components, encompassing actors (such as farmers and buyers), resources (such as land, fields, seeds, cattle, labour, and trucks), processes (agricultural production, cattle reproduction, markets, seasonality), and interactions (like sending labour to markets or the city for non-farming work). This conceptual model serves as guidance for the subsequent gamification steps in the game (model) development (Étienne et al., 2011).

We conducted 10 data collection game workshops between February and March 2023: five workshops with participants from the village of Donomadé and five with participants from Tétékpo-Copé. Each workshop consisted of six participants. They were selected based on their availability and willingness to engage in a four-hour session, and those who participated in the game test were disregarded. We had local authorities collaborating with us and facilitating the identification of participants. We tried to keep a gender and age balance in each game workshop. Given our interest in understanding livelihood strategies in farming systems, we only considered people involved in crop production and/or animal husbandry. Participants received two meals, one before and one after the workshop. Participants with children also received financial compensation to arrange food for their children's school day.

2.4. Game development and structure

A game is a model and an abstraction of reality covering the main dynamics of a certain environment (Étienne, 2014). When participants play the game under the guidance of researchers and collectively discuss their experiences, it becomes a shared process that helps everyone engaged to understand how the system works. In this study, we designed a game that simulates constrained farming systems in Togo. They are constrained because land is scarce, labour and input expensive, and crop performance low. Despite the low availability of resources, there is a diversity of households, which were represented into different archetypes in a previous study (Novotny et al., 2023). These archetypes were also represented in the game. The design of the game followed the Companion Modelling (ComMod) approach (Barreteau et al., 2014; Étienne, 2014). ComMod is an iterative and participatory process relying on the assumption that involving local actors in model design and development benefits the actors, researchers, and decision-makers (Reibelt et al., 2019). The game's elements, such as the board and tokens, represent the landscape and its various components identified by co-developing a conceptual model with local actors. In a game, players take on the roles of stakeholders who influence the game landscape (game board), while the rules of the game mirror the processes and ecological, social, and economic dynamics of the system. The game designed in this study sought to facilitate creative and constructive discussions among stakeholders while adhering to the framework outlined by Simon and Etienne (2010).

We conducted a total of 10 crash test workshops aimed at evaluating and correcting issues related to pacing, engagement, understanding, and game mechanics. These tests allowed us to consolidate a final version of the game which we used for data collection. Three of these workshops involved students and game experts from ETH Zürich between March and August 2022. Four tests were run in Donomadé and three in a nearby village, Tétékpo-Copé in October 2022. The inclusion of this village was to avoid participants' exhaustion in Domomadé, who had already participated in several activities before the development of the final version of the game. By testing the game with the citizens of Tétékpo-Copé, we were able to validate if the game also represented their reality.

The goal of the game, as introduced to players during the briefing, was "to sustain a living and improve the quality of life of your family." The game had no winning conditions, and players were free to explore different options (Fig. 1) to reach their objectives. In the game, players were randomly assigned a profile. These were inspired by three out of the five most contrasting archetypes previously identified by Novotny et al. (2023) for simplification purposes. They differed in available resources. As such, all players embody the role of farmers with different starting conditions linked to plot size, family size, labour availability, and number of goats. The first player's profile in the game, the Small-sized Family (SF), had two plots available, three labour tokens (related to the family size), and two goats. The second one, the Mid-sized Family (MF), had one plot available, five labour tokens (related to the family size), and one goat. The final profile, the Large-sized Family (LF), had three plots, six labour tokens, and one goat. Every player started with one bean seed. They also started with a maize seed for every plot they had available. Players could decide to plant their seeds in monoculture or polyculture.

The game was structured in six rounds, each round representing a growing season. The six-round structure was selected to offer players ample time to familiarise themselves with the game, develop their strategies, and assess the outcomes of their actions while fitting in a two-hour session. On each round, players could perform a sequence of actions that involved deciding whether to acquire additional resources like labour and seeds, send their labour to perform off-farm activities and borrow money from the bank (Fig. 1). Subsequently, they had to define what and where to plant. At the end of the round, players had to feed their families. They could decide to fully or partially feed them at the cost of undernourishment. They were also given the choice to pay for school tuition fees and invest in household improvements or not. The choices of household improvements (e.g., cell phone, books, clothes, motorized vehicle, and house in the capital city, Lomé) were defined and validated by participants in the crash test workshops described above. Finally, they were asked to pay back the money they had borrowed (if they did), with a 10% interest rate. After that, the season would be concluded, and a new one would start. The validation of the game was conducted during the final field missions.

The game session was run in the local language (Ewe) by a trained facilitator, two local observers, and three researchers. We documented every action of each player across the whole session, gaming, and debriefing phases. Their actions involved decisions on crops planted, labour hired, food bought, and food sold. Once the 6 rounds of the game were concluded, a debriefing session started. The debriefing was structured around four main steps (Crookall, 2014). First, the facilitator asked how players felt, allowing players to describe their emotions. Second, players described major events that have occurred in the game and commented on what they would do differently. Third, players were asked if some events from the game could be bridged to reality. Finally, discussions were opened to future projections (e.g., "*next time I decide what to plant I will consider how to better use my available labour*"). It is during the debriefing phase that the game and reality come together (Garcia et al., 2016), and players consider their actions during the game and relate them to personal experiences in their everyday lives (Bos et al., 2020; Ponta et al., 2019). The players' responses were

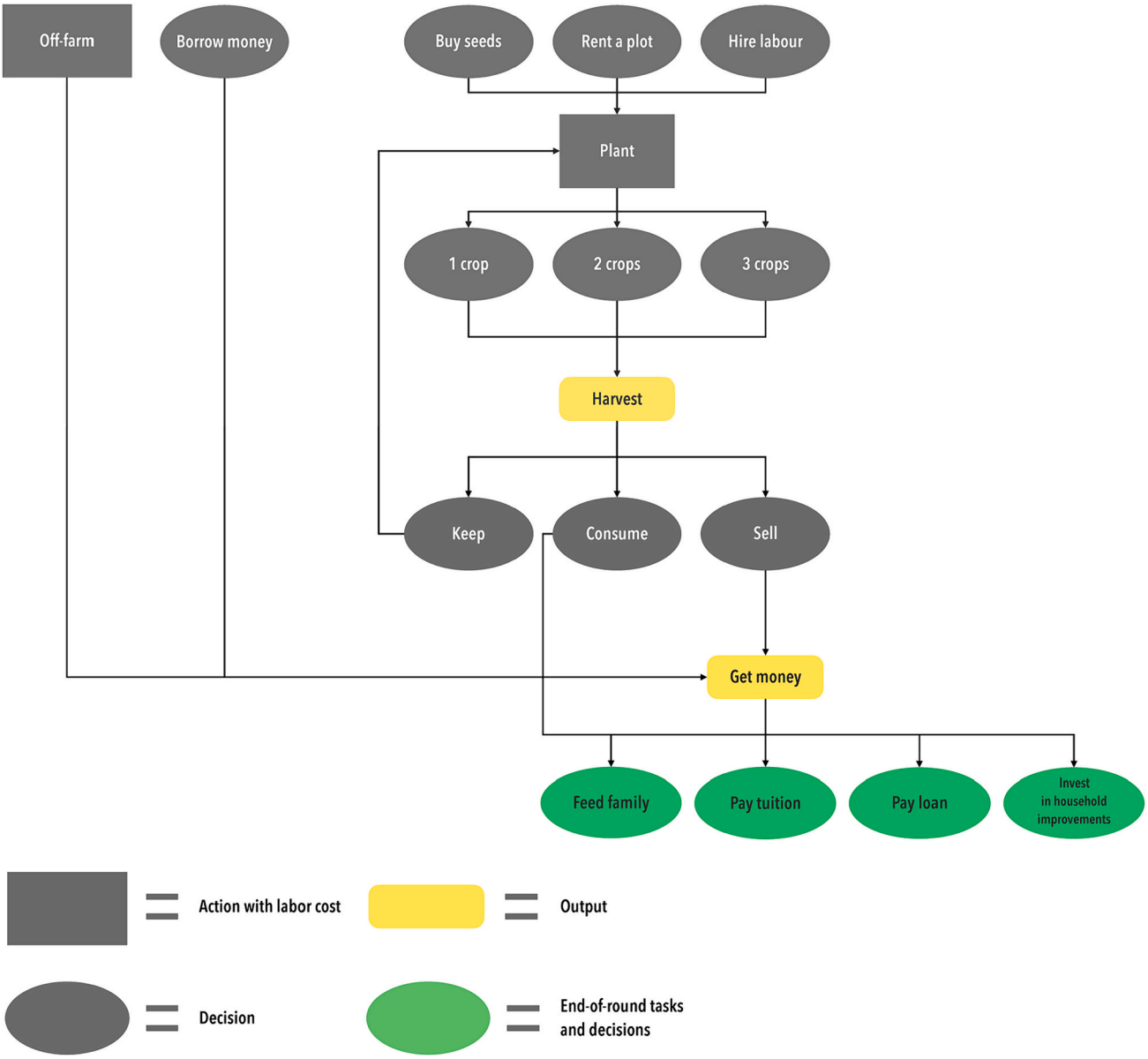

Fig. 1. Schematic model of one game round.

documented by the two local observers. Players' mentions of their intentions during the game were extracted during the second and third steps of the debriefing and coded later by the researchers.

2.5. Statistical analysis

In this research, we focused on collecting data related to assets collected and activities performed during the game as proxies for livelihood strategies. We separated livelihood strategies into 3 categories: 1) planting choices (maize, bean, soy, and pineapple), 2) sources of income (agriculture, off-farm income, goat shepherding, and loan), and 3) investments behaviours (labour, seeds, education, food, and household improvements).

We further analyzed these data using a Permutational Multivariate Analysis of Variance (PERMANOVA) and a Principal Component Analysis (PCA) followed by a Hierarchical Cluster Analysis (HCA) to answer how the available resources influence the decisions taken by household managers. PERMANOVA is "a geometric partitioning of variation across a multivariate data cloud, defined explicitly in the space of a chosen dissimilarity measure, in response to one or more factors in an analysis of variance design. Statistical inferences are made in a distribution-free setting using permutational algorithms" (Anderson, 2017). We ran a PERMANOVA to assess first if there were differences in the strategies among the pre-established player profiles within the groups (SF, MF, LF). Specifically, we examined whether various variables related to expenditure like seeds, labour, or household improvement, varied among SF, MF, and LF profiles. Important to note; that PERMANOVA does not compare pairs of variables, instead, it assesses whether overall differences exist among groups when considering all the analyzed variables. We ran three PERMANOVA models to compare crop composition, income source, and money spent between players' profiles and gender. Dynamics within a game workshop are unique and depend on the interactions between individuals (Jean et al., 2018). To account for these unique interactions in our PERMANOVA models, data collected from individual players were nested in the game workshop they participated.

In addition to the PERMANOVA, we also performed a Principal Component Analysis (PCA) followed by a Hierarchical Cluster Analysis (HCA). The PCA and HCA allowed us to group players based on their strategies and actions developed during the game. The PCA was run using the variables described in Table 1. The number of principal

Table 1
List of variables used in the Principal Component and Hierarchical Cluster analyses. $ corresponds to game currency.

Variable	Explanation	Unit
Land with two crops	Proportion of land occupied by two crops	%
Off farm income	Average money generated through off-farm activities	$
Crop selling	Average money generated by selling crops	$
Spent on seeds	Average money spent on seed acquisition	$
Money borrowed	Average money borrowed from the bank	$
Money spent on improvement	Average money spent on household improvements	$
Start money	Average money players had at the start of each round	$

components kept was defined by the "Elbow Method" (Lopez-Ridaura et al., 2019). For all the analyses, we used R (v. 4.2.2) in RStudio (v. 2023.06.0). We used the vegan package (v. 2.6–4) for PERMANOVA analysis, the ade4 (v. 1.7–22) for the PCA, and the stats (v. 4.2.2) for the HCA.

3. Results and discussion

3.1. Players' intentions

Players expressed their intentions during the debriefing session, which was recorded by the observers. Across all game sessions and player types, the most reoccurring intentions players expressed were to feed their families and pay for tuition fees (Fig. 2). The second most common intention was to buy a house. Saving money and improving crop or animal production was the least common intention. Similar to what Franke et al. (2014) and Ritzema et al. (2017) observed, farmers do not usually prioritize investing in agriculture. Fan et al. (2012) argue that, to have a prosperous agricultural activity, farmers and households should first, be healthier. Players noted that they occasionally had to compromise, prioritizing food subsistence for their families over their most ambitious goals. One player expressed this by saying, "*I wanted to buy a house in Lomé. But I was not able to do it since I had a lot of mouths to feed*" (player 3, workshop 8 – talking about the game and real life). In contrast, some individuals initially focused on fulfilling their basic needs and then progressed to pursue more ambitious objectives. As one player mentions, "*First life was hard, so I did my best to feed my family and send the kids to school. When I realized that there was enough money, I decided to invest in a motorcycle*" (player 2, workshop 3—talking about the game). These quotes underscore the significance of prioritizing the fulfilment of essential family needs, such as access to food and mobility, as fundamental contributors to the overall quality of life for households. Players have clearly expressed their strong desire for these necessities.

Failing to provide the most basic needs to one's family is a major bottleneck for agricultural investment, as expressed: "*In real life, the first task is feeding and making sure kids can go to school. Later, when we can accomplish that we can buy clothes etc.*" (player 1, workshop 10—talking about real life). Among players, some used agriculture primarily to serve the purpose of providing for their families. Even for these players, an additional step was required before they decided to invest in agriculture, as shown in the following statement: "*It was hard to feed in the beginning. I started sending my labour force to the village to gain some extra money. In the end, I started to plant on two plots… after the kids are gone, I will reduce production because I do not have the strength anymore*" (player 3, workshop 8—talking about the game and real life). In some cases, agriculture was perceived as insufficient to reach farmers' goals: "*In the beginning I wanted to have a house, which I could not afford. If my field would not give enough money, I would go far to get the money to be able to build a house*" (workshop 3, player 4—talking about real life). Finally, we observed responses that indicated that agriculture could be used to attain more ambitious goals: "*With pineapple production, I was able to make good money so now I can cultivate on all of my plots to buy a motorbike*" (player 6, workshop 2—talking about the game and real life).

Most of the recent studies focus on farmers' drivers to adopt different technologies or techniques (Adebayo et al., 2022; Bazrafkan et al., 2022; Fujisawa et al., 2015; Muzari et al., 2012; Zhang et al., 2018). Although these drivers are relevant, we argue that to improve the efficiency and adoption of new technology, the overarching goals and deadlocks farmers face should be accounted for when designing or promoting a given technology or other forms of support (e.g., subsidies, Brown et al., 2021). For instance, in a place with a restricted connection to markets and a high concern over nutrition, technologies should target food security instead of promoting cash crops. As shown by players during the game, some of their intentions were not immediately related to agriculture, such as the desire for the acquisition of a new house or a

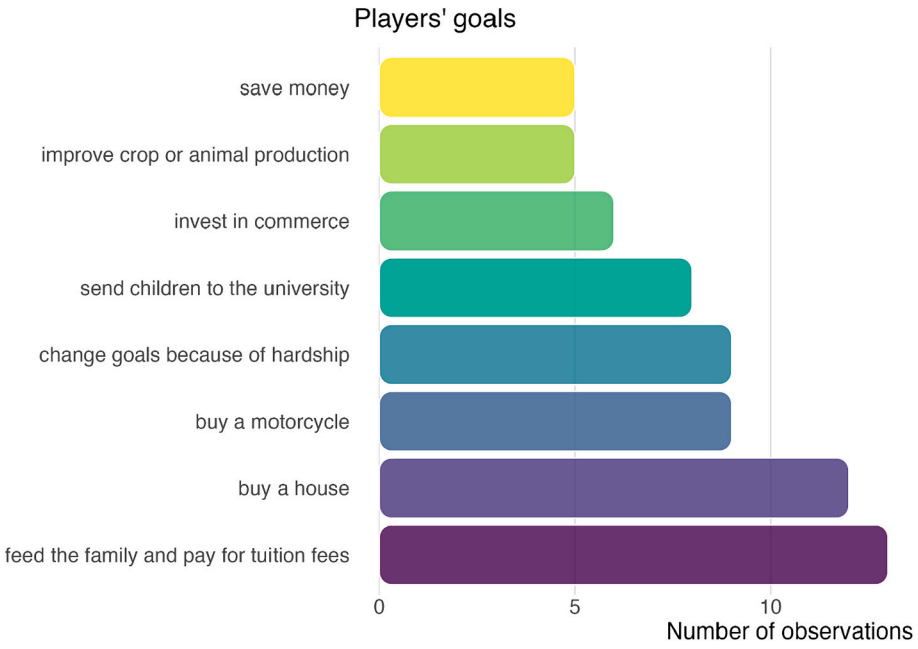

Fig. 2. Frequency of players' intentions. Multiple intentions per player were allowed.

motorized vehicle. Nevertheless, it is very unlikely that farmers would invest in agriculture when their most basic needs are not satisfied. Without active governmental intervention, farmers who are found in difficult financial positions will be unlikely to gain access to solutions to problems like low yield and food insecurity; remaining trapped in a downward spiral of poverty (Stoudmann et al., 2019).

3.2. Household economy as affected by player's profile

The player's profile mirrors the imbalances in resources available to households. We tested for the influence of profile on money spent and income generation. The permutational multivariate ANOVA showed significant differences between Small- (SF), Medium- (MF), and Large-sized Family (LF) players for income generation and expenditure variables ($p \leq 0.05$), but it did not show significance when comparing crop composition. Furthermore, there was no difference in gender in the PERMANOVA analysis ($p > 0.05$). SF spent more money on labour, while LF spent more on buying seeds (Fig. 3). There were no clear differences when it came to money spent on household improvements between these players. In terms of income sources, all players, regardless of their in-game roles, primarily earned income through crop sales, with MF players having the lowest crop-based income (Fig. 4). This could be explained by the size of their family, determining the amount of labour force they can allocate to the field. SF obtained more money from selling animals, compared to the others. MF and LF had more interest in engaging in off-farm activities. All players loaned similar amounts of money.

While a few recent studies have demonstrated the relationship between gender and decision-making strategies (Larson et al., 2020; Michalscheck et al., 2020), this study did not yield conclusive findings regarding the influence of gender roles on income sources and spending behaviour. This ambiguity may be attributed to the prevalent male influence within families, which can ultimately affect the decision-making influence of females, as exemplified by Ndlovu and Mjimba (2021) in Zimbabwe.

3.3. Livelihood strategy types

Additionally, to the results presented in Fig. 3 and Fig. 4, we observed differences between strategies developed during the game, identifying a total of 5 groups through our PCA and HCA (Fig. 5, Table 2). In our PCA, the three principal components utilized accounted for 69.5% of the variability. The five groups identified by our HCA were classified as such:

- *Loan seekers*: Characterise players who decide to loan more money from the bank (20 $/round). They also tended to do less off-farm activities (38 $/round) and sell more crops (105 $/round).
- *Subsistence farmer*: Represent players who did obtain more money from selling crops (67 $/round) and spent less on buying seeds (22 $/round) for planting. These players had a moderate off-farm income (77 $/round)
- *Crop centric*: These are players that made most of their money from selling crops (108 $/round) while having higher expenses for purchasing seeds to plant for the new season (58 $/round). Together with the Loan seekers, the seed-dependent group borrowed more money than others (15 $/round).
- *Household investors*: Encapsulate players who made important investments into their households (112 $/round). Together with the Off-farm workers, they were the largest group having more off-farm income (128 $/round).
- *Off-farm workers*: This is a group defined by players who obtained more money from off-farm activities (134 $/round). Although this group is like the Household investors, players did not spend much money on improving their households (3 $/round).

By combining our results in a Sankey diagram (Fig. 6), we observe some notable connections between players' profiles (Small-, Medium-, Large-sized family—SF, MF, LF) and strategy types (Loan seeker, Subsistence farmer, Crop centric, Household investor, Off-farm worker). Players from both the LF and MF were found across the five different strategy types. Most MF players were more strongly related to the Subsistence farmer type. LF players were evenly distributed across all five strategy types. SF players were not found in either the Household

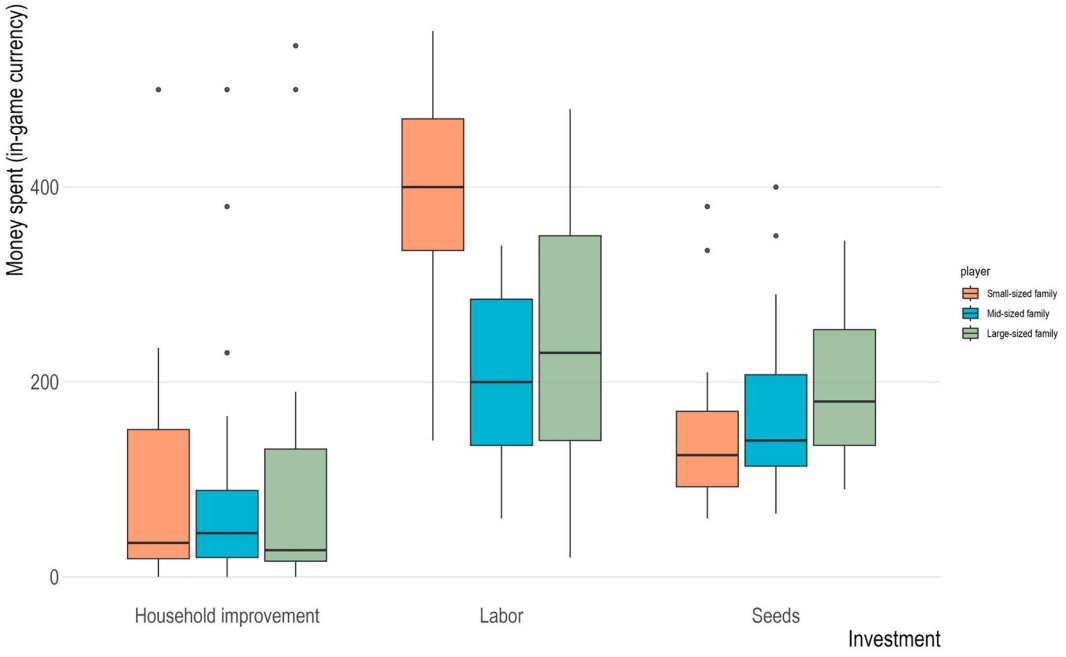

Fig. 3. Average total money invested per player type. The variables employed in these plots were also utilized in the PERMANOVA analysis ($p \leq 0.05$), indicating differences in the total money invested per player type.

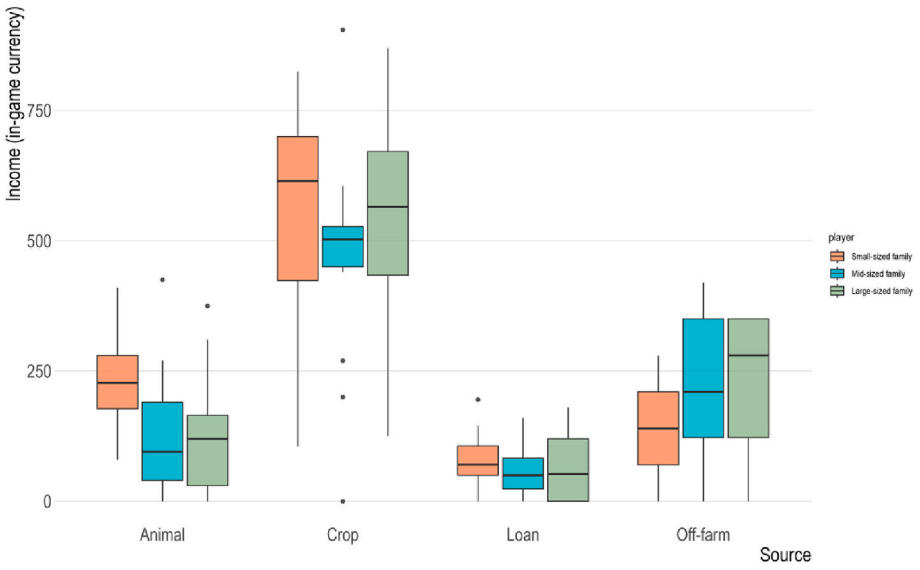

Fig. 4. Total Income generated by multiple sources per player type. The variables employed in these plots were also utilized in the PERMANOVA analysis ($p \leq 0.05$), indicating differences in the total generated income per player type.

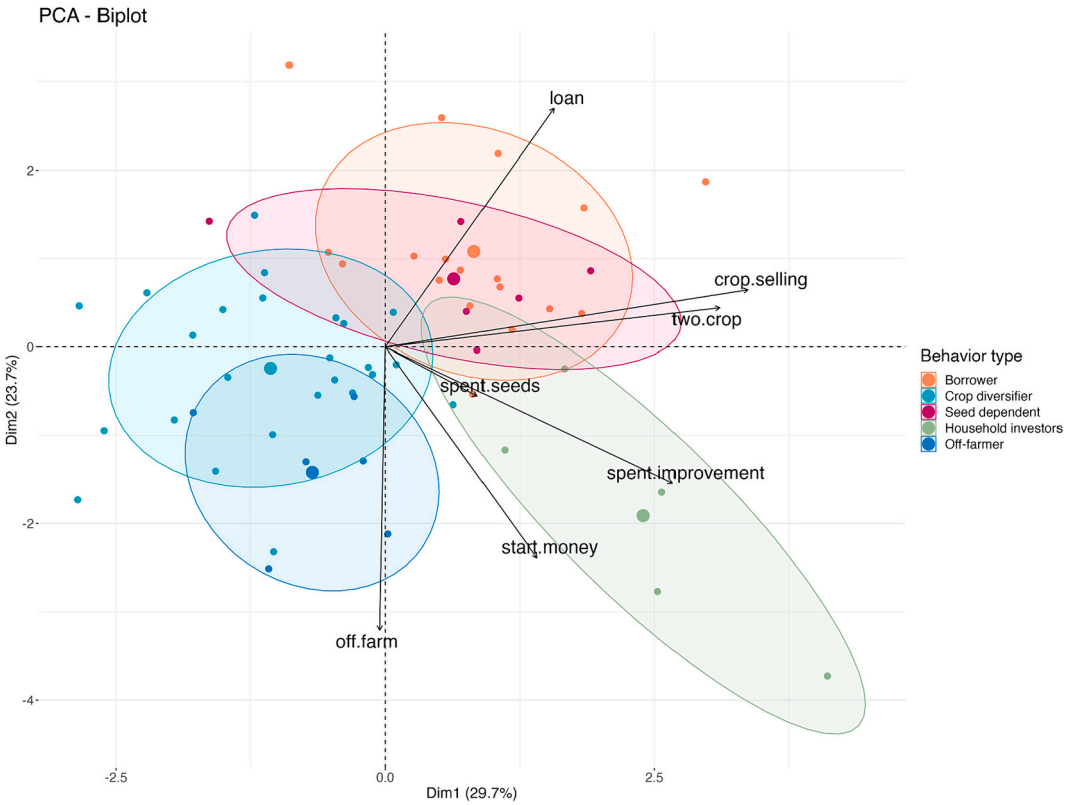

Fig. 5. Strategy types. Principal components 1 (x-axis) and 2 (y-axis). The arrows represent the seven indicators used in the analysis. Individual players are represented as small dots. Large dots are the centroids for each resulting group from the Hierarchical Cluster Analysis.

investor or the Off-farm worker type. Furthermore, players from the MF profile were also the largest borrowers of money. This connection between resources and strategy types observed during the game was observed by Jezeer et al. (2019) in coffee production systems, and it can be explained by how individuals build a livelihood based on resources at the household, community, and institutional platforms (Brown et al., 2017).

Alemayehu et al. (2018) describe how risk aversion might prevent farmers from engaging in high-risk, high-reward activities. They further explain that farmers prefer to diversify their crop production for subsistence. While we agree with this notion, our results show how resource availability and household composition might also affect farmers' decisions and strategies. In their book on scarcity, Mullainathan and Shafir (2014) explain how the concept of scarcity hampers our capacity to solve problems, retain information, and engage in logical reasoning, ultimately impacting agricultural production. For the SF players, labour

Table 2
Main differences between strategy types. Average indicators per round for each group identified in the Hierarchical Cluster Analysis. Different letters after the values indicate significant differences between groups (Kruskal-Wallis test, $p < 0.05$).

	% of land with two crops	Off farm income ($)	Crop selling ($)	Spent on seeds ($)	Money borrowed ($)	Money spent on improvement ($)	Start money ($)
Loan seekers	0.80 ab	38 a	105 a	22 a	20 a	23 ab	106
Subsistence farmer	0.49 c	77 ab	67 ab	22 a	6 bc	7 a	98
Crop centric	0.67 abc	45 a	108 a	58 b	15 ab	12 a	75
Household investor	0.97 a	128 b	113 b	36 ab	8 abc	112 b	154
Off-farm seeker	0.50 bc	134 b	83 b	43 b	1 c	3 a	111

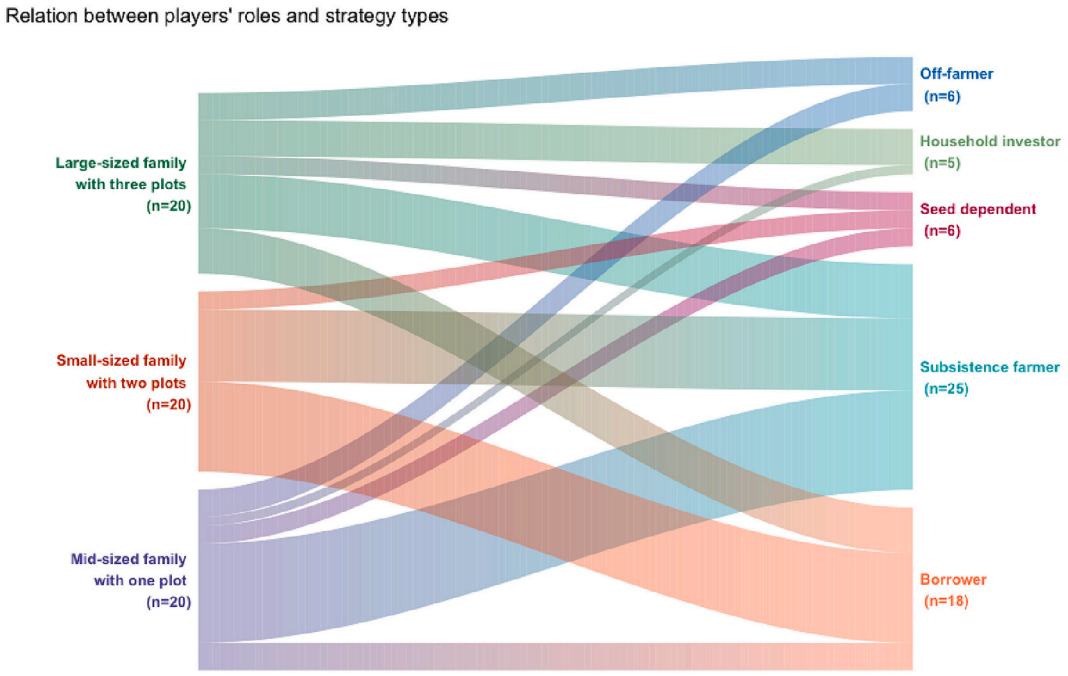

Fig. 6. Sankey diagram showing the connection between players' profiles and strategies.

was a major scarcity. Consequently, these players explored fewer options compared to those from the Medium-sized or Large-sized profiles. Similarly, MF players, who owned less land, were mainly connected to the Subsistence farmer type.

3.4. Significance and limitations of this study

There are growing worldwide concerns about the sustainability of food systems (Clapp, 2021; Lindgren et al., 2018). While many studies have explored the significance of gender roles in adopting climate-smart agriculture or implementing climate change mitigation practices, and have highlighted promising technologies to help farmers adapt to climate change while enhancing the sustainability of agricultural systems, a fundamental issue persists in rural areas—food insecurity (Ampaire et al., 2020; Anugwa et al., 2022; Pearse, 2017). Players in this study expressed significant concern regarding the prioritization of satisfying their families' basic food needs. Enhancing agricultural productivity and income among smallholders plays a pivotal role in poverty reduction and the attainment of food security. This, in turn, can catalyse economic transformation, growth, and the development of the non-farm sector, as emphasized by Lipper et al. (2014). For farmers contemplating investments in diverse areas, addressing their fundamental needs is the preliminary requirement. Notably, agriculture typically does not emerge as their preferred avenue for investment.

One criticism addressed to strategy games is how much you can extrapolate the findings obtained during a game workshop to real life (Jackson, 2012). According to Garcia et al. (2016), the game achieves validity when early players, involved in development and testing, express the sentiment "this feels real." Once this threshold is reached, every player in a game session undergoes an authentic interaction with the system from their unique perspective. Fully immersed in the fictional world, individuals take on distinct profiles and perceive their experiences as genuinely authentic (Garcia et al., 2016; Garcia et al., 2022). The debriefing phase after each game session also helped to triangulate our observations with people's reality. For example, a player said: "*In real life, I grow multiple crops as I like to eat a diversity of food. That is why I planted several crops in the game.*" Another one said: "*I grew beans in the game as I heard it has a lot of vitamins and it prevents kids from getting sick. I do the same thing in real life*" (player 3, workshop 3). Another player explained: "*Just like in real life, I decided to save some of my seeds instead of feeding my family. This way I do not have to buy seeds in the market when it is time to plant*" (player 4, workshop 5). By analysing players' interactions with the game, discussing them, and explicitly asking players to compare their actions with those in real life, we were able to blur the line between the game and reality. While many of the issues and constraints raised by players during the game sessions were particular to their real-life situations, we believe that these concerns are usually not completely voiced, understood, or taken into consideration when targeting development interventions. Effective and socially equitable conservation initiatives should be guided by a deeper understanding of

people's strategies, motivations, intuitions, and their ability to adapt to changing circumstances (Bennett et al., 2017; Feintrenie et al., 2010; Garcia et al., 2010; Garcia et al., 2022; von Diest et al., 2020).

4. Conclusions

In employing a strategy game, our study effectively collected insights from farmers' intentions. It reveals that, for most of the participants in this study in southern Togo, investing heavily in agriculture is not their foremost priority, even when agriculture is intrinsically related to food security and the main source of income for the farmers in our study area. Instead, their primary concern centres around ensuring the quality of life for their families, encompassing sufficient food provision and securing their children's education. Agricultural production is usually insufficient to satisfy both the economic and nutritional needs of families. Consequently, families are forced to sell part of their production to ensure education for their children or deal with emergencies like hospitalization. In doing so, the food security of rural families becomes compromised, reducing thus the chances for investing in agriculture when other needs must be first satisfied. This presents some of the challenges farmers must face when confronted with difficult choices between short-term and long-term decisions—prioritizing immediate family sustenance to investing in future agricultural productivity. This observation suggests that to foster greater interest in agricultural investment, it is imperative to address the most fundamental needs of families, primarily focusing on food security, education, and adequate housing. In a broader global context, it's evident that food insecurity is on the rise after decades of improvement, driven by disruptive global events like the COVID-19 pandemic, trade conflicts, and geopolitical tensions. Addressing this recurring issue is crucial because farmers may find it challenging to make the necessary investments to enhance their agricultural systems. Even if such investments were made, there is no guarantee of success, especially given that most families rely on small arable land plots.

Many farmers find themselves with limited alternatives, often compelled to rely on agricultural systems that struggle to provide sufficient output for family sustenance and meet essential needs such as education and decent housing. Our analysis has highlighted the significant role of household structure, including available land and family size, in farmers' decision-making. Larger families with more extensive landholdings tended to allocate fewer resources to subsistence farming and focused more on generating income from off-farm activities. This underscores a clear link between labour availability and the pursuit of alternative income sources. Notably, among all the groups, only large and middle-sized families ventured into off-farm businesses, emphasizing the trend of farmers investing in off-farm activities when they have the necessary resources.

These disparities in conditions should be considered when devising new solutions for farmers. Prioritizing food security is crucial for enhancing human welfare, alleviating hunger, and laying the foundation for sustainable development. In the face of escalating challenges related to climate change, resource scarcity, and population growth, governments, international organizations, and humanitarian efforts must prioritize addressing food security issues. The enduring challenges observed in agricultural systems are succinctly encapsulated in Giller et al. (2021) inquiry: "*Farming for food, income or lack of better option?*". Improving agricultural production is key to solving the first two facets of their question, a task that could be approached through subsidies, private investment, dedicated research, and extensive outreach efforts. However, making this activity attractive for the next generations remains a challenge, particularly amidst the global trend to move away from the arduous, unpredictable, and risky aspects inherent in farming practices.

CRediT authorship contribution statement

Ivan P. Novotny: Conceptualization, Methodology, Software, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. **Nastasia Boul Lefeuvre:** Conceptualization, Investigation, Data curation, Writing – original draft, Writing – review & editing. **Koffi S. Attiogbé:** Conceptualization, Methodology, Investigation. **Atakpama Wouyo:** Conceptualization, Writing – review & editing. **Folega Fousseni:** Conceptualization, Writing – review & editing. **Anne Dray:** Conceptualization, Writing – review & editing, Funding acquisition. **Patrick O. Waeber:** Conceptualization, Writing – review & editing, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Research data (Original data)

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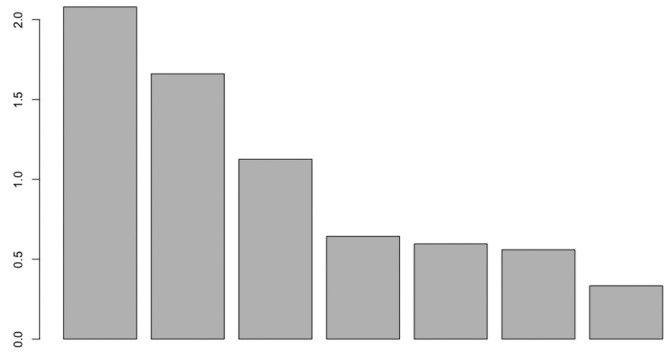
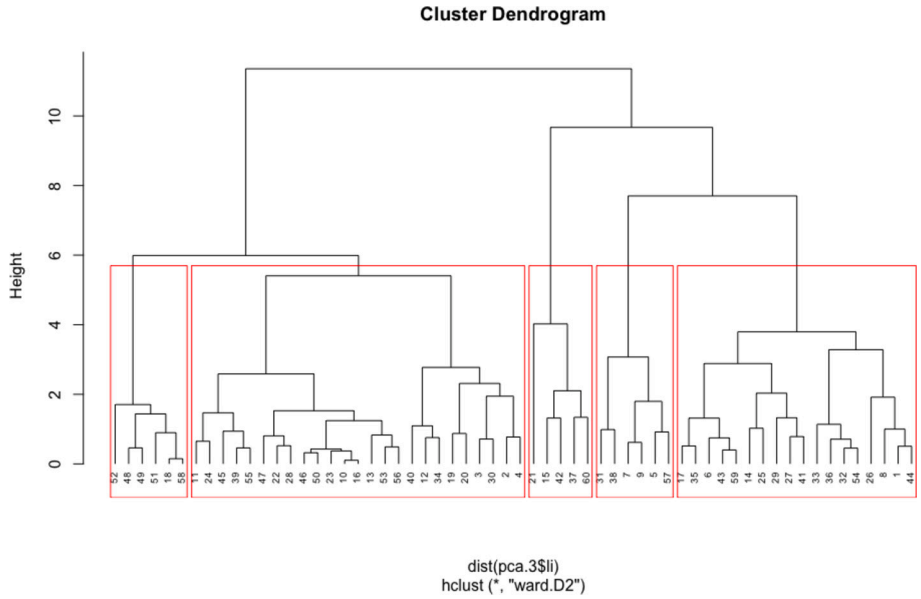
Appendix A. Appendix



Appendix 1. Eigenvalues per principal component.



Appendix 2. Cluster dendrogram displaying five groups of players' strategies.

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